Exploring the Distribution of Urban Socio-Spatial Interactions through the Perspective of Digital Mobile Communication

Aminreza Iranmanesh

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Architecture

Eastern Mediterranean University
January 2019
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Assoc. Prof. Dr. Ali Hakan Ulusoy
Acting Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy in Architecture.

Prof. Dr. Resmiye Alpar Atun
Chair, Department of Architecture

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Doctor of Philosophy in Architecture.

Prof. Dr. Resmiye Alpar Atun
Supervisor

Examining Committee

1. Prof. Dr. Resmiye Alpar Atun
2. Prof. Dr. Naciye Doratli
3. Prof. Dr. Arda İnceoğlu
4. Prof. Dr. Çağatay Keskinok
5. Asst. Prof. Dr. Nevter Zafer Cömert

ABSTRACT

Cities are among the most complex structures humankind has ever constructed; they are multidimensional entities comprising layers of movements, interactions, and information. The complexity and interconnectedness of interactive urban layers are ever increasing in the contemporary world. The institute of communication has faced a paradigm shift with the widespread use of digital mobile devices. Accordingly, research on cities must consider this phenomenon as it directly affects two of the basic components of the urban network: location and communication. Mobile digital communication has undermined the has undermined the necessity of being present and the need for physical proximity. The effects of this fundamental shift are not well understood in recent urban literature. This research first tries to develop a theoretical framework for addressing the mutual dialectic between urban space and socio-spatial interaction via the perspective of the emerging digital communication and the process of integrating social media into everyday life. Second, the dissertation explores the relationships between levels of accessibility to urban space throughout the spatial grid and the possibility for the establishment of socio-spatial interaction through geo-tagged data (in this case: Twitter). The study aims to contribute to the existing literature by suggesting a new methodological approach for reading the complex socio-spatial network of the city that takes mobile digital interactions into account. Accordingly, the methodological approach of the study comprises two overlapping types of network data: firstly, the graphically-tagged social network data that citizens produced within the urban space, and secondly, the physical accessibility through the space syntax measurements.

The results show the significance of local accessibility in predicting geo-tagged Twitter data. The outcome also suggests that, in exploring emerging types of data, it is critical to look at the outliers and patterns of behavior that align with the increasing complexity of the urban structure.

Keywords: Socio-spatial interactions, urban accessibility, public space, space syntax analysis, geo-tagged social media, Twitter, GIS science

ÖZ

Şehirler, farklı kentsel hareket katmanlardan oluşan etkileşimi ve bilgiyi içerisinde barındıran çok boyutlu ve kompleks organizmalardır. Günümüz dünyasında interaktif kentsel katmanların karmaşıklığı ve birbirine bağlılığı giderek artmaktadır. İletişim Enstitüsü, dijital mobil cihazların yaygınlaşmasıyla birlikte bir paradigma değişikliği yaşadı. Bu bağlamda, konum ve iletişim kavramlarının, kentsel ağın iki temel bileşeni olduğundan ve şehir yapısını doğrudan etkilediğinden, şehirler ile ilgili yapılan araştırmalarda bu iki konunun göz önünde bulundurulması gerekmektedir. Mobil dijital iletişim, iletişim için fiziksel olarak orada bulunmanın veya fiziksel yakınlığın gerekliliğini zayıflatmıştır. Bu temel değişimin doğadaki etkileri güncel kentsel literatürde çok iyi anlaşılamamaktadır. Bu bağlamda, bu araştırma ilk olarak, ortaya çıkan dijital iletişim perspektifinden ve sosyal medyanın gündelik hayata uyum sürecinden yararlanarak, kentsel mekân ile sosyo-mekânsal etkileşim arasındaki karşılıklı diyalektiği ele almayı ve teorik bir çerçevede geliştirmeyi amaçlamaktadır. İkincisi, bu tez, mekânsal düzen üzerinden kentsel alana erişilebilirlik düzeyleri ve coğrafi etiketli veriler (Twitter) ve de sosyo-mekânsal etkileşim kurma olasılığı verileri arasındaki ilişkiyi araştırmaktadır. Bu çalışmada, yerel halkın mobil dijital etkileşim verilerinden yararlanarak, kentin karmaşık sosyo-mekânsal ağını okumak için yeni bir metodolojik yaklaşım önerip, mevcut literatüre katkıda bulunak amaçlanmaktadır. Bu bağlamda, çalışmanın metodolojik yaklaşımı, iki tür ağ verisinin üst üste konularak incelenmesini içermektedir. Birincisi, kentsel alandaki yerli halkın sosyal ağ verilerinden yararlanarak oluşturulmuş, aralarındaki etkileşimi gösteren grafiksel verileri ve ikincisi de, mekân sözdizimi (Space-syntax) ölçümleri yoluyla erişilen fiziksel erişilebilirlik verileridir.

Sonuç göstermiştir ki, coğrafi etiketli Twitter verilerinin öngörülebilmesinde, yerel erişilebilirliğin büyük önemi vardır. Aynı zamanda, kentsel yapının artan karmaşıklığına paralel olarak, davranış biçim ve kalıplarına bakmanın ve bu konuyla ilgili yeni veri türlerini araştırmanın kritik önemi vardır.

Anahtar Kelimeler: Sosyo-mekânsal etkileşimler, kentsel erişilebilirlik, kamusal alan, mekân sözdizimi (space-syntax) analizi, coğrafi etiketli sosyal medya, Twitter, GIS bilimi

ACKNOWLEDGMENT

First and foremost, I like to express my gratitude and deep appreciation to my dear supervisor Prof. Dr. Resmiye Alpar Atun for her continues support throughout my Ph.D. studies. Her guidance and open-mindedness helped me to explore new horizons in my studies. I could not have imagined having a better mentor during my time on this island.

I would like to thank my thesis monitoring committee Prof. Dr. Naciye Doratli, and Asst. Prof. Dr. Nevter Zafer Cömert for providing me with valuable insights and recommendations since the beginning.

My sincere thanks to Prof. Dr. Şebnem Hoşkara for providing me with scholarship opportunities that enabled me to continue my studies in peace.

Endless love to my beloved wife Aida Jalalkamali for her unconditional support.

I would to extend my gratitude to all kind members of EMU architecture family for their encouragements.

I would like to thank the jury members Prof. Dr. Arda İnceoğlu, and Prof. Dr. Çağatay Keskinok for their invaluable contribution and insightful comments.

TABLE OF CONTENTS

ABSTRACT ... iii

ÖZ ... v

ACKNOWLEDGMENT ... vii

LIST OF TABLES ... xii

LIST OF FIGURES ... xiv

1 INTRODUCTION ... 1

1.1 Background of the Problem: Cities and Emerging Communication Technologies ... 3

1.2 Defining the Notion of Socio-spatial Integration through the Perspective of Mobile Digital Communication ... 8

1.3 The Statement of Problem ... 11

1.4 Methodology and Research Design ... 13

1.5 Case Study ... 16

1.6 Limitation ... 17

2 CITY AND NETWORKS, A THEORETICAL FRAMEWORK ... 20

2.1 Social Network and Human Community ... 21

2.2 The Effects of Network Society on Everyday Life ... 23

2.3 Networked Individualism ... 27

2.4 Effects of Social Media on Everyday Social Ties ... 29

2.5 The Growth of Telecommunication and Socio-spatial Interactions ... 31

2.6 Urban Public Spaces, the Main Nodes of Interaction in Cities ... 32

2.7 The Changing Role of Citizens through Social Media ... 35

2.8 Chapter Summary ... 36

3 ACCESSIBILITY AND CHANGING CONCEPTION OF DISTANCE IN THE AGE OF DIGITAL NETWORKS 38

3.1 Accessibility through Urban Spatial Network 42

3.2 Measuring the Accessibility of Urban Network 50

3.2.1 Exploring the Concept of Accessibility through Space Syntax Analysis 51

3.2.2 Metric Distance and Street Centrality Measurements 54

3.2.3 Measurements of the Angular and Metric Cost of Travel 55

3.3 Chapter Summary 56

4 RE-READING URBAN SPACES THROUGH 'BIG DATA' AND MIXED METHODS 58

4.1 Big Data and Contemporary Research 59

4.2 Why Understanding the New Data Is Important in Reading the Contemporary Urban Spaces? 61

4.3 New Data and Contemporary Urban Issues 63

4.4 Exploring Socio-Spatial Interaction of Urban Space through 'Big Data' 64

4.5 Challenges of 'Big Data' 65

4.6 Twitter as the Source of Geo-tagged Socio-spatial Data 66

4.7 Chapter Summary 68

5 METHODOLOGY AND CASE STUDY 69

5.1 Designing the Methodological Approach 69

5.2 Case Study 73

5.3 Data Collection 75

5.3.1 First Layer: Geo-tagged Twitter Feeds, the Source of Socio-spatial Interaction 75

5.3.2 Second Layer: The Name-Generator, an Insight into People's Perception of Urban Public Space 79
5.3.3 Third Layer: Spatial Accessibility, Space Syntax, and Metric Centrality . 81
5.3.4 The Segment Map 82
5.3.5 Space Syntax Measurements 83
5.4 The Process of Overlaying the Three Layers Data 85
5.5 First Objective: Testing the Predictability of Geo-tagged Twitter Data via the Name-Generator Survey 90
5.6 Second Objective: Exploring the Predictability of Geo-tagged Twitter Feed Data via Space Syntax Measurements 91
5.6.1 Multivariate Predictions of Geo-Tagged Twitter Data 97
5.7 Third Objective: Exploring the Potential Patterns of Socio-spatial Characteristics of Urban Spaces 98
5.8 Outliers, Having a Closer Look 104
5.9 Testing, Controlling and Repeating the Analyses 108
5.9.1 Controlling for Metric Measurements of Accessibility 108
5.9.2 Testing the Reliability of Grid System through a Segment Base Overlay System 111
5.9.3 Re-checking the Methodology in the City of Girne (Kyrenia) 114
5.10 Discussion 122
5.11 Utilization of the Research for Planning and Development 131
6 CONCLUSION 133
REFERENCES 139
APPENDICES 161
Appendix A: A Sample of Check-in Geo-tagged Twitter Feed Data 162

Appendix B: A Sample of Free Geo-tagged Twitter Feed Data 163

Appendix C: Descriptive Statistics of All Variables Assigned to the Hexagonal Grid 164

Appendix D: Correlation Coefficient Between Twitter Data and All Independent Variables.. 165

Appendix E: Internal Correlation of Space Syntax Angular Integration at Different Proxies... 166

Appendix F: Internal Correlation of Space Syntax Choice at Different Proxies . 167

Appendix G: Internal Correlation of Closeness Centrality (C_C) at Different Network Proxies... 168

Appendix H: Internal Correlation of Betweenness Centrality (C_B) at Different Network Proxies... 169

LIST OF TABLES

Table 1. The traditional group-based social structure vs. the emerging properties of the network society based on Rainie and Wellman (2012a, p. 38)................................ 30

Table 2. Formulas for the centrality measures... 56

Table 3. The process of collecting and filtering Twitter feed data 78

Table 4. The segment map descriptive statistics... 82

Table 5. Descriptive statistics of different layers of data.. 87

Table 6. Correlation coefficients between the first layer and second layer: exploring the reliability of geo-tagged Twitter feed 90

Table 7. Descriptive statistics regarding the distribution of DV and cumulative distribution of spaces in the hexagonal grid.. 92

Table 8. The multivariate regression showing the predictability of the outcome using local choice and global integration (the best fit model).. 98

Table 9. Exploring patterns of socio-spatial interactions and outliers based on their distance from the mean 98

Table 10. The identified types of spaces based on the one standard deviation away from the mean. 99

Table 11. The typology of outliers outside the 2 standard deviation away from the mean 105

Table 12. Predictability of geo-tagged data through integration at street level. 113

Table 13. The process of collecting and filtering tweets 115

Table 14. The descriptive statistics of angular integration in local/global level in the city of Girne (Famagusta is repeated for comparison).. 116

Table 15. The predictability of geo-tagged Twitter data via different levels of angular integration 118
Table 16. The predictability of geo-tagged Twitter data via different levels of angular choice 119

LIST OF FIGURES

Figure 1. The estimate of the global diffusion of mobile internet usage 2014-2019 (Liu, 2015) 6

Figure 2. The rise of digital communication and networked society......................... 10

Figure 3. The general outline of the research and methodological approach of the dissertation. 19

Figure 4. A network with multiple local nuclei, the two marked spaces are both locally accessible within a walking distance from all other spaces in the grid...................... 45

Figure 5. A globally accessible segment of the network, which could be reached from all other spaces in the network regardless of physical proximity 46

Figure 6. This line represents a space with attractive functionality, located in the most integrated part of the network, the functionality increases the probability of socio-spatial integration... 47

Figure 7. A highly active space through social media might increase the possibility of socio-spatial interaction. 48

Figure 8. Potential and probable accessibility by considering social media as a defining factor in urban public space 50

Figure 9. Fundamental differences between space syntax and street centrality analysis 56

Figure 10. Data collection and the analytical process, exploring the possible patterns of explanations for the objectives. 72

Figure 11. The city of Famagusta and its borders... 74

Figure 12. The city of Famagusta (a), the historic walled city (b), EMU campus (c), the UN camp inside the city (d), and the large military camp restricting access to the seafront (e) 74

Figure 13. The distribution of all geo-tagged Twitter feeds throughout the city represented via heat-map 79

Figure 14. The location of places tagged through the survey represented via a heat-map. 81

Figure 15. Space syntax local measurements left: integration at 500m at, right: choice at 500m 84

Figure 16. Space syntax local measurements, left: integration at 5000m, right: choice at 5000m 85

Figure 17. An example of the overlaying process via hexagonal grid 86

Figure 18. Distribution of places tagged via survey 88

Figure 19. The spatial distribution of geo-tagged Twitter feeds superimposed on the grid 88

Figure 20. Distribution of space syntax angular measurement with metric proxy superimposed on the hexagonal grid: (a) global integration R=5000m, (b) local integration R=500m, (c) global choice R=5000m, (d) local choice R=500m 89

Figure 21. Predictability of DV & DVt via Space syntax angular integration in the incrementally increasing radial proxy, all presented correlations are significant at 0.01 level. 93

Figure 22. Predictability of DV & DVt via Space syntax angular choice in the incrementally increasing radial proxy, all presented correlations are significant at 0.01 level. 94

Figure 23. Global Integration through two main arteries of the city: Salamis street and Mustafa Kemal Blv. 96
Figure 24. Visual representation of the spatial distribution of socio-spatial interaction typologies. 102
Figure 25. the distribution of outliers identified through filtering the data using the 2 standard deviation threshold 106
Figure 26. Examples of the outliers, type 5: palm beach (a), center of Salamis street (b), type 8: EMU campus (c), student dormitories (d), the walled city (e), type 10: major traffic junction (f), type 12: a suburban neighborhood (g) 107
Figure 27. Metric Street centrality measures, (a) global closeness at R=5000m, (b) local closeness at R=500m. 109
Figure 28. Distribution of metric street centrality measurement with metric proxy superimposed on hexagonal grid: (a) CC R=5000m, (b) CC R=500m, (c) CB R=5000m, (d) CB R=500m.......... 110
Figure 29. Predictability of DV & DVt via metric closeness centrality in incrementally increasing network proxy, all presented correlations are significant at 0.01 level. 111
Figure 30. Predictability of DV & DVt via metric betweenness centrality in incrementally increasing network proxy, all presented correlations are significant at 0.01 level. 111
Figure 31. Counting Twitter data entry for each segment within a 30 meters diameter. 112
Figure 32. The location of outliers in segment level data entry.......... 114
Figure 33. The heat-map of geo-tagged tweets throughout the city of Girne.......... 115
Figure 34. The angular integration or Girne through segment map, right: local at R=500m, left: global at R=5000m 116

Figure 35. Angular integration map of Girne represented on the 250m hexagonal grid. 117

Figure 36. Angular choice map of Girne represented on the 250m hexagonal grid. 117

Figure 37. Distribution of geo-tagged tweets throughout the city of Girne represented on the hexagonal grid 117

Figure 38. Distribution of socio-spatial patterns considering 2 standard deviations away from the mean in the city of Girne 120

Figure 39. Distribution of outlier considering 2 standard deviations away from mean in the city of Girne 120

Figure 40. Global integration through two main arteries of the city: Ecevit Street: a&c and Ziya Rızkı street b&d. 121

Figure 41. The correlation between angular choice measures and the name generator survey, the results are significant at 0.01 125

Figure 42. The correlation between angular integration measures and the name generator survey, the results are significant at 0.01 125

Chapter 1

INTRODUCTION

The socio-spatial structure of human settlement and its dynamic processes are central in urban studies; the urban systems evolve over time and adapt to emerging conditions. Creative capacity and collective learning have allowed society to change the dynamic of cities. Throughout the process of collective learning, every new invention also brought forward its consequences and consequently, has changed the dynamism and complexity of the socio-spatial form of urban life.

Jacobs (1961) referred to cities as the problems of "organized complexity." She argued that cities not only contain numerous variables but endless interconnections and relationships among those variables. The nature of organized complexity is in an ever-evolving state as the foundation of organization and complexity are subject to emerging changes. Urban settlements are being instrumented with pervasive mobile technologies that record and return new layers of data in an unprecedented way (Kitchin, 2014). As new studies unfold new effective variables and the interrelationships among them, it seems to become more redundant to provide generalized assumptions to explain how cities work. Today, the possibilities of interactions between the city and its inhabitants reach beyond physical form and into the morphology of social life.

The urban field of information is wide and multidisciplinary. Madanipour (2007) argued, “The urban fabric is composed of many different components, whose underlying mechanisms cannot be grasped all at once.” Thus, as cities evolve into a new form of communication and networking, the methodological approaches must evolve to study them. The rising complexity of interacting mediums renders the isolation of any research subject exceedingly difficult. As a consequence, this might potentially cause the drawing of inaccurate conclusions when new layers of data are overlooked. Therefore, the process of limiting factors in order to extract correlations among fewer variables must be approached with caution. Comprehensive studies that take digital communication into account and simultaneously try to be decisive must be considered an essential component of contemporary urban studies. Advancements in analytical tools and data collection techniques in the past decade have increased the possibility of exploring complex urban systems with more confidence (Salingaros, 2005). Research on the ubiquitous emergence of communication technology in public spaces of a city has become more vibrant in recent years. According to Townsend (2000), the speed and metabolism of urban life are swiftly increasing due to the ease of communication through emerging mediums. This process happened fast and in the real life of the city, changing the structure in which urban space works. The transformation of space-bound social ties to mobile devices makes public space an inevitable aspect of the discussion of the social network. The term public space in this research refers to non-residential public domains that are distinguishable by their extroverted functions, attracting all members of the society.

The emerging nature of new mediums of communication has created a gap in our understanding of contemporary urban socio-spatial interactions. Urban studies need to address the advent of digital mobile communication into everyday interactions.

Although many researchers tried to fill this gap, forming new frameworks to explore and evaluate the relationship between digital communication and urban space needs more investigation." Moreover, there seems to be a gap in methodological scientific studies undertaking the fundamental relationships between constantly “evolving social networks” and the spatial network structure of the city on a smaller scale. The power of the emerging interactions because of mobile devices should be understood in order to reach more comprehensive strategies for designing efficient contemporary urban spaces. Such understanding could challenge the way of approaching the design of vital contemporary urban spaces. This study is an attempt to see the new socio-spatial interactions in urban space in order to provide a ground for further development. Christopher Alexander (1964) argued that due to the increase in urban populations, solving functional issues has become more difficult. Instead of trying to develop methods to understand the complexity, the design solutions often cling to a set of predetermined formal frameworks, and the problem remains unsolved because of its natural complexity. Problem-solving in the urban design field requires analytical processing of a vast quantity of information (Christopher Alexander, 2002).

1.1 Background of the Problem: Cities and Emerging Communication Technologies

The communication revolution has restructured the meaning of being present and interacting in everyday life. Giddens (1991) advocated the introduction of the telegraph as a defining point that rendered a new time/space paradigm. The invention of the telegraph at the beginning of the 19th century redefined the concept of distance and communication. This then-new form of communication gradually superseded the necessity of physical proximity in the realization of social groups (Zachary, 2012). Accordingly, as the means of producing social relationships becomes less spatially bounded, the values in which these relations are constructed and the definition of social ties should be re-evaluated. Chambers (2006) saw individuality as the main characteristic of contemporary communications under the shadow of constant internet connectivity. This paradigm shift also happens in how people perceive and interpret their network, especially for new generations born into a world full of these mediums. Manual Castells used the term 'space of flow' to define this new hybrid space that is an agglomeration of physical and digital spaces. He defined it as "re-conceptualiz[ing] new forms of spatial arrangements under the new technological paradigm" (Castells, 1989, p. 146). This new dynamic form of space is not restricted by physical distance and reproduces new sets of meaning and values that need to be studied in more detail. Therefore, the research needs to explore the mutual interactions between society and space in a new light.

Moreover, contemporary socio-spatial interactions in urban spaces are being reconfigured by the reproduction of emerging information field. Urban space is a social phenomenon and society retains inherent spatiality; therefore, it is not possible to consider them as separated entities. Space might create positive or negative opportunities for social production, and social activities can reshape spatial configuration (Hillier, 1996). Space is not a framework for social and cultural behavior; it is rather a 'built-in quality' by which all urban forms have been produced. Every social interaction has its own spatial form (Hillier & Hanson, 1984). Therefore, human activities have fundamental spatial patterns. It could be argued that the interconnectedness between society and spaces is an ever-evolving process that provides possibilities for new activities and spaces to come to life. This dissertation tries to explore the concept of 'interaction' as a socio-spatial entity. The necessity of addressing the relationship between cities and emerging mobile digital communication becomes stronger when considering the following: the increasing population of urban settlements with access to the internet and mobile devices, the paradigm shift in the definition of socio-spatial interaction, and the large quantities of data that are being produced as the result of these changes.

First, the growing population of cities must be addressed. The human population has moved continually toward urban settlements since the industrial revolution. It is expected that 69% of people worldwide will be living in urban settlements by 2050 (UN, 2018). The rise in population is coupled with increasing access to information technology. Therefore, it seems necessary to investigate the mutual effects of space and society on the rise of connectivity and complexity through the window of digital communication and social media. Activities of the user and the pattern of choices they make shapes new species of socio-spatial space which is partly physical and partly virtual. Moreover, the annual report of the International Telecommunication Union (ITU) shows the rising diffusion of cell phone users and internet users all around the world (ITU, 2013). According to (Liu, 2015), the rate of mobile phone per person was estimated to be at 52.7% globally in 2015 and it is rapidly increasing (Figure 1).

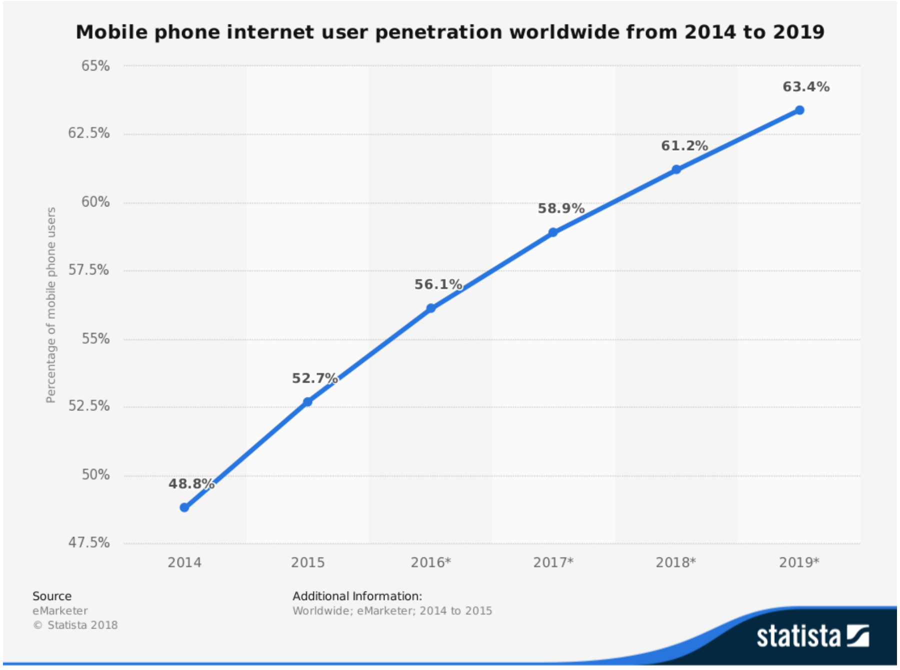


Figure 1. The estimate of the global diffusion of mobile internet usage 2014-2019 (Liu, 2015)

The ease of access to new communication mediums is rapidly increasing as mobile devices become an inseparable aspect of everyday life. The simultaneous development of new communication tools through social media and the increasing population of cities shows the importance of exploring new horizons in this field of research. These new phenomena are fast in becoming and have been widely understudied especially in regard to urban space. The easy access to internet connections has become a necessity rather than a luxury in the past few years. Today, internet access does not belong to a certain ethnic or economic profile and it connects more people every day all around the globe. Using social media has become a necessity that impacts people's opportunities for a better life; the majority of people spend a portion of their income on digital communication which provides them with a variety of new learning opportunities and job-related connections. Furthermore, the rise in virtual networking creates its own data as virtual communication in the information age has the ability to record peoples' interactions and interests in real time. The new data needs new methodological approaches and could improve our understanding of contemporary city life.

Second, the meaning of the “social production of space” must be explored with regard to the distance-less nature of digital communication because human connection might become partially segregated from the proximal boundaries of space. The rise of distance-less ties gives socio-spatial interactions a new appearance. People are getting more networked regardless of their person-to-person physical interactions. Thus, the possibility of this paradigm shift (the rise of distance-less ties) must be further tested and understood in regard to urban space. By considering the reciprocal interaction between society and space, this dissertation tries to develop a framework for testing and expanding the understanding of socio-spatial interactions under the influence of distance-less mobile communication (network society and social media).

Third, the development of understanding complex systems and more intricate analysis should be used as an opportunity to discover more about cities as the growing core of the future life of humankind. As cities become more connected and complex new types of data and advancements in computers can explain the dynamic nature of the contemporary city. The analytical processes for reading emerging urban interactions must take advantage of the computational power to reflect the increasing complexity of cities. Data tools like geographic information systems (GIS), visual graph analysis, social network analysis, computer-aided design, and complex statistical analysis are becoming more detailed and available. To understand the city as it is now, and as it could potentially become, urban-related research should be further developed in these ways.

1.2 Defining the Notion of Socio-spatial Integration through the Perspective of Mobile Digital Communication

The evolution of cities is built upon the interaction of people and urban fabric is composed of different components like spaces, networks, nodes, and connections. Exploring these patterns together could increase the predictability of human interaction with the environment and improve the process of decision-making and design. In order to clearly define the concept of socio-spatial interaction as the core concept of this dissertation, the two main typologies of network interactions are explained. *First,* the elemental interactions are the relationship between analogous elements (nodes) of the network. For instance, spatial network analysis contemplates the elemental interactions between spaces. A social network in its pure form consists of similar nodes (people, actors) and ties as examples of elemental interactions also. *Second,* interactions (ties) happen (form) between nodes with different natures. The relationship between people and places could be considered as such. It could be argued that because urban public space is a container of social interactions, all social networks are partially spatial, and all spatial networks are social entities to some extent. Batty (2012) argued in favor of the critical importance of exploring how the first types affect the second.[1] Nevertheless, all interactions are being formed on the actual ground of the city, therefore they possess a spatial dimension (Scellato, Noulas, Lambiotte, & Mascolo, 2011). Moreover, the elemental forms of interaction are not without social dimensions; as Hillier and Hanson (1984) argued the mutual relationship between how people think, move, and interact shapes the construct of these elemental forms, and in return, those spatial elements shape people's movements and interactions. Accordingly, this dissertation retains the keyword "socio-spatial interaction" as a tie

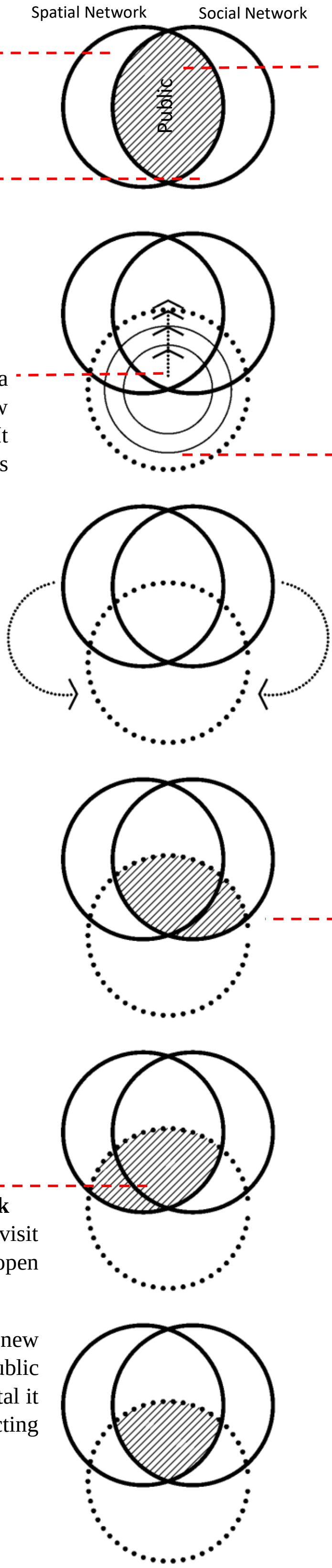
[1] To some extent, Space Syntax theory, at its core, is about expanding this relationship (see chapter 3).

that forms (is being formed or potentially would be formed) in the multidimensional relationship between actors of the society and urban public spaces.

In order to better investigate the significant socio-spatial networks of the city, this study uses both types of interactions via a spatial network (which retains its inherent social properties), and a socio-spatial network which consists of the digital footprints of people with intact geo-location tags. These semi-digital/semi-spatial interactions happen between the spatial structure and the social content of the city. The core idea is to explore the possible spatial patterns in the formation of these ties and see if/how the structure of the spatial network affects these processes. Granovetter (1983), argues that the flow of information, which can be considered the main production of urban spaces, moves through the weak ties. Strong ties are not critical in the flow of information as they often share the same values and interactions. Weak ties, on the other hand, are comprised of people who know each other loosely and share information from other parts of the network. It can be argued that urban public spaces were the major platform for the formation process of these ties. Public space is the spatial medium of interaction between social ties; therefore, it is a socio-spatial entity at its core. Hence, it is critical to investigate this platform through the window of digital communication which offers more variety of choices and is less bound by physical proximity. It seems that with the rise of social media and hyper-connected society, some of the functions of urban public spaces shifted to social media space. People tend to have more weak social ties and connections and people tend to connect more selectively with each other and with space.

Spatial Network
A network of spaces and their connections (spatial nodes and ties) which contains everyday urban life

Social Network
A network of people, groups, institutions, and their connections at different levels stretching from private to public.



Socio-Spatial Network of city
Urban public spaces: Person-to-person connections within a physical proximity, Every day public interactions with weak and strong ties

Growing influence of social-media and mobile devices is creating new types of socio-spatial integrations. It is rapidly growing into many aspects of the everyday life in the city.

The rise of the networked society
The rise of social media

Changing Dynamic of the Socio-Spatial Networks in the City
Many activities and functions of the social and spatial network of cities are being shifted into this new hybrid and dynamic space; accordingly it transforms the nature of the social networks.

The intersection between social media and social networks is growing. People keep in touch with each other regardless of their distance or goal. Urban weak ties which use to be the dominant factors in the flow of information are being replaced with social media weak ties.

Social Media and Spatial Network
People talk about the places they visit and their activities in the city on an open platform.

Vitality of urban public space has a new influential element: trending. If a public space or activity tends to remain vital it needs the people who are interacting with it to properly presented.

Socio-Spatial Network of City and Social Media
An emerging dimensions added to public spaces by new medium of social media and networked society creates a new hybrid space the does not merely exist only in the physical form or in people-place interactions in the space, but also in social media. People get their information from extended weak ties through others feelings and activities. New technologies need new theories and discussions.

Figure 2. The rise of digital communication and networked society

It could be argued that proximity is becoming less prominent in forming and maintaining the ties, and unlimited optional values, interests, and activities are becoming more dominant. The promotions and public recommendations made through social media are critical aspects of what a contemporary public space represents. Here, the aim is to explore whether urban public space is being delocalized and deterritorialized by the distance-less interactions formed through social media or if local physical accessibility is still significant in the formation process of these interactions (Figure 2).

The focus of this research is where these layers overlap in order to define how people access a place and if their interaction with space and each other creates further feedback and consequences. Figure 2 shows different stages of development of the urban socio-spatial network in relation to the emerging social media technologies.

1.3 The Statement of Problem

Despite the recent growth in scholarly activities targeting various physical and social dimensions of the city, the adaptations and understandings of the effects of the new social media and its connections with urban space remain a gap in the body of the literature. This dissertation focuses on the ways that the new mobile digital communication mediums render peoples' interactions with urban public space by putting emphasis on the distance (accessibility) as a defining variable. Distance-less communication has changed the way people use and interact with urban space. As the medium of interaction changes, the concept of proximity in the formation of socio-spatial interaction changes. This phenomenon shifts the socio-spatial interactions from local nuclei of the city to the more central public spaces of the city. The study explores how the rise of social media affected the socio-spatial form of urban life by changing the fundamental properties of its network, and how it affects the socio-spatial interaction resulting in delocalization of human activities. The general aim is to test whether the new communication mediums potentially could be the force of delocalization and deterritorialization of human activities in cities.

Furthermore, the emerging communication methods are not mere means of producing ties but a new source of information and a footprint through which researchers can understand the socio-spatial interactions. Therefore, new methods are required to understand urban space with its new components and productions. There seems to be a shortcoming in practical methodologies for analyzing the effects of the "network society" in the information age and how it affects the urban networks.

Accordingly, the main research question of this study could be phrased as:

- How does the utilization of social media by people affect their way of access to and interaction with urban public spaces throughout the spatial network of the city?

The first sub-research question explores the reliability of the data retrieved from social media in conducting research on socio-spatial interactions throughout the city.

- To what extent could digital footprints of people through social media be utilized for research and how reliable is this layer of information in representing people's interaction with the urban network?

Further sub-research questions were designed to explore the possibility of meaningful patterns in socio-spatial interaction through the perspective of digital mobile communication.

- Do the changes in social interactions via the rise of social media affect spatial accessibility to urban public spaces of the city, and if so, how?
- Does the selective accessibility to common values and activities create homogeneous urban public spaces or vice versa?
- Do the changes in social interactions and the rise of social media affect the spatial form of urban life, and if so, how?

This dissertation tries to develop a way of looking into the interactions between society and space through the glass of digital communication by utilizing the new developments in data collection and data analysis techniques. It focuses on the geo-tagged socio-spatial data as interactive layers of urban settings. Furthermore, the study focuses on the configurational view of how emerging changes in communication technology and formation of new socio-spatial ties might affect and be affected by the urban space. Looking at the city as "organized complexity" indicates that there are potential dimensions that might be hidden from direct observation; therefore, understanding it requires a more comprehensive approach. The reality of urban space shows that individually well-designed parts of the city might fail because of their poor relationship to other parts of the social or spatial network in which they take place (Gehl 2011).

1.4 Methodology and Research Design

One of the primary goals of this research is to develop new methodological possibilities to read the mutual interaction between the elemental spatial network (measuring accessibility) and the socio-spatial interactions (the data produced by users of the city retrieved from social media). By these means, it tries to re-evaluate the way they interact with each other through the complex socio-spatial structure of the city. The research starts with an extended literature review in three parts:

Chapter 2 explores an emerging understanding of the foundation of society, space, and network through the lens of social media and digital communication. This part of the study tries to establish a theoretical outline, expanding on recent developments in how modern society forms and connects with space.

Chapter 3 explores the concept of accessibility and distance in the socio-spatial network of the city. The concept of distance in light of new communication mediums is addressed. In order to provide a tangible quantitative measure of distance and accessibility, the "space syntax" method is used. Space syntax is a configurational theory of socio-spatial behaviors that explores the possibilities in peoples' movements through the elemental spatial network. The spatial network is formed with an inherent "social logic" (Hillier & Hanson, 1984). Peoples' movements and spatial properties of space are inherently connected (Hillier, 1996; Hillier, 2012). Therefore, in line with the aim of this study, space syntax offers a rich framework for evaluating socio-spatial interactions because it argues that there is a mutual relationship between how those interactions and urban spaces form and reform together. Space syntax uses the mathematical properties of the spatial network to estimate the movement in a network of spaces (for more detailed explanations see chapter 3.1.1). Here, the accessibility to urban spaces is being measured via "integration" and "choice." **Integration** (also known as to-movement or closeness) evaluates the ease of accessibility to each space in the network from every other node. It evaluates the position of each space as a destination compared to all other spaces in the city. Space syntax literature suggests a strong correlation between integration and natural movement of people in urban spaces

(Law, Chiaradia, & Schwander, 2012; Penn, Hillier, Banister, & Xu, 1998). **Choice** (also known as through-movement or betweenness) explores the space as a passage, a move through space, or in-between spaces. It can be used to analyze the possibility of people choosing a particular path to reach all spaces in a given distance. Moreover, both measures could be calculated locally, to explore pedestrian access, or globally, for reading the more vehicular accessibility of urban space (Hillier, 1996).

Chapter 4 tries to explore the data citizens produce through mobile devices during their daily interactions. It investigates the concept of 'big data' as the natural product of social media and how it can be used to read and explore the city. This data is a side-product of peoples' activities within the context of urban public spaces. Here, geo-tagged Twitter feeds are utilized for reading the distribution of these activities throughout the city. This layer is the representation of the new communication revolution on the actual ground of the city. The digital presence of people can be extracted from the virtual space in order to understand how they interact with space.

Chapter 5 explores a new methodological approach in reading different layers of interaction in regard to proximal accessibility. Accordingly, three layers of quantitative data are systematically collected:

1. Geo-tagged Twitter feeds was used as a testament of socio-spatial interaction through social media. The data was collected using the NodeXL application and was filtered systematically (see chapter 5.2.1).
2. A traditional name generator survey was used for checking the reliability of the Twitter feeds addressing the second research question (see chapter 5.2.2).
3. Space syntax theory and methodology was used for addressing accessibility through the urban special network at various levels. To address the primary objective of this research, the study used to-movement (integration) and

through-movement (choice) in eleven radii proxies from local (Radii=250m) to global considering all space of the city (see Hillier & Schwander, 2012). The utilization of these measurements in research on the socio-spatial network of cities is further investigated in chapter 5.2.3.

Furthermore, GIS science is used for overlaying various layers of data with different natures. Accordingly, this study utilizes the power of quantitative methods and analytical computation of socio-spatial data in addressing its main objectives. The data analysis was done in each layer and the correlation between layers illustrates the social and spatial interactions through the perspective of delocalization and distanciation.

The next stage of the methodology focuses on testing and rechecking the reliability of data. Various precautions are being made here including: the systematic filtration and classification of geo-tagged Twitter data, a different approach toward overlaying the three layers of data, replacing "space syntax" analysis with "urban metric centrality measures", and repeating the study in different cases (see chapter 5.8).

Figure 3 shows the detailed general design of the research and its components. Each section is further elaborated in its respected chapters and sub-chapters. The research tries to approach the complex structure of the city and the newly emerging social phenomenon, and provide a theoretical and methodological approach to read the city as "organized complexity".

1.5 Case Study

The study is conducted in the city of Famagusta (also known as Gazimağusa and Mağusa). The city is located in the east coast of the island of Cyprus. The city has a long and rich history of development (for more details see Önal, Dağli, & Doratli, 1999). The city is bordered in the south by closed Maras region which has been uninhabited since 1974 as the result of "Cyprus conflict." The city reaches historic Salamis ruins at its northern edge. The city contains a historic walled city. Currently, Eastern Mediterranean University campus – one of the prominent features of the city – has shifted the urban development toward the northern section of the city. The city population is mainly comprised of local Turkish Cypriots, Turks, and students of various nationalities from the university. During the process of data collection, the balance between different segments of the population was carefully monitored.

In advanced stages of the study, the methodology was tested in the other major coastal city of Girne (also known as Kyrenia). This step was taken in order to test the validity of the applied methodology. Furthermore, the construal reading of the outcome in a different city provides a reference point for the influential variables that might have been affected by the features of the initial case study.

1.6 Limitation

Research on the topics including social media, big data, and socio-spatial interactions have the potential to explore endless possibilities. Therefore, the limitation of the research must be clear in order to reach a clear outcome. According to the aim and objectives, this research holds various limitations. In terms of the spatial network of the city, it only covers the accessibility of the spatial network of the city through "space syntax" analysis by using "integration" and "choice" as the main analytical variables. Socio-economical, land-use, morphological, and topological aspects of the environment are outside the scope of this research. Physical proximity, which plays an important role in the definition of the main research question, is addressed by using radii proxy limiters from 250 meters being the most local to the global scale (all space without considering distance) . The overlay of geo-tagged digital data and spatial analysis through centrality measures and space syntax was used to address the main research question. Furthermore, many countermeasures are set in place as control variables. The space syntax and centrality measures were selected because the theoretical framework suggests fundamental social characteristics inherent in these spatial properties.

In terms of socio-spatial interaction, the study uses Twitter geo-tagged public records. Social network analysis was limited to the density of nodes in a spatial grid of city and the other parameters of social nodes like, in degree, outdegree, and common values, were assumed as outside scope. The social media data was collected through the Twitter public record and it is limited to geo-tagged data, the data is anonymous, but the tags and content were used for filtering purposes. The research focuses on socio-spatial interactions in urban space and their mutual effects on urban public space.

The research considers all non-domestic spaces in the urban network as the public domain of city and relevant in the analysis if the necessary data exist. All tweets in this public domain are considered socio-spatial interactions, but if the content specifically mentions indoor activities those entries are eliminated. Accordingly, all the variables are seen together. This approach has the potential to provide a more comprehensive insight into the topic.

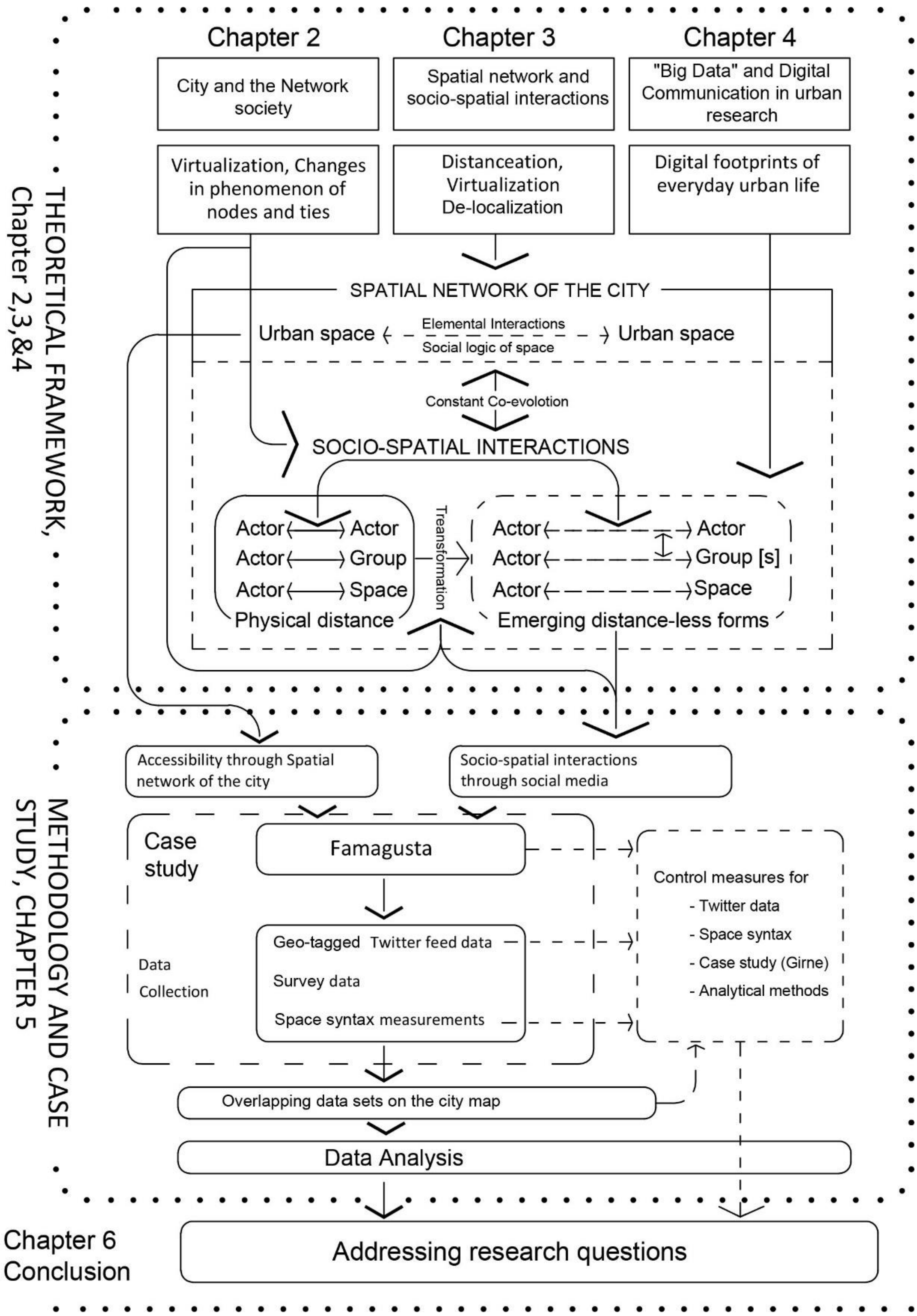


Figure 3. The general outline of the research and methodological approach of the dissertation.

Chapter 2

CITY AND NETWORKS, A THEORETICAL FRAMEWORK

The research on social media is an emerging field that covers a wide variety of topics, in the early 2000s, the term “Social media” started to appear in the social science literature (Gruzd, Jacobson, Wellman, & Mai, 2017). Wellman (2018) analyzes the effects of digital communication on people’s personal relationships, debating the digitalization, and industrialization of communication has caused an overwhelming loss of strong social ties. The question arises that whether or not this might facilitate the process of fragmentation in urban communities. However Wellman (2018) indicates that the social nature of human eventually created thriving communities regardless of technological revolutions, the communities will develop new ways to reinvent the emerging communication technologies into their everyday life.

The new technological advancements constantly affect the values and means of society. The medium that people produce, reproduce, and transfer the flow of information in the context of contemporary urban space has gone through a significant transformation process. The lack of necessity of being present for communication through the internet has pushed the networks to become more individually centered and isolated. Accordingly, people’s perception of networks and social structure in everyday life has been transformed (Chambers, 2006). People see their socio-spatial networks in light of endless streams of pictures, videos, text messages, and metadata constantly. Perception of distance, proximity, and accessibility has changed as a natural side-effect of digital communication mediums. Potentially, anybody can connect with anybody at any time, how does this potential connection render the spatial dimension of urban form?

Prior to the social media revolution, a similar paradigm shift has happened in transportation mediums. The introduction of automobile dramatically influenced the physical form of cities and its related time-space relations. Accordingly, it seems critical to invest in reading cities in the light of contemporary advancements.

This chapter explores the social network data that is produced by citizens within the urban space, and secondly, the physical accessibility through the spatial network of the city. This chapter aims to provide a brief reading on urban social and spatial networks and explore how the advancements in communication technology have restructured the means, which people interact with each other and with spaces of the city. The chapter tries to explore the social, spatial, and socio-spatial networks of the city by having a critical look at the effects of social media.

2.1 Social Network and Human Community

Georg Simmel is one of the first scholars to approach the life of the cities through the fluid dynamics of networks. Simmel (1976) in the article "The Metropolis and Mental Life" expand on the idea that humanity has become more and more individuals with larges networks. According to Simmel (1976), the flow of information between different part of the social network is critical and happens through bridge ties. Granovetter (1983) expands this idea on the ground of the strength of weak ties. These casual everyday ties between people who have no strong connection are responsible for the majority of information flow between different parts of the network. Accordingly, the possibility of interaction through weak ties is linked with a fundamental socio-spatial being of the city. The weak ties have the potential to connect clusters that otherwise tend to be more isolated. These different types of connections could be called local/global, internal external, or cosmopolitan/local (Breiger, 1974; Burt, 2011).

Feld (1981) uses the term “foci” to explain some bases for the formation of communities. Any value that can provide opportunities for interaction and consequently, the formation of social ties can be identified as a ‘foci’. In this study, the public ground of the city is considered the shared interest that attracts people. The public space could be a local place of worship, a football club, festivals, event, or even a popular cafe shop. The foci are not the community itself, but the foundation on which it stands (Feld, 1981). Accordingly, shared activities provide a common ground in which individuals make new interactions. The community clusters shape around similarity in activities. Can we consider the urban public spaces as a common ground for social activities? As many researchers would argue (Gehl 2011; Jacobs, 1961; Whyte, 1980) people are attracted to public spaces due to the presence of other people. People are interested in seeing their fellow citizens, and in expanding the possibility of weak social ties. It could be argued that the presence of people is the most important ‘foci’ that urban space has to offer. Thus, exploring the underlying order which brings people into urban spaces is a dual process which in return identifies those spaces. Urban spaces –in its nature- is home to a variety of activities, but the inherently, spending time inside the urban grid that runs the engine of the city could be considered the common ground. Going back to the main research objective, it is critical to address what happens when the common ground for activities loses some of its spatial dimension.

2.2 The Effects of Network Society on Everyday Life

Manuel Castells is one of the pioneer scholars illuminating the research and philosophy by focusing on the new development in communication, technology, and social media. According to Castells (1996), the new information/communication technology creates new rules. The new rules imposed by digital communication should be better understood in the context of urban public space. Here, the research tries to look closer at urban space and their properties in relation to social media and digital communication on a smaller scale.

Castells (1989, p. 146) uses the term 'space of flow' to describe the paradigm shift between virtual and physical space; it is an abstract idea that shows the way of interaction between the digital age society and space. The 'space of flow' is a hybrid space of interactions which represent the new form of urban space. This new space creates a socio-spatial form of interaction which is less bound by physical proximity and more with the flow of information that happens through social networking. Interpretation of ideas introduced by Manuel Castells on a smaller scale and in everyday life in the city is critical to understanding the mechanics of the interconnected relationship between the flow of information and spatial aspects of urban space. The new communication mediums and the movement of capital (information) in the "space of flow" affects the interaction between people and places. The network by itself is not the dominant defining factor in these new hybrid spaces, but the evolution and transformation of information is the dynamic structure and defining factor. For Castells (1996) there are fundamental differences between the information and the networked society. *The information society* is referred to as a society in which processing the information is a significant driver of the economy, politics, and culture. This happens throughout the transition process in moving from "industrial society to an information society" which has happed in the past two centuries and is a key factor in the development of social constructs (Castells, 1996). *The network society* is a structural form of social connections which operates by transferring the flow of information through digital means of production, in the network society the knowledge is being accumulated, or produced in the nodes and can be accessed from other nods (Castells & Cardoso, 2006; Van Dijk, 2012). In the networked society, the structure and properties of the network are more significant than individual actors (Castells, 1998). Accordingly, it is possible to extract patterns of behavior and interaction by analyzing the properties of the networks. For Castells, the emerging social structure is an entity between the individual (self) and the network. The network in this theorem stands for means of production in social level, accordingly, the rising penetration of social media in the socio-spatial fabric of the city provide a new phase of inevitable opportunities. Thus, the role of technology in the flow of information becomes increasingly important. He argues that the network is the essence and structure of our age. The collective identity and the way society defines itself is changing as the media and methods of communication are changing (Castells, 1998). Nevertheless, the quintessential spatial properties of all networks must be taken into account. It is not possible to separate the social network from the spatial network. Granting the properties of the network are critical in this argument, exploring how these networks are being distributed through the spatial network is vital. Although the advancement in technology is a prominent player it is not a necessity for the formation of the new social structures (Castells & Cardoso, 2006). Networks are the oldest and fundamental form of society, however, the old form of the network which consists of face-to-face interaction had a clear size limitation. Beyond what Castells (2000b) calls “a critical size” traditional networks are incapable of staying stable due to increasing complexity. The networks in their primal form are central, contextual, and geographically tied. The emerging social structure is defined by the properties of ever-changing networks. The electronic linkage among members of the society as sender and recovers of information creates little pockets of socio-spatial production in the form of interactions that might affect all aspects of modern life. The most important effect of digital communication is perhaps the possibility of decentralized social networks which are more flexible, high performance, and highly specialized toward certain values and means. These networks take benefit from the ever-increasing computational power that becomes cheaper and more accessible to all segments of society. Another key difference in digital networks is their great capacity for expansion regardless of physical limitations of the spatially bound networks (Castells, 2000b). Accordingly, technology and society do not dictate changes to one another but rather evolve simultaneously into a new form of agglomeration which allows them to form a new entity. His argument is very critical for this research as it emphasizes the dynamic relationship between developments in technology and society and how social interactions have been changing together with new technologies. Hence, new ways of understanding are necessary for understanding society in its new hybrid form that takes the digital communication into account.

Due to the limitation of this research the concept of the network would be considered in a meso/micro urban scale with its social and spatial characteristics, nevertheless, understanding Castells’ ideas and philosophy would bring insight into this research.

Expanding on our understanding of how new socio-spatial urban forms function is critical because the new technology is not a mere tool, but a vessel of social production that transfers ideas, news, and desires via images, videos, and text. It seems that we are still in the middle of the internalization process of technology and society, and that highlights the importance of the research matter. The fundamental importance of technology and knowledge has not changed over time, but the way information circulates through the social fabric is being constantly reformed. On the other hand, mobile devices have created a platform that could be used to create new knowledge through analyzing fields of information produced by devices with no geographic limitations.

Arguably, flexibility is one of the distinguished and critical features of digital communication. The flexibility has two sides, it could be considered a freedom from the system/network because it can contradict the flow of information, or it could expand the overall integration of the social structure. Massiveness and variety in new means of communication are what Castells (2000a) calls "Hypertext". And the flow of information and communication through hypertext reproduce its own contextual culture. This is significant for the purpose of this study because it emphasizes the importance of the accidental and volunteer nature of digital communication that emphasizes choice, content, and values in the socio-spatial network.

Digital communication through the medium of Social media has formed emerging types of connection among actors of the society and among actors and spaces. In order to make sense of these complex connections and rendering scientific results, the research methodology must be revised accordingly because there is always the possibility that the existing theories might not be adequate in the undertaking of the complex nature of emerging socio-spatial interactions. The research methodology must explore new possibilities in order to evolve with the emerging socio-spatial changes in the everyday life of cities. The digital interactions of citizens provide new sources of information for researchers which would be inadequate to undertake without adjusted theories and research frameworks. According to Castells (2000b), the empirical aspect of social sciences requires new methodological approaches when faced with emerging unprecedented conditions. The increasing computational power enhances the analytical possibilities for exploring complex networks of socio-spatial entities.

2.3 Networked Individualism

The dominant factor of any social network is the shared passion, common values, and activities (Rainie & Wellman, 2012a; Wellman & Haythornthwaite, 2002). Members of the society are getting better at multi-user interactions, and multi-tasking. Although at first, it might seem that the development of mobile devices and social media hooked people on these gadgets, but it could be argued that people are rather hooked on each other. The need for communication is a fundamental aspect of human nature, but its means and mediums are always constantly changing and creating new dynamics. According to Crooks et al. (2016), mobile devices have become one of the most important aspects of youths' lives. Rainie and Wellman (2012a) show that the frequency of small but strong interconnected group (e.g. family, villages) is declining. To the contrary, the loosely bounded social groups that consist of individuals with well-connected social media are increasing. Rainie and Wellman (2012a) developed a model named "triple revolution" which tries to explain how emerging digital communication mediums are transforming the way people interact with the world as follows:

- First, the emerging social network revolution has expanded the opportunities to interact and connect to other members of the society beyond their immediate group, and beyond their immediate surroundings. It has created more diversity in the possibility of forming new ties.
- Second, digital communication and mobile devices have given substantial information gathering tools, communication power, and production capabilities. People can create and broadcast content through their network of choice.
- Third, the ease of access to mobile devices has rendered the social networks as an integrated and inevitable part into people's life. A mobile device is no longer a mere tool, rather an extension of peoples' presence in the world; allowing people to access friends and information at will, wherever they go. Continues access and presence of in the network makes it a passive presence in everyday life.

People act as part of a larger network even when they are surrounded by their close friends and family members (strong ties). Having a personal computer in hand, private space becomes public, and a part of private life started to infiltrate the public realm. Nevertheless, the most striking aspect of social networking is the possibility of being a flexible, non-permanent node in a multitude of networks. This has enabled people to share their experiences and stories, it has enabled people to find an audience which can be a source of help and inspiration or a disadvantage at the same time. Therefore, the choices in selecting networks are becoming more correlated with the values of those networks. Wellman and Haythornthwaite (2002) argue that the revolution in social network precedes the internet revolution or the takeover of mobile devices. Fundamentally, it could be argued that this is not a paradigm shift in technology; it is a shift in people way of interaction with others. There are several key changes that have initiated this communication transformation:

- Affordable transportation, cars, commercial flights, public transportation, has increased the possible boundaries of interaction
- The families have become smaller in the past decades, which lead to a smaller strong internal relationship, hence, forcing people to expand their network outward.
- The increasing value of creative work vs the manual labor has made networking an essential commodity in the contemporary world.
- Education has become more accessible to everybody, expanding the limits of human capacity.
- The competition in the telecommunication market has led to affordable powerful devices for all sections of society.

2.4 Effects of Social Media on Everyday Social Ties

The networked interactions could fit into two categories: one-to-one (person-to-person) which a normal conversation between two friends, or could be an E-mail, and one-to-group (person-to-network) which is talking to a group. The majority of social media interaction is the second type, even beyond private layers, the interaction is usually person-to-network. This process of transformation is important because people are becoming huge sources of information. The mere usage of social media creates a new form of capital. This information capital has become the top priority for advertisement companies (Kaplan & Haenlein, 2010). People produce this information knowingly and unknowingly, it is widely accessible through the web, it is accidental in nature, and can be used to understand peoples' interactions (Arribas-Bel, 2014). This information is called 'big data' and will be further argued in chapter 4.

Table 1. The traditional group-based social structure vs. the emerging properties of the network society based on Rainie and Wellman (2012a, p. 38)

Group-centered Society	**Networked**
Strong but limited connections between members of a tight social group	Communication between individuals in search for common values
Neighborhood/local/ proximally closed community	Multiple communities with vague borders
Local Ties	Local and distant ties
Homogeneous ties around limited values	Diversified ties around diverse values
Somewhat involuntary and geographically and socially forced	Voluntary friendship ties
Strong social control by members of the group	Weak social control, institutional surveillance
limited social information resources within the group	Diversified search for specialized social capital/values via access to vast available resources.
Clearly defined boundaries with other groups/ flow of information/capital happen via limited weak ties.	Loosely defined boundaries / Permeable boundaries with other networks
Limited socio-spatial recreational opportunities	Variety of socio-spatial opportunities for individuals

Robert Putnam (2001) in his landmark book “Bowling Alone” argues that people's immediate traditional person-to-person networks are shrinking; this shift results in more selectiveness toward the network. People tend to attach themselves to networks that represent the behaviors that they find appealing (Marin & Wellman, 2011). For example, Wellman and Frank (2001) research show that in a network with obese members other members are more likely to become obese, the same result appears for smoking and alcohol drinking. The social media has negative and positive attributes. People can use it freely to develop and interact. Therefore, it is critical to investigate the “Emergent properties” of this new hybrid urban public spaces, because it could illustrate how and why people access and interact with space in contemporary cities. Table 1 shows some of the major transformations from traditional group-centered social structures to the network structure according to Rainie and Wellman (2012a).

2.5 The Growth of Telecommunication and Socio-spatial Interactions

Before the mid-1990s, almost all phones were landlines and place-bound, but with the development of internet and mobile devices, the interaction among people has changed. This transformation is so recent in human history that our theoretical framework might not be sufficient enough to address its effects on everyday life. Furthermore, mobile access to the internet and social media started to become mainstream around 2010. The integration of the internet as a tool for increasing convenience also gave the people to observe themselves as a selected node in endless possibility of networks. In helping people understand what networks are and what networks do, the internet has become a useful metaphor for the new network operating system as well as one of its primary driving forces. Besides, an intriguing aspect of mobile devices is the creative aspect of it in urban life, people invent a new and creative way in using social media; these ways some time goes beyond what the creators of these platforms had in mind. For instance, a video/photography camera used to be expensive and reserved for special occasions, it left very limited room for people to explore the possibilities, but today it can be freely used to document and express the flow of everyday life.

Mobile social network forms a hybrid spatial entity in which people can choose to be in constant communication and never alone. The time and place of a meeting are now always flexible. This flexibility is becoming a quintessential essence of the new generation which is growing with the evolution of mobile networking (Thulin & Vilhelmson, 2007). Furthermore, it could be argued that the bound between communication and physical space has lost some of its strength; changing the limitation of connections between people from geographically-bound to person-bound.

This flexibility enables the instant interactions and updates to and from the selected parts of the network to people (Thulin & Vilhelmson, 2007). The presence of mobile networking in everyday life in cities allows urban residents to become more involved in their social circles but with weaker ties (Foth & Hearn, 2007).

Foth and Hearn (2007) argue that more access to information communication technology enables urban residents to gain more control over their social relations. This new level of virtual control competes with the conventional methods of identity development in urban communities. In fact, people might have complex social networks but prefer to keep their virtual profile separated from their neighbors. Therefore, community network might work more sufficiently when facilitation person-to-person interactions in physical space. The growth of virtual interaction mediums has extended our communication beyond face-to-face connection. It could be further argued that the key component of place-based communication is physical proximity, but the place and proximity could be redefined by the principles of virtual connection (Mahmoudi Farahani, 2016).

2.6 Urban Public Spaces, the Main Nodes of Interaction in Cities

Public spaces of the city are the point of social interactions. The most attractive element of public space is, in fact, the presence of other people. Humanity is a social entity and grabs every opportunity to increase interaction. According to Carr , Francis, Rivlin, and Stone (1993) public spaces in the city provide a platform for more casual forms of interactions that allows people to bind, this in return, gives them a sense of identity, self-esteem, and meaning. This argument goes in line with the critical importance of “weak social ties” developed by Granovetter (1983). Furthermore, a successful urban space could be identified by the presence of people in a self-organizing process (Whyte, 1980).

One of the quintessential characteristics of public space is its optional nature (Carmona, 2010). The “choice” that people make to form a socio-spatial interaction seems to be affected by the flexibility and diversity that social media offers. The visibility and possibility of interaction have increased as the locality is no longer a necessity for the decision-making process, hence, the optionality of public space increases accordingly. Ideally, public space could potentially offer homogenous opportunities to everybody when all members of society take part in its constant becoming process (Gehl 2011; Jacobs, 1961), but the very definition of “everybody” must be revisited as the digital communication reforms the notion of what it means to “take part” in urban space. Considering the socio-spatial interactions as the production of urban space renders the spatial structure as the primary means of production, however, it could be argued that said interactions are being produced through new means which are not entirely spatial in nature as they are not restricted by distance. The main core of urban public space remains the same, but the interpretation of people-place relation is being re-conceptualized. The transformation in the means of production of socio-spatial interactions marks the importance of interdisciplinary approaches toward reading and interpreting urban spaces. Citizens in the area of digital communication are producers and broadcasters of data. The emerging role of people in recording and sharing their interaction with urban space forms the “new media urbanism” (Malecki, 2014). The information which is being produced and shared by people is not merely a layer of data, but an essential part of the contemporary urban life that emerging research must take into account. In return, this data provides a valuable tool for reading and understating its nature.

Castells (2008) argues Individuals as the most basic nodes and users of the network will shape the system, they will do this as the citizens of this new world following the previous dissuasion, the physical core of urban spatial network seems to stand strong and fundamentally unchanged, but the apparatus of interaction in being reidentified through the distance-less (person to many) communication mediums. In this research, the term “public space” refers to the non-domestic physical domain of city which is potentially accessible for all members of society such as streets, alleys, restaurants, shopping places, parks, etc. (Lofland, 1998). While some of these places are not matching the conventional definition for public space, this research includes all semi-public spaces in the discussion as they can potentially be accessed by everybody.

In recent years, people are able to find their interests in real space by the use of social media, faster and more selective, therefore, their interaction with space is becoming more selective and heterogeneous as defined by their common interests (Carr et al., 1993; Goffman, 1963). On the other hand, the common interest would be reinforced by people promoting it through social media and can cause more social heterogeneity in public space. In a distance free city, people would connect to the spaces that represent the activities of their common values easier and faster. This very phenomenon is one of the discourses of this dissertation. Humphreys (2010) argues: “People increasingly use mobile social networks to transform the ways they come together and interact in public space”. Pew Research Center’s Study (2015) shows that by 2016 2 billion people worldwide would use Smart-Phones connected to the internet and the rate is rapidly increasing. These services enable people to interact and work with existing friends or potential friends in the physical realm of the city; it can be used for reinforcing existing ties or formation of new ties. The term tie in this research can be the connection between people or people and places. New mobile social network possibilities are playing an important role in flowing new information into and through public space and restructuring the socio-spatial characteristic of it. This dissertation tries to look into the socio-spatial accessibility and interaction in urban public space by considering the new mobile social media as a part of it. Mobile devices have made it easier for people to interact with the spatial structure of cities and with each other to some extent. There are various daily digital mediums in which people guide each other to choose particular parts of the network; Twitter, Instagram, Google maps, yelp, and TripAdvisor are few examples of such services that are being used in finding and interacting with urban spaces.

In order to provide a tangible reading of urban spaces, this research suggests that each public space as a node represents attraction variable according to the values, interests, and activities that it provides for the social network of the city. This variable is passing through the filter of social media and networked society. People's interaction with space could potentially motivate others to share their experiences too.

2.7 The Changing Role of Citizens through Social Media

Social media has enabled people to become producers of content/information, citizens who used to be mere consumers of media have found a platform in which to represent themselves and be heard. People are not simple observers in the mobile network area, they are potential documenters of urban space in the process of becoming (Bontcheva & Rout, 2014). Fundamentally, these productions should not be considered a simple digital footprint for research, but an inseparable aspect of urban life. Accordingly, this shift in the social production of space should be supported by methodological approaches which are as vibrant and are able to address the complexity and interconnectivity of these data (Brenner & Schmid, 2014). Mobile devices offer a variety of complex data collection sensors among which Global Positioning System (GPS) and cameras are most pertinent to this research. The large comprehensive data which is collected as the digital footprint of citizens is enormous and require new means of processing and visualization (Ang & Seng, 2016). This data has the potential to transform our understanding of urban space and the way people move throughout the city because it represents the socio-spatial interactions within the city through social media. this data shows a high degree of accuracy and provide insight into real-time interaction in the actual ground of the city through a semi-digital semi-physical medium (Weiler, Grossniklaus, & Scholl, 2015). Chapter 4 will look deeper into the phenomenon of big data and its effects on the nature of research on urban structures. The citizen of the contemporary city is in content engagement with urban space as a recorder, documenter, and provides commentary on it by simply being a presence in space or by engaging with the mobile device. The mobile device might have some downsides, but it seems that it has created a platform for people to interact with space in new ways (Couclelis, 2004).

2.8 Chapter Summary

This chapter explored the city and its network properties through the window of social media and digital communication. A network forms when more than two nodes form bonds over a common value, interest or quality.

The theoretical approaches of Manuel Castells and Barry Wellman were explored as the main backbone of the theory to support the dissertation. Castells explains the concept of the ‘space of flow’ as a hybrid space of interaction between physical and virtual that is the reality of the contemporary world. The transformation into the information society is the fundamental shift in the contemporary world that affects all aspects of everyday life. The network defines people more than their individual self. Furthermore, Wellman categorizes the effect of social media on everyday life into increasing opportunities, expanding access to resources, and instant connectivity of other members of the society. The third change (mobile devices) has changed the meaning of distance and territorial definition of communication as all networks are accessible on demand for all citizens. It enables citizens to take more control over their social relations and at the same time offers more choices for interactions. Reading on the topic suggest that a new form of communication has strengthened people's involvement in urban space.

When looking at urban networks, the social network is one of the layers. Urban public spaces as nodes of interactions are integrated parts of this complex system. Cities are bound with diversity and variety of choices throughout the history, and they can offer opportunities for everybody only when they are being developed by everybody, and digital communication is providing this possibility more and more.

Social media by providing these opportunities have changed the role of today's' urban residents from the consumers or transformers of information into the creator of information. This change creates large datasets of interaction with other social actors and with spaces of cities. This so-called 'big data' is the by-product of social media which will be investigated further in chapter 4.

Chapter 3

ACCESSIBILITY AND CHANGING CONCEPTION OF DISTANCE IN THE AGE OF DIGITAL NETWORKS

This chapter aims to explore two concepts: first, how the new digital communication has affected the spatial structure of urban life, and second, how to measure accessibility throughout the urban network via Space Syntax and centrality measures. The discussion first focuses on the changes in perception and the flow movement (accessibility) in the city and how this has been affected by the revolution in communication technology. Furthermore, the chapter tries to provide a tangible measurement through network analytical models, this provides an empirical ground for a more complex mix-analysis approach in chapter 5.

The utilization of new data in addressing the rising complexity of the interactive layer of cities has been increasing in recent literature. The availability of advanced analytical tools and techniques has made it easier to conduct such studies (Batty, 2012). Social studies that explore social movements in relation to city space (Carpio, 2016); people participation and urban development process (Moreno Pires, Magee, & Holden, 2017); distribution of hot-topics and interests throughout the city (Lansley & Longley, 2016). Politics, planning and policy development for cities (Seresinhe, Moat, & Preis, 2017) are few examples of this vibrant emerging field. Nevertheless, the meso/micro space analysis in regard to local/global accessibility seems to be in need of a more thorough investigation. The body of literature seems to be divided into two main discussions in regard to digital communication, physical accessibility, and urban socio-spatial interactions. These two discussions provide mixed answers in addressing the main research question.

First, the technological advancement in digital communication and the advent of social media into everyday life creates actors (people, individuals) who are very well connected with many people through social media despite their decreasing interaction with their local urban surroundings. This phenomenon is coupled with the ease of access to further distances (the revolution in transportation). Accordingly, an accessible distance might be interpreted differently having access to public transportation and vehicles. Cairncross (2001) states: "New communications technologies are rapidly obliterating distance as a relevant factor in how people conduct their business and personal lives." Cairncross argues that emerging communication making the distance less relevant in the way people, institutes, and businesses interact with each other. Some researchers suggest that, in fact, active users of the internet are more likely to have a higher active circle of friends in real life. Accordingly, it seems that activities at local scale would eventually become less relevant compared to interactions that are happening over long distances. The first one happens by the presence, and the second might happen in connection with absence and presence. As it was theorized by Giddens (1994), today the separation between time-space distanciation becomes higher than ever before. Therefore, social forms are likely to stretch beyond particular space and time. This dissertation tries to investigate the effects of this very phenomenon on urban life in both social and spatial level by decoding the interaction between those layers. The general abstract idea suggests a degree of separation between social interaction and proximal limits of the spatial structure of urban spaces. Thus, the local accessibility might become less critical in the formation and evolution of urban spaces. Digital mobile communication at the hand of every member of the society gives birth to a nonlinear urban socio-spatial geographical entity which can be better defined by the free flow of information in a hybrid space -semi-physical, semi-virtual (Castells, 1996). Some studies suggest that the usage of mobile devices has increased and expanded the range of movement in the urban spatial network (Yuan, Raubal, & Liu, 2012). Scellato et al. (2011) show that the expansion of the network through social media can increase the spatial heterogeneity of the network. Moreover, this process has reformed the public-private hierarchy of urban spaces (Rainie & Wellman, 2012b, p. 119). People bring a window of their private life into the public spaces, and they may interact with a public space from the privacy of their home. This section of the literature suggests that the social media networks/ties are the medium and facilitators of the already established human hierarchy of connection and movement. These new distance-free ties might make the network more complex and less important at the local level (Cass, Shove, & Urry, 2005; Hampton & Wellman, 2001).

Second, the section of the literature covers arguments in favor of the critical importance of distance and physical local proximity of the urban spaces. The core of this part revolves around the "first law of geography" declared by Tobler (1970) as following "everything is related to everything else, but near things are more related than distant things". According to Tobler, the cost of distance is critical in geographical analysis, thus this could be argued that the transformation in digital mobile communication is not a strong enough indicator that can potentially change the way cities operate at socio-spatial level. According to Sarkar et al. (2015), local accessibility (at around 400m) is the most dominant predictor of human movement and interaction with urban space. The second family of discussion persists on the significance of local accessibility despite the digital communication. Kotzias, Lappas, and Gunopulos (2014) study indicate that people's interaction with urban space at the local level has not been subject to change despite the increasing use of digital communication. Furthermore, they argue that –in fact- the new means of communication facilitates interaction with urban spaces by increasing engagement and variety. Other studies suggest that the increasing use of social media does not have a negative impact of locally-centered activities, even to the contrary (Hampton, Sessions, Her, & Rainie, 2009). Furthermore, the second argument does not merely exist in relation with distance, for instance, according to Cho, Myers, and Leskovec (2011) the structure of existing (established and physically bound) the social network can better explain everyday movements. Hampton and Wellman (2001) argue that the internet by itself does not affect people's personal and physical social network size; rather it facilitates the continuity of existing ties and the formation of new ones. Moreover, the data suggest that ties that are formed in real space are stronger and more likable compared to those that formed online. If the tie has a possibility of integration in real space it is more likely to survive or becomes stronger over time (Kraut et al., 1998). Wang, Chin, and Wang (2011) argue physical proximity could facilitate the formation of online social ties later by increasing the chance of social selection in face-to-face interactions. It could be argued that the spatial complexity of social network has a visible influence over the total movement of their members regardless of strong interaction on social media (see also Cass et al., 2005; Hampton & Wellman, 2001; Urry, 2003).

According to these two main discussions in the body of the literature, it could be argued that both arguments could stand true under different circumstances. Despite the fact that some social ties in the contemporary city remain online, in reality, people try to create the necessary connection through any means necessary and do not really care for the type of communication (Rheingold, 2000). Accordingly, maintaining and reproducing the social ties on the actual physical ground of the city seems necessary. The shape and density of people's network are affecting the number of resources and level of accessibility that is required to maintain the existing social networks and the formation of new ones. Members of communities in which members are in close physical proximity are less likely to move when compared to groups in which members are separated by larger distance. Some social groups seem to be spread wider in the contemporary cities and local neighborhoods might seem to be home to a wider variety of people with fewer values in common as a result of the communication revolution. The possibility and flexibility of social media by offering membership in a variety of social groups might create longer distances more feasible for some members. As a result, the citizens might cover longer inner-city travels to create physical contacts with a member of their online groups or suggestions (Urry, 2003). Axhausen and Kowald (2015); Kenyon, Lyons, and Rafferty (2002) argue that the increasing accessibility through the internet (distance-less) might decrease the overall physical mobility in the cities.

3.1 Accessibility through Urban Spatial Network

To increase human interaction, different public and private activities must co-exist together. According to Bentley (1985) in public spaces watching other people is the most common activity. This is one step above the absence of tie and below the weak social tie, but it is an introduction to engage in a weak tie, to become more than mere strangers if only for few minutes, and that is one of the fundamental aspects of public space. The movement from the absence of social to weak social ties could take place in such space, where strangers find a common ground to interact. Whyte (1980) argues that a successful urban public space should invite and engage pedestrians to interact with it. Christopher Alexander (1977) argue that surrounding functions of urban public space should cover a variety of needs, goods, and services for different age and gender groups, and it should cover activities for various times of the day. This variety in the edge of the space allows different ties to form. The public space should enable engaging activities like street art and performance, carnivals, and local values in order to facilitate the formation of social ties between subgroups of the city. Jacobs (1961) symbolizes the public space as a ballet dance that should offer a platform of veracity and wholeness at the same time for everybody. The successful public edges are supporting extroverted functions. Although they might have a dominant functional type in which the area is known for it, at the same time they support a diversity of uses from the public to private (Moughtin, 1992). Lynch (1960) states: "Concentration of special use or activity along a street may give it prominence in the minds of observers." Here all non-private spaces of the city that can be accessed by people are considered as public spaces, the degree in which they engage the public is dependent on their level accessibility and instructiveness. These variations are subject of the change according to their relationship with other spaces and how they are being portrayed through social media. This dissertation utilizes the idea that in a given network of public spaces (all possible spaces) level of socio-spatial interaction varies according to the degree of accessibility and further investigates the effects accessibility on how people interact with space through the perspective of social media.

Accessibility has become a central topic in urban planning and development literature for addressing the relationship between micro-economy and peoples' movement. The spatial grid of the city is in a state of co-evolution with land-use and urban points of interest. If the spatial accessibility of urban space offers more socio-spatial interaction, the micro-economy would be more engaging and this duality forms and reforms the land use. According to W. G. Hansen (1959) “The more accessible an area is to the various activities in a community, the greater its growth potential”. Here, the study tries to expand the concept accessibility and the effects of social media through a series of hypothetical scenarios. These hypothetical examples are based on the discussions in the literature review and try to clarify the possibilities of accessibility with the effects of the urban spatial network as the underlying structure and social media as a new dynamic force.

The example one tries to explore the possibilities of the accessibility and public space. Four alternative scenarios are presented here: First: Consider the given grid as an urban network. Each line represents a path in the network. Measuring the local accessibility of the network within a walkable distance of R=500 meters shows the line ‘A’ and ‘B’ are the most possible spaces in walkable distance. If we consider it a colorless and functionless space and let people into the network these two lines are more likely to develop social activities in local scale because it is more reachable for two different part of space. This is the possible access in local scale from a purely classical physical standpoint (Figure 4).

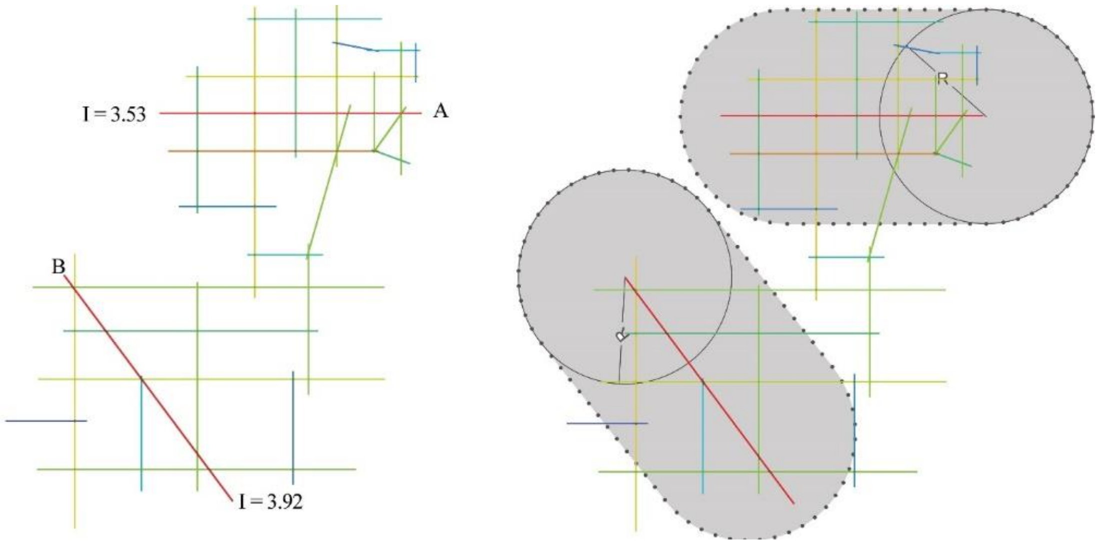


Figure 4. A network with multiple local nuclei, the two marked spaces are both locally accessible within a walking distance from all other spaces in the grid.

Figure 5 shows a distance free network in which the proximity is not an issue for movement in hate grid. In this case, the line ‘C’ stands out as the most reachable member of the network. Therefore, considering the entire network this space would create more possibilities for social interactions. Its connectivity between two part of the grid plays a critical role in the development of socio-spatial interaction. There is a mutual relation between the possibility of social communication and the development of certain public activities as suggested by Hillier. But as in any scientific analyze, correlation does not mean causation, therefore it is necessary to explore other possibilities.

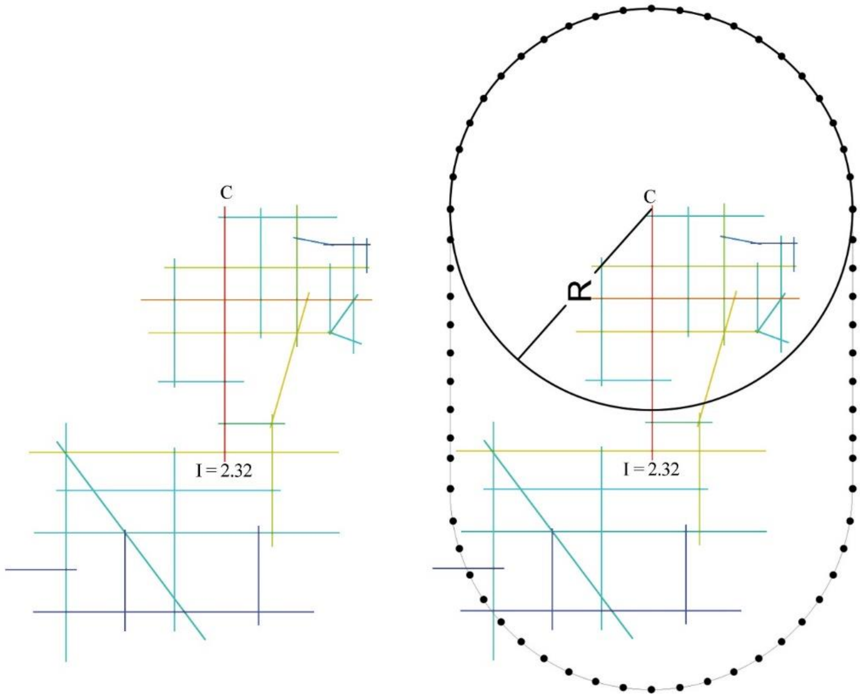


Figure 5. A globally accessible segment of the network, which could be reached from all other spaces in the network regardless of physical proximity

Figure 6 shows the probable accessibility, consider the line 'D' represent certain retail functions and activities regardless of its relative accessibility, the magnetic value of the space and people's promotions in person-to-person communication would attract people from two sides of network to that particular place due to the common interests among all people in the network. Accordingly, this space would represent a public space which has been promoted by users and it has more probable accessibility. This example does not suggest that the first three lines cannot possess this quality, but the probability of such space existing is worth mentioning.

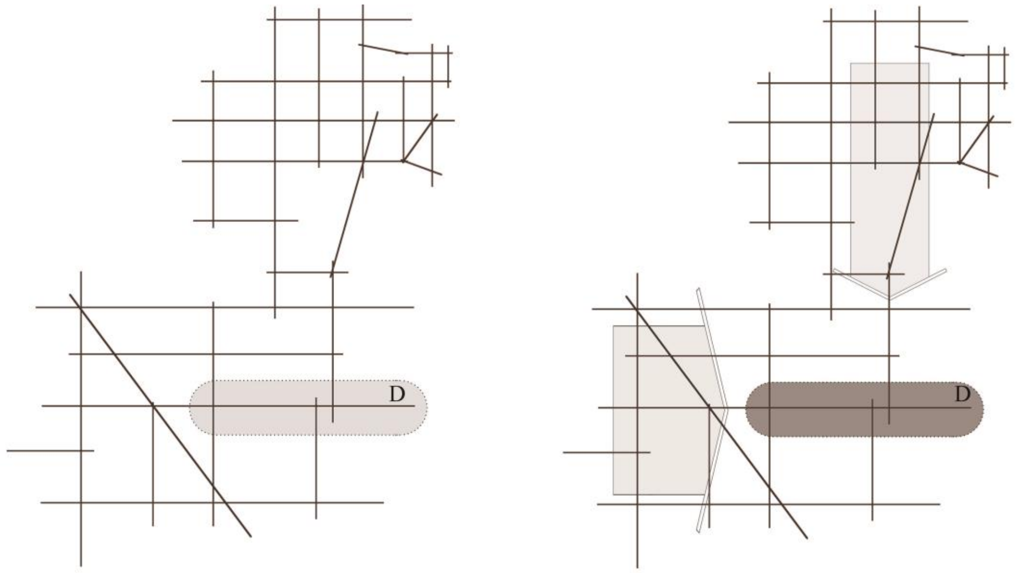


Figure 6. This line represents a space with attractive functionality, located in the most integrated part of the network, the functionality increases the probability of socio-spatial integration

Figure 7 shows the Probable accessibility suggested by social media, consider the marked line an urban space with is being constantly promoted for a certain social value (like political, Art gallery, a particular ethnic group gathering point etc.). Therefore, there are some people interested in that particular value that is interacting with the real space regardless of their physical proximity to the site. The difference between the third and fourth is that an activity like a retail shopping is a commonly interesting activity for the entire society, but the forth is targeting its audience.

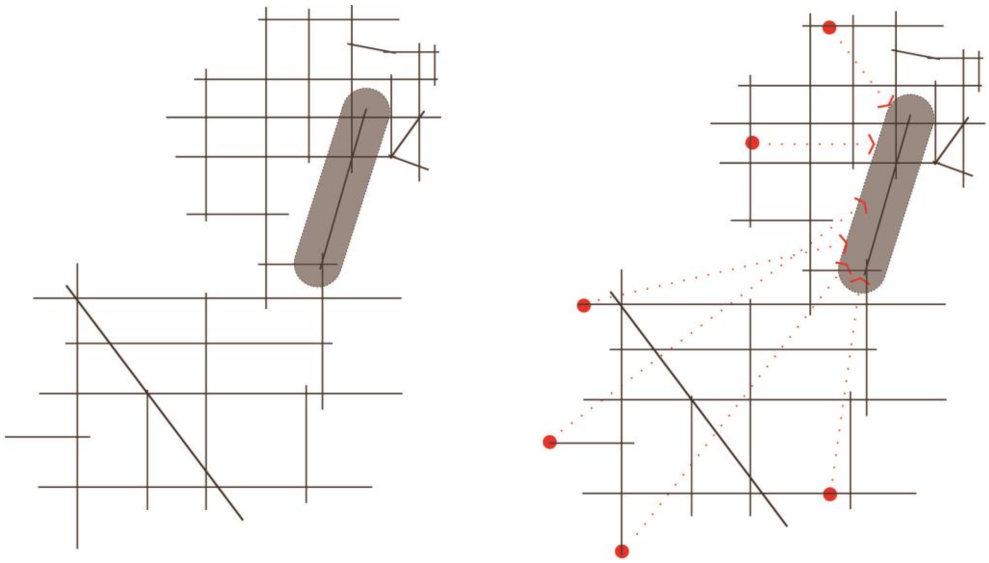


Figure 7. A highly active space through social media might increase the possibility of socio-spatial interaction.

According to the preview discussion, this research proposes two types of access to public space through the socio-spatial network of the city in regard to social media as one of its prime factors representing an emerging form of interaction (Figure 8).

First, the random accessibility through the network that could be measured from the spatial structure of the cities. The possible accessibility is the inherent quality of the network. This is what Hillier and Hanson (1984) call the “social logic of space”. This shows that in any given network what spaces represent the most potential possibilities for social interactions. Second, by considering all the effective variables of social media, and people as producers and distributors of information, feedbacks, common values, and interests, the case can be made for probable accessibility to urban space that is being constantly influenced by these processes. It could be argued that the accessibility to urban space under the influence of social media might undermine the proximal limits of space. There is a mutual correlation between the probable accessibility, physical realm of the city and social network due to its dynamic and ever-changing connections. The flow of information and feedbacks are the dominant factors of this probable accessibility, not the nods and paths.

According to these possible scenarios, the measured variable can be identified: the spatial network analysis which contains both local and global accessibility can be used to test these possibilities, these spatial constructs contains an underlying socio-spatial logic. The properties of the network as a graph can give insight into how the rest of it works. On the other hand, by considering the social logic of space there is a high chance that possible space and probable space overlap in many parts. The probable accessibility to urban space which shows the interaction of people under the influence of digital communication could be obtained from online sources that exist in the public domain. The digital footprint of citizens of the digital age is a side-product of everyday movements and interactions often referred to as “Big Data” and provides a tangible reading into these types of accesses (see Chapter 4). The raw data contains numerous variables but the study looks for the data that has a geographic identification tag. Geo-tag is the locational information that shows the exact location of which the interaction through social media had happened. By tracking the users, the data would look for patterns of interactions and movement upon the physical layer of the public space and its surrounding network.

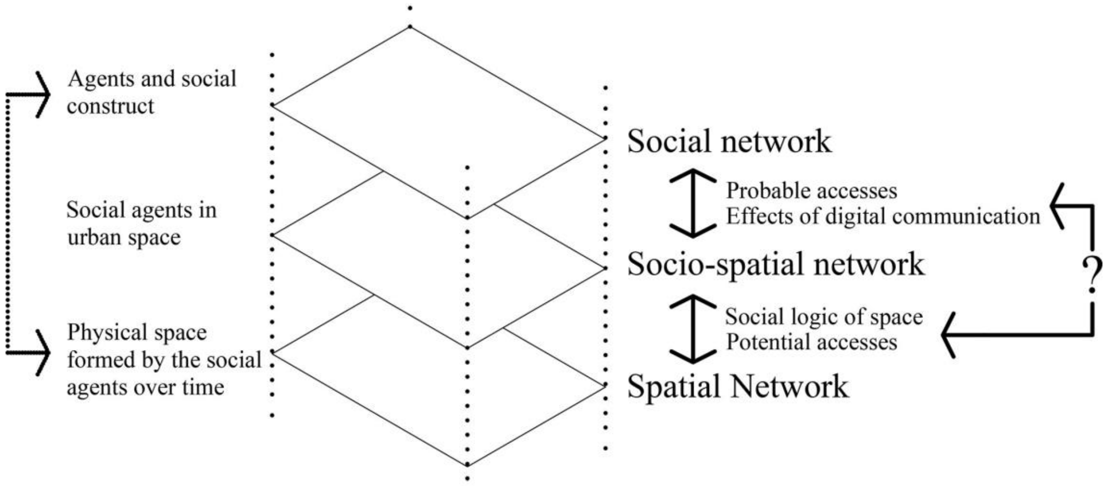


Figure 8. Potential and probable accessibility by considering social media as a defining factor in urban public space

3.2 Measuring the Accessibility of Urban Network

In the past few decades, measurable accessibility has become a central part of urban development and planning (Batty, 2009). A wide variety of mathematical measurements of the urban network have been developed to address the degree to which each part of the network is accessible to people. These measurements use numerous variables to formulate accessibility indexes. The cost of travel changes across the literature (Bhat et al., 2000), time, Euclidian metric distance, angular distance, topological distance, network distance, a proximal distance to function and land-use, the density of functions, attractiveness, employment, and transportation. This dissertation uses space syntax angular measures as the main predictor variables and uses the centrality measures as the control variables. These measures were selected due to the significant body of literature that supports the affiliation between them and people's interaction with urban space across pedestrian/vehicular accessibility to urban space. The difference between the two approaches will be explored in subsection 3.2.3.

3.2.1 Exploring the Concept of Accessibility through Space Syntax Analysis

In its spatial form, the city carries the collective intelligence of society. The urban centrality measures are a methodological and theoretical way of looking at the urban spatial structure. The properties of these measurements are based on the mathematical calculations coming from network analysis. The body of literature suggests a strong correlation between the way spatial grids are organized and the way people use urban spaces in their every life. People's natural movement through the urban grid seems to be closely dependent on the properties of the network itself (Hillier, Penn, Hanson, Grajewski, & Xu, 1993). The network analysis at special level can utilize distance, connectivity, and cost of travel through the grid into the measurement. These measurements provide a tangible reading of the spatial network base of topological, angular, or metric distances in any given network (Hillier, 1996; Hillier & Hanson, 1984). The location of each space in relation with others indicated its critical importance in the structure (Crucitti, Latora, & Porta, 2006).

The space syntax is a set of computational and configurational theories, and methods grounded in graph analysis. Space syntax measures the quantitative properties of spaces in relation to one other. According to space syntax theory, the potential social function of a space can be understood by its position in the larger spatial structure (Hillier et al. 1987). Space syntax uses the mathematics of spatial graphs to predict the accessibility and movement of people through the urban network. Hiller (1984) argues that city could be represented in two sides; a first spatial structure which is buildings and spaces among them as a link, spaces, and connections, second, is a complex system of human interactions and activities. They are social city and physical city, but it is not possible to distinguish the two because they are interconnected systems working and affect each other constantly (Hillier, 1996; Hillier & Hanson, 1984). Hillier (1996) further explain these relations: “Space is more than a neutral framework for social and cultural forms. It is built into those very forms. Human behavior does not simply happen in space. It has its own spatial forms.” All human activities that are happening within the framework of cities are an inherent part of the procedure that has shaped the network for a long time and is embedded into those forms (Hillier 1996). It could be argued that the influence of space on social relations is not direct; it is how it provides the possibilities of interaction or prevents them. Accordingly, the question here is what accessibility related characteristics of urban space make it more suitable for human interaction?

According to Steadman (2004), the originality of space syntax is in its inherent relationship with how people shape space functionalities (Steadman, 2004). Space syntax theory offers a variety of measurements and analysis for understanding urban networks. The space syntax explores the built environment as a system of potential movements that connect every possible origin-destination. The analysis begins with the production of an axial map, which is a two-dimensional representation of visual connectivity, or un-abstracted line of movement through spaces from the ground level (Hillier & Hanson, 1984) This map represents the collective set of unobstructed movements in space if the spaces are connected (Hillier, 1996). In urban studies the axial map is often constructed based on open spaces of the street layout, adding up to a network of the most extended possible lines of sight representing the spatial network of the city (Y. O. Kim & Penn, 2004).

This study uses ‘integration’ (also known as to-movement, and closeness centrality), and ‘choice’ (also known as through-movement, and betweenness centrality) as the primary predictor variable.

Integration (To-movement) enables the measurement of accessibility and physical distances because of its inherent connection with the movement of people and their interactions with the city (Batty, 2017; Law et al., 2012). Integration expresses the ease of accessibility to each particular line in the axial map from any other line in a given number of turns, angular change of direction, or metric distances. The higher value of integration shows easier accessibility to that specific line. Space syntax literature advocates a strong correlation between integration and the probability of people's presence in urban space. Jiang (2009) shows that integration can explain human movements, 38-70% for pedestrian (local), and 55-64% for vehicular (global), he concludes that on average 60% of human movement can be predicted by the structure of the urban network. Various researchers suggest that there is a positive correlation between the integration value and accessibility of urban spaces (Bafna, 2003; Baran, Rodríguez, & Khattak, 2008; Law et al., 2012; Penn et al., 1998). The integration cores of the city are expected to be the places of interaction, movement, and exchange of information (Peponis, Hadjinikolaou, Livieratos, & Fatouros, 1989). According to Hillier et al. (1993), the logarithmic representation of pedestrian count can be explained by the integration value of streets. Evidently, there is a definite association between the 'integration' and the accessibility of urban space and, therefore, a higher probability of socio-spatial interaction.

Choice (Through-movement) represents the possibility of a path being passed through when people are moving toward destinations in the urban grid(Hillier & Iida, 2005). Accordingly, considering all possible movements between all nodes, spaces that are being passed through ore often are having a higher through-movement (choice) values (Hillier, 2012). According to Turner (2007) betweenness shows a stronger relationship with natural movement throughout the city, as it highlights the foreground structure of the city.

A significant part of space syntax literature has been built around the predictability of count data[2] in various disciplines like, pedestrian movement (Turner, 2007), crime prevention (Summers & Johnson, 2017), mobility (Read, 1999), transportation (Lerman, Rofè, & Omer, 2014), micro-economy (Hillier, 1999b), but inadequate attention has gone toward the spatial distribution of social media as a unique entity. For instance, Shen and Karimi (2016) use the check-in social media data to weight space syntax measures; their result shows the effectiveness of using social media data in enriching our understanding of contemporary cities. Nevertheless, geo-tagged volunteer shared data through social media is a unique trace of human interaction that has a very limited presence in the space syntax literature. The strength of space syntax for this study comes from the possibility of limiting the measurements with radii proxies. This flexibility provides the ground for comparing local vs global proxies of accessibility in addressing the main research objective.

3.2.2 Metric Distance and Street Centrality Measurements

The study is initially conducted only using space syntax measurement. Nevertheless, because the concept of "distance" was a dominant part of the theoretical framework, street centrality measures were used as a control measurement to check for the metric reliability of the result. The centrality is prior to space syntax analysis. these measures were developed in social network and social analysis for identification of critical nodes (Freeman, 1978; Wasserman & Faust, 1994). Nevertheless, the urban street pattern can be represented as a network by putting intersections as nodes and connections and ties.

[2] For instance, number or pedestrian encounters in a given interval, vehicles, crimes, functions, etc.

The initial implementation of centrality measures in urban research was for reading network distance and physical metric Euclidian proximity of urban spaces in relation to each other. The centrality measures have shown promising results in terms of predicting urban socio-spatial interaction (Irwin & Hughes, 1992). Furthermore, it seems that the formation of land-use and points of interest can be explained through street centrality measures to some extent (Porta, Crucitti, & Latora, 2006), see Table 2. *Closeness Centrality:* is similar to integration, the difference being the type of network, and network metric distance as the cost of travel. The closeness centrality at global scale often shows the Euclidian center of cities. *Betweenness Centrality* is similar to "choice" in space syntax measurement, only uses metric network distance as the cost of travel.

3.2.3 Measurements of the Angular and Metric Cost of Travel

Both measurements use the same logic for calculating to-movement and through-movement, but there are subtle differences between the two methods of analysis (Figure 9). In both analyses, the cost of travel could be set to topological, angular, or metric. Here following the recommendation of the literature the space syntax angular measurement (choice, and integration) seems to be the most effective variables in predicting people's movements (as shown in a large meta-analysis by Sharmin & Kamruzzaman, 2018), accordingly, those measurements were used as the primary variable. The angular cost of travel has shown to be close to how the human mind perceives accessibility and act during the process of wayfinding and decision making. The superiority of centrality analysis is in measuring network distance as the proxy for defining local/global measurements. In other words, because the centrality measures use intersections as the nods, it is possible to define proxies on the bases of actual travel distance as opposed to the crow flight radii, which is used by the space syntax analysis.

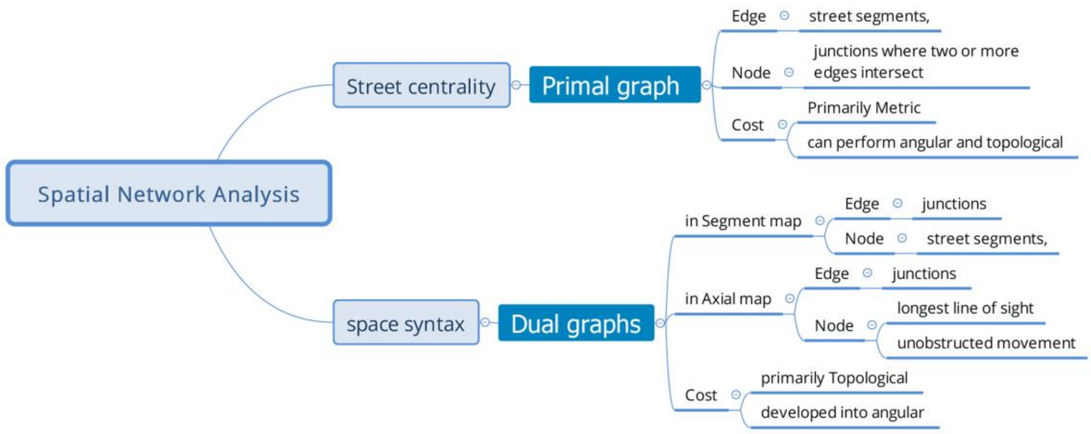


Figure 9. Fundamental differences between space syntax and street centrality analysis

Table 2. Formulas for the centrality measures.

Calculated Variable		Formula	Description	References
(C_c^g) (C_c^l)	The Closeness centrality, also known as: to movement,	$C_c^g(x) = \frac{n}{\sum_y^n d(x,y)}$ $C_c^l(x_r) = \frac{n_r}{\sum_y^{n_r} d(x,y)}$	n is the total number of nodes in the graph G d (y,x) is the shortest distance between y and x.(angular or metric) n_r is the number of nodes in the given radius of r for local measures. In smaller networks sometimes (n-1) is used. g:global, l:local	(Freeman, 1978) (Jiang & Claramunt, 2004) (Crucitti et al., 2006) (Hillier & Hanson, 1984)
(C_B^g) (C_B^g)	Betweenness centrality, also known as: through movement,	$C_{B\,(x)} = \sum_{s,k \in G, s \neq t \neq x} \frac{\sigma_{st}(x)}{\sigma_{st}}$ $C_{B\,(x_r)} = \sum_{s,k \in G, s \neq t \neq x}^{\sigma_{st} < r} \frac{\sigma_{st}(x_r)}{\sigma_{st}}$	N is the total number of nodes in the graph G. σ_{st} Is the number of shortest paths from s to t throughout the network $\sigma_{st}(x)$ Is the shortest path that passes through node x. r is the Diameter of the calculated area for local measures.	

3.3 Chapter Summary

Chapter 3 explores the mutual relationship between social and spatial forms of urban life which is referred to as socio-spatial interaction in this study. In other words, the formation process of social interaction cannot be separated from its' spatial form. The advent of long-distance communications into the fabric of everyday life of the city has put the critical necessity of physical proximity under question. Is distance a necessity for the formation of ties in light of the new forms of urban life? This new phenomenon has rendered a new reality of urban space in which people can interact with space and with each other without being present in said space. There are two main arguments in the literature, firstly, social media has created individuals that are more isolated in their immediate physical surrounding but very well connected throughout the social network. Easy access to vehicular transportation facilitates this isolation. Secondly, many researchers argue that the social-media has not fundamentally changed how human socio-spatial interaction are working, but it facilitates and amplifies it. This thesis argues that the answer is actually a combination of the two, and different patterns of behavior might emerge from these combinations.

Presence of people in public space is the essence of urban life. Accordingly, any interaction virtual/physical that leads to the movement toward the foreground of the city is a process toward increasing weak ties and urban flow of information. People often leave a digital footprint of their activities and interaction through social media. These volunteer sets of data could be used to study people's movement throughout the city.

In the end, the practicality and importance of Space Syntax methodology and urban street centrality is emphasized. These tools can be utilized to read and explore the accessibility of urban space. to-movement and through-movement provide an objective approach with considering distance and accessibility in different scales.

Chapter 4

RE-READING URBAN SPACES THROUGH 'BIG DATA' AND MIXED METHODS

In the past century, there has been a constant effort to implicate new technologies and analytical tools in urban planning. New types of data are being created that ten years ago would have been beyond imagination. Urban planners and researchers are embracing new scientific methods to understand the city as a complex structure. Accordingly, undermining the adaptation process of new technologies with design, development, and research could lead to failure as the dynamic of the city is evolving with these new technologies. There has been a long history of looking into urban problems through the lenses of science. Ford (1913) sees city planning as a form of science that addresses all developments by a conducting a comprehensive investigation and scientific approach. The problem appears that conducting a comprehensive investigation of urban problem often includes so many variables that form a natural state of dichotomy with the initial intention. The lack of capacity to collect the necessary data to understand urban problems is often the weakness of research on the urban phenomenon. The multidimensional complex structure of the city makes it difficult to isolate the main effective players. LeGates, Nicholas , and Kingston (2009) argue the "first wave" of scientific approach toward cities lacked the methodological complexity that is necessary for reading city structures, and it is followed by the second wave of "systems revolution" which tries to address the complexity of cities by dissecting it into manageable components. The third wave of scientific approach includes digital data and spatial information (GIS).

The contemporary era is a digital and computational evolution where the natural complexity of urban systems can be matched by the complexity of analytical approaches. The attempt to make general models for cities leads to the creation of ever impossible assumptions, modeling complex structures require flexibility, dynamism, and change (Allen, 2012). Over time, the use of statistical analysis by computers became a new vision for urban studies. Some influential scholars started using this potential to analyze, predict, and model urban systems (Hall, 2002).

Recently, development in the geographic information system (GIS), and the accessibility of computational power has made it possible to test larger datasets in search for patterns and models of socio-spatial behavior. These methods with the help of advanced computing and newly available data could be used to look at the city in a more complex way. It provides the ability to look into the city structure in a more comprehensive way, but without powerful theories to support emerging methodologies the usage of these methods might not be as helpful as predicted. This geo-tagged data which connects the data to the actual ground of the city should be seen beyond mere dots on the map and with high regards to socio-spatial processes that have created them (Crampton et al., 2013).

4.1 Big Data and Contemporary Research

New sources of data are being produced every day, mobile phones; social media, geo-referenced information are creating a cross-reference mine which is called “Big Data”. This data is usually raw and wide, and therefore analyzing it requires advanced selective methods. The interest in “Big Data” is increasing in the science of cities as well as in other fields. Where you could have a limited number of observations and interviews to analyze an urban problem before, we can have a collective sample of millions. If the data is being properly extracted and analyzed, the reliability might be uncanny.

Big data is a dynamic field of research that demonstrations promising results in biology, economy, management, linguistic, and human geography (George, Haas, & Pentland, 2014; Huang, Guo, Kasakoff, & Grieve, 2015; Kitchin, 2013; Leszczynski, 2012). The definition of big data varies throughout the literature. Boyd and Crawford (2012) state “Big Data is less about the size of data [being big] than it is about a capacity to search, aggregate, and cross-reference large data sets”. De Mauro, Greco, and Grimaldi (2016) define it with three main characteristics: Large Volume, variety, and velocity in a scale that necessitates computational analytical methods for the transformation process into tangible values and variable. Big data could also be characterized by the volunteer, self-production of content by people that create inter-disciplinary opportunities for research on a different aspect of human life (Gold, 2012; Klauser & Albrechtslund, 2014). According to Arribas-Bel, (2014), the nature of big data is accidental and researchers should take this simple fact into consideration that this data is a natural by-product of everyday life in the city.

Big data should not be considered a mere technological entity, but rather a cultural, and ontological phenomenon that re-identifies certain aspects of everyday urban life. These emerging properties of big data together with the development of computational and analytical tools enables the undertaking of large volumes of data which is impossible via traditional method. Furthermore, the acceptability of big data in producing reliable results is increasing rapidly in scientific communities (Dana & Kate, 2012), accordingly, new analytical approaches and visualization techniques is essential in addressing big data. The utilization of big data has created a paradigm shift in some research areas, Lazer et al. (2009) argue that the collective scholarly improvement of, collecting, analyzing, and integrating big data into research is creating new in-depth and detailed explanations in all sciences. For Graham & Shelton (2013) big data is defined by the concept of "change" because it stands as a new alternative beside the traditional data collection method.

4.2 Why Understanding the New Data Is Important in Reading the Contemporary Urban Spaces?

Types of accessible data are growing rapidly every day. People are producing, recording and sharing endless data about their activities, feelings, movements, etc. This data opens new windows for researchers to lower their dependency on old methodology and discovery of a new way. These new methods could be particularly useful in urban research because people's movements and interactions with urban spaces are being recorded by themselves on the public domain. The ever-evolving social structure of cities might be better understood by the integration of new layers of data, rendering a higher resolution image for researchers (Hao, Zhu, & Zhong, 2015). Boyd & Crawford (2012) argue that the definition of big data covers significant changes in three areas of culture, technology, and methodological advancements:

- Technology: to take the most advantage from computational powers and advance computers.
- Analysis: drawing new software and analytical reading of large sets of data

- Methodology: exploring new patterns in fields where very little research has been done due to the technical difficulty and sheer volume of data (Boyd & Crawford, 2012).

Anderson (2004) argues that there is a great opportunity in these emerging types of data because they render new perspectives when addressed through statistical analysis. Anderson (2004) states “Correlation supersedes causation, and science can advance even without coherent models, unified theories, or really any mechanistic explanation at all there’s no reason to cling to our old ways”. Anderson calls this process ‘End of Theory’, and elaborates on the nature of the new data as being more accurate, objective, and naturally occurring. The increasing quantity of the data and computation power produces more accurate analysis, or as he puts it “With enough data, the numbers speak for themselves”. Accordingly, a new taxonomy of research has emerged in which is not necessarily based on an initiating hypothesis or research question, rather it is seeking patterns among a large number of variables and datasets (Anderson, 2008; Graham & Shelton, 2013).

Are numbers trustable? Boyd & Crawford (2012) are arguing on the contrary. Restricted accessibility to data and its context, lack of theoretical and philosophical models to analyze the data, and ethical issues could negatively affect the outcome. This argument could be made that these are the necessary steps toward the development of these new methods as they are fairly new, therefore conducting more research on the subject would lead to a more structured and well-modeled methodology. Wyly (2014) argues that research in Big Data lacks hypothesis or/and research question because the data has been produced by a system which is careless for those methods. The majority of researchers in the field are starting with exploring data and looking for correlation, trying to “letting the data to speak for itself” Wyly (2014) argues that big data could expand the horizon of our knowledge by diving into the unknown. Such critiques on big data are valid in a sense that over-dependence or out of context interpretation might negatively influence the purpose of research. Nevertheless, the unprecedented opportunities that big data provides for research makes it an inseparable aspect of contemporary urban studies. For instance, most of the official census data are often outdated by the time they get released and provide very few spatial variables for research. Therefore, using data that can be traced in real time is beneficial for the research, and could provide useful insight into urban studies. In this study, we utilize big data in form of volunteer geographic data to show how big data can be used to read and understand human movement throughout the city. big data provide an alternative to the traditional understanding of the city and urban processes (Sheltona, Poorthuisb, & Zookb, 2015).

4.3 New Data and Contemporary Urban Issues

New sources of data and emerging technologies have played an essential role in urban research and planning, the process of adaptation and understand these new techniques requires time and effort. Recently these technologies have changed from computer main-frame to desktop and mobile devices. While these new technologies are being developed it could be argued that the very notion of Big Data and social media is inherent in the fabric of the city, the flow of information is a fundamental property of the city and a part of it is in the process of transformation from physical to virtual interaction (Kitchin, 2014). The transformation of having constant access to the network –not just as the consumer of data but as the producer- should not be ignored. The digital footprint of citizens provides a new framework for research on pedestrian movement within the city with greater resolution and more detailed micro-level analysis; this in return creates new design tools which could be used for better and healthier urban design (Vanky, 2017). One of the critical ways in which big data connect with urban research is through the production of geographically tagged data as a testament to people's presence in the space. Photography, videos, text, and combination of these techniques in relation to an actual coordinate on the map provide the research with an invaluable amount of usable data. Though creating a geo-tagged tweet, or making a new story on Instagram might seems to be a very small or unrelated interaction, the accumulation of thousands and millions of these small geo-tagged data points that shows socio-spatial interaction with urban space is allowing for new ways of studying and understanding cities (Arribas-Bel, 2014; Sheltona et al., 2015).

4.4 Exploring Socio-Spatial Interaction of Urban Space through 'Big Data'

The body of literature on spatial properties of big data is expanding rapidly. Several studies undertook the integration of big data in macro scale (see Ahmed, Hong, & Smola, 2013; Cheng, Caverlee, Lee, & Sui, 2011; Kotzias, Lappas, & Gunopulos, 2015). However, the majority of research using big data is conducted in a larger macro scale, and emphasis on a smaller micro scale of urban interaction with regard to contextual characteristic remains understudied. It seems that exploring larger sets in smaller scale could provide a ground-up approach in reading big data within its spatial context. The relationship between spatial networks of the urban grid as the container of everyday life needs to be further investigated. This gap seems to persist in both theoretical frameworks and empirical endeavors. Nevertheless, the new form of communication provides an invaluable digital footprint that could be utilized for research. The built-in Global Positioning Systems of mobile devices especially when shared on public platforms creates a link between the content produced by people and a particular time/location on the ground. This interactive content includes photos, videos, and hypertext. In some cases, the users share their geographic tag which remains as a trace of their interaction on the hybrid space. Throughout these mediums the interaction might take numerous forms such as reviewing services, restaurant, or a café, checking in a place in order to inform others, and sharing images or micro-blogs on Twitter are just a few examples. Although these data are accidental in nature, when aggregated in large quantities could widen the horizon in our understating of contemporary urban dynamics (Arribas-Bel, 2014). A study did by Sheltona et al. (2015) investigates the social segregation using geo-tagged Twitter data and explores the possibility of a fine grain investigation with sensitivity toward the context. Lee, Wakamiya, and Sumiya (2013) research shows impressive potential in understanding patterns of socio-spatial behaviors using social media, their findings demonstrate the readability of reading urban activities through social media data.

4.5 Challenges of 'Big Data'

Like any new phenomenon, big data brings forward a few challenges and shortcomings. First and foremost, it lacks a unified and strong theoretical, philosophical, ontological, framework (Dana & Kate, 2012). To the contrary, it could be argued that big data brings its own essential new ontological framework which is inherent in its computational, multivariate, and technological power of exploration. The other challenge is the irregularities and accidental nature of the data sets. Big data is in its nature, unsorted, uncategorized, unmonitored and random. Therefore, using big data must be with great caution, and it must undergo the process of filtering, sorting, and organizing methods together with theoretical background to support it.

Furthermore, big data should be used cautiously, as the name implies, it is big and mostly un-edited and unfiltered. It is processed through automated computational processes; accordingly, the researcher should be aware and in control of these processes. Nevertheless, if all the necessary precautions and clarification steps are taken, the data could offer unprecedented possibilities for scientific endeavors.

4.6 Twitter as the Source of Geo-tagged Socio-spatial Data

In terms of availability of data for research, the social media platforms could be categorized in two major groups: first, platforms that create a private network for individuals with the goal of offering a privatized public space to individuals. At this time (2018), Facebook, Instagram, Pinterest are examples of such platforms. The second type is the platforms that thrive of their snappy and public nature of access. The second types are inherently public realms alike the urban public space. Although, it is possible to create private, conversation, block people, as is possible in the physical public space. Twitter and Flicker are a good example of these platforms. The Twitter privacy policy reads: “Most activity on Twitter is public, including your profile information, your time zone, and language, […] You also may choose to publish your location in your Tweets or your Twitter profile” (Twitter Privacy Policy "Twitter Privacy Policy," 2018). In this study, the microblogging service Twitter was used for the following reasons:

- Public nature of the data produced by people
- The possibility of having volunteer geo-tagged attached to the content
- Short content, especially the inclusion of keywords and # makes the exploration, and classification much faster
- Twitter is one of the most popular social media in Turkey (Cint, 2018).

However, using geo-tagged Twitter data for research comes with caveats. Some researchers argue that Twitter data might carry some inherent biases, which are the natural side-effects of such data. The data might not be evenly distributed according to gender, age, and socioeconomic status when being compared with the official census data (García-Palomares, Salas-Olmedo, Moya-Gómez, Condeço-Melhorado, & Gutiérrez, 2018; Ruths & Pfeffer, 2014). Accordingly, this issue needs to be addressed that the users of Twitter do not represent the general population. However, as long as the boundaries of data collection are clearly defined (see chapter 5) and these issues are publicly addressed within the context of the research case study (Boyd & Crawford, 2012), geo-tagged Twitter data is one of the most significant and intuitive sources of data in the contemporary world. The geo-tagged Twitter could be seen as a detailed observation of the hybrid socio-spatial public realm of cities.

Despite the public nature of Twitter data, it is necessary to follow an ethics code in order to respect people's privacy and anonymity of research data. Accordingly, this study follows the Rivers and Lewis (2014) guidelines for using Twitter data:

- The transparency in methodological and empirical aspects of research design and data collection.
- The Twitter data should be analyzed with respect to the context in which it is produced.
- The anonymity of the producers of the tweets should be protected, in other words, it should not be possible to connect any part of the data to an identifiable individual.
- The public nature of Twitter data should not be used to obtain private information of users.

Moreover, this dissertation only uses the volume of data and it related public geo-location information, although the public content of tweets is used for filtering purposes, all data points are anonymous (Bruns, Burgess, Crawford, & Shaw, 2012).

4.7 Chapter Summary

Social media and mobile devices have changed the medium of peoples' interaction with space, simultaneously, providing opportunities to record and investigate these new interactions. Big data is the digital footprint of society materialized in a new form. These datasets are created by the people themselves and can provide in-depth insight into how contemporary society operates the spatial grid. Accordingly, in order to understand, today's urban space research should take the issue of 'Big Data' into account. Big data should not be considered a mere tool for research but a part of the theory of understanding how contemporary cities work. The nature of big data requires great care for filtering and sorting of the data. Making sense of this data is the greatest challenge when approaching research on the topic.

Chapter 5

METHODOLOGY AND CASE STUDY

One of the main challenges of this research was to develop a proper methodology and data collection method in relation to the theoretical framework. The nature of this research requires analyzing large datasets attempting to explore the possible correlation among the various variables. Therefore, making sense of data is considered to be the most important challenge in this dissertation. Thus, this chapter tries to establish a clear and comprehensive step-by-step explanation of data collection and analysis. Furthermore, the testing and controlling for all variables were considered to be of great priority while designing the methodology. The social media data due to its nature might seem random and disoriented, but there is an intangible order underlying this massive data as it is the by-product of the contemporary everyday life of cities. This chapter tries to establish a methodological approach for reading the city through various types of data. Regardless of the outcome, this study tries to address a methodological gap in understanding life in urban spaces in the context of network society and if physical accessibility plays a role.

5.1 Designing the Methodological Approach

Designing a methodological approach for understanding spatial accessibility in relation to the formation process of socio-spatial interactions through social media is a significant part of the contributions of this research to the existing body of the literature. By decoding the research questions and in line with the two main discussions in the literature, the main layers of the data collection were identified. The methodology was designed on the bases of the exploring computational/statistical correlations among variables of spatial accessibility, the interactions that are happening through social-media which are tied to the special grid (geo-tagged), and citizens' opinion regarding the important points of the grid. The methodology tries to address the importance of pattern seeking. The first arguments in the literature are in support of the deterritorialization of activities vs. the second argument in favor of physical proximity as the force behind the formation of socio-spatial activities. These arguments moved the data collection process to first address the second research question in addressing the reliability of the Twitter data throughout the city before checking for the patterns of distribution in relation to accessibility and distance. Thus, three groups of data were collected to address the research question and literature review (Figure 10):

- ***1st layer:*** the distribution of socio-spatial interaction with urban space is represented by the Tweeter feeds with intact geo-location data.1st layer is the principal Dependent Variable (outcome variable: DV)
- ***2nd layer:*** the reliability of geo-tagged Twitter feeds in representing the distribution of social activities in urban spaces were tested by a name-generator survey. The 2nd layer identifies people's assumption of interaction with urban space by targeting a statistical 95% confidence level (Independent Variable, Predictor: IV).
- ***3rd layer:*** the accessibility of spaces in the larger network of the city were measured by two families of measurements: to-movement and through-movement. The measurements were conducted via the space syntax angular analysis due to the strong body of literature suggesting the reliability of the outcome. Furthermore, the Euclidian street centrality as control variables were used to address a set of pure distance-based measurement alternatives. All measurements were conducted

in incremental steps (proxy limits) to explore the degrees of accessibility in different scales.

In order to answer the main and sub-research questions, the predictability of geo-tagged social media data (DV: Twitter feeds) through various layers of IVs was addressed through three main objectives. Although 'objective two' is mainly corresponding to the main research question, exploring the first sub-research question seems an essential step that explores the validity of the main question. The three objectives are as following:

- ***Objective 1*** tests the reliability of geo-tagged Twitter feeds in representing people's interactions with urban space. The first objective explores the extent of overlap between how people perceive their interaction (IV: 2nd layer) with urban space and their digital footprint through geo-tagged tweets (DV). Furthermore, the first objective tries to provide a comparison between a traditional name generator list and volunteer geographic information (in this case geo-tagged tweets). Accordingly, the predictability of geo-tagged Twitter data via the tagged spaces on the survey provides insight into this matter.
- ***Objective 2*** tests the predictability of Twitter data through space syntax and street centrality measures: DV: 1st Layer, IV: 3rd Layer. The second objective addresses the main research question by first reflecting on the two main theoretical discussions in the literature; does the digital communication mediums and social media decreased the importance of local accessibility. In other words, is long distance-free nature of digital communication has reshaped the way people interact with the city within the framework of their everyday life? Objective 2 explores the importance of accessibility from local to the global scale of the city.

- ***Objective 3*** (socio-spatial typology): Objective 3 also comes from the theoretical discussion in chapter 4 regarding mining the big-data for patterns of behavior instead of exploring a predetermined question/hypothesis (Anderson, 2008). Accordingly, two approaches toward exploring these patterns are suggested: first: the normal distribution of spaces through space syntax measurements and Twitter data within one standard deviation (σ) from the mean (μ). This section explores the subtle socio-spatial patterns of behavior in urban settings concerning social media and accessibility. Second, the same analysis has been done using the 95 percentiles (two standard deviations from the mean). The second part is exploring the outliers and statistical anomalies. Objective 3 is the natural outcome of statistical classification of data; the socio-spatial complexity of urban network goes beyond a simplified answer and requires a deeper dive into the pattern of behavior within the emerging sources of volunteer geographic data.

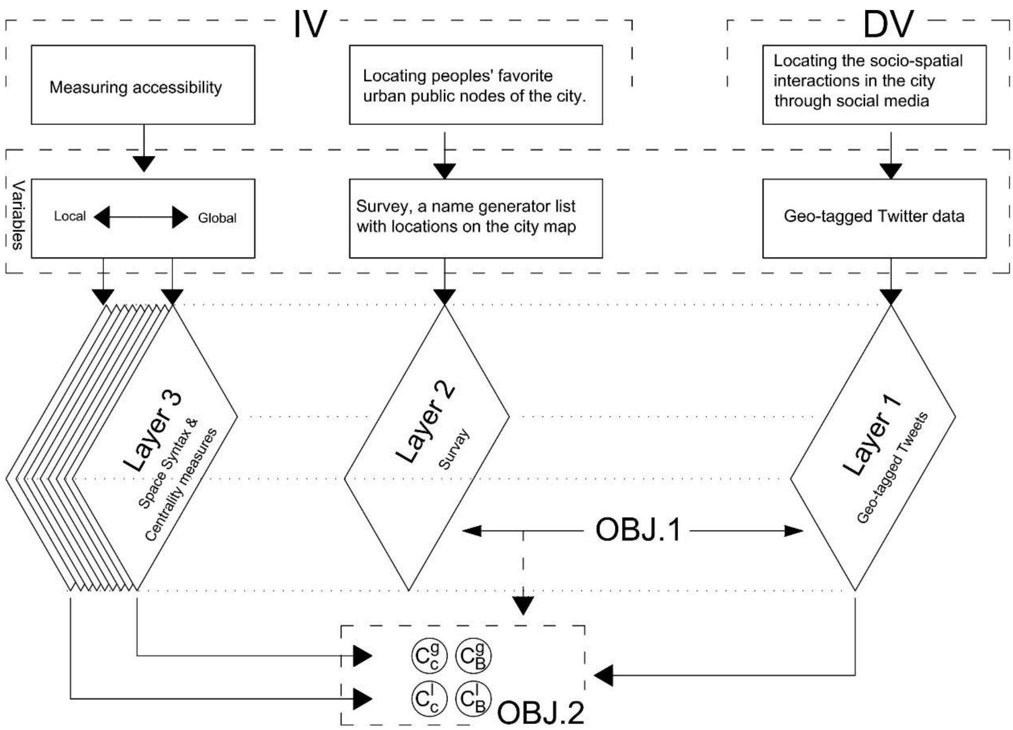


Figure 10. Data collection and the analytical process, exploring the possible patterns of explanations for the objectives.

The following sub-headings would provide a systematic detailed framework of the data collection procedure.

5.2 Case Study

The study was initially conducted in the city of Famagusta. Located in the eastern coast of the Island of Cyprus (Figure 11 & Figure 12: a), Famagusta is home to more than 40 thousand residents. The city has a long and rich history that has shaped it into its current form. The city reached the ancient Salamis ruins at its northern section. Portions of the city are physically divided due to the Cyprus conflict since 1974. A buffer zone cuts through the city that contains the uninhabited Varosha district. The aftermath of the Cyprus conflict is still clearly visible through the city. Large portions of the city are occupied by Turkish (Figure 12:e) and UN military site (Figure 12:d). Consequently, the city has very little engagement with the waterfront due to the large military camps occupying the strip of land between the city and the Mediterranean Sea. The historic quarter of the city is a dense urban fabric surrounded by walls (the walled city of Famagusta, Figure 12:b). the collective effects of the border at the south and the attraction of university for the private sector in the northern section of the city have greatly changed the morphology of the Famagusta. The city has been developing toward the university campus which currently is one of the major drivers of micro-economy in the city (Doratli, Hoskar, Vehbi, & Fasli, 2007; Guley & Abbasoglu; Önal et al., 1999). Figure 11 shows all the borders and inaccessible areas in relation to the University campus.

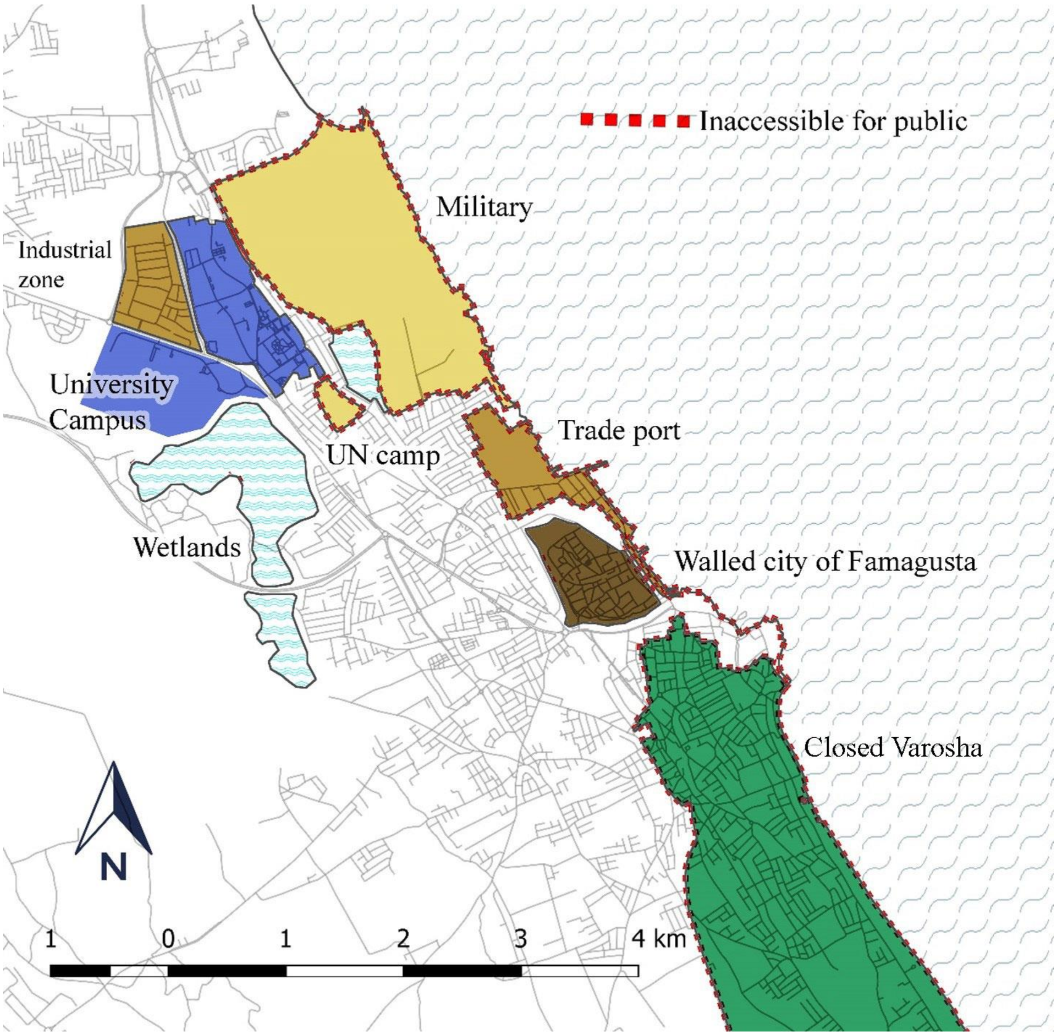


Figure 11. The city of Famagusta and its borders

Figure 12. The city of Famagusta (a), the historic walled city (b), EMU campus (c), the UN camp inside the city (d), and the large military camp restricting access to the seafront (e)

The University campus (Figure 12: c) is one of the main social and economic drivers of the city. According to EMU annual report, in the academic year of 2015-16, the population of the school is 19730 from 106 countries. The majority of these students are from Turkey, Nigeria, Iran, Jordan, Palestine, Libya, Azerbaijan, and Cyprus. The study has tried to involve both students and locals in the study. Although the cultural background is out of the scope of this research and would not be considered as a definitive variable, keeping the ratio and information might provide insight to further researches on the topic.

5.3 Data Collection

The research tries to draw the power of quantitative calculation and statistical analysis to explore the intersections among different sets of variables and relationships between these layers in the city. It is worth mentioning that the socio-spatial data provides qualitative measures due to its nature, as it is the real-life experience of people living in the city. The socio-spatial data can be observed by studying traces of social media activities that people produce in real time within urban public spaces. However, the lack of practical study in this field stirred the study toward investing this phenomenon: could the data collected from social-media represent the reality of what is happening in the real ground of the city? The most difficult part of this data collection was obtaining geo-tag data, both for the questioner and social- media. This information was vital for the analysis as physical accessibility is one of the main independent variables of this research, and the utility of mapping requires such data.

5.3.1 First Layer: Geo-tagged Twitter Feeds, the Source of Socio-spatial Interaction

The digital footprint of socio-spatial interactions is being represented in the dataset via geo-tagged Twitter feeds (see 4.6). Twitter data could provide insight into people's interaction with each other and with space, but this data must first undergo a careful and mindful process of filtering and cleaning (Lansley & Longley, 2016). This study uses the NodeXL platform for collecting the Twitter data. The application NodeXL is created for sophisticated data collection and network analysis (see further explanation and full documentation in D. Hansen, Shneiderman, & Smith, 2010; Yoon, Elhadad, & Bakken, 2013). Only a very small portion of the Twitter data includes geo-tagged coordinates. Approximately 1% of all tweets contain coordinate information (Kumar, Morstatter, & Liu, 2014), but the proportion might change according to the context demographics, Morstatter, Pfeffer, Liu, and Carley (2013) report it around 3.17% in the publicly available tweets. The Twitter data was collected and filtered in 7 systematic steps:

1. All the related tweets using hashtags related to the city or its main spaces such as streets, squares, and public buildings were collected. 5560 Twitter handles that mentioned the city were identified through this process.
2. 1105 of these handles had often their geolocation enabled and were tweeting from the boundaries of the city.
3. The final group (N=1105) were screened one by one for commercial sources, retail shops, and advertisements, 166 handles were eliminated through this process.
4. The Twitter data collection rates are very limited, in this case, only the latest 3200 tweets per user were available. Accordingly, N=1559294 tweets produced by the 939 Twitter handles between 2012-2018 were collected.
5. All collected tweets were filtered by the existence of geo-tagged data and boundary of the case study. From the collected data set, 67861 tweets were both geo-tagged and within the defined boundary of the case study.

6. In few instances, close inspection of data revealed heavy Twitter users only tweeting from their home, this happens due to the extended time-frame of data collection from selected handles and it disturbs the spatial distribution of data. The same issue might happen in non-residential areas by employers of commercial functions. Accordingly, we addressed this issue by removing tweets when a segment included more than 100 tweets from an individual handle.
7. Stage 5&6 leaves the final count of N=67861 tweets for the data analysis. The final dataset was visualized on the map using QGIS software.

All stages of data collection and filtering are shown in Table 3. The abundance of geo-tagged Tweets inside the city and Famagusta might be caused by the presence of the university campus as an integrated part of the city (approximately 50% of the city population are students, hence, heavy social-media users). The collected data could be viewed in two categories the check-in data and free geo-tagged tweets. Check-in data shows promising readings of human mobility in relation to urban land-use (Zhan, Ukkusuri, & Zhu, 2014), and urban points of interest (Gao, Janowicz, & Couclelis, 2017). A random sample of the collected Twitter check-in data is provided in Appendix A. The majority of these points can be seen as pedestrian interactions as they require a link between a physical active function and an individual. In this study more than half of the final tweets (66.8% in Famagusta) include check-in data, these tweets start with the phrase "I'm at" being followed with a particular place in the city. The rest of tweets are random interaction which is referred to as "free" geo-tagged tweet here. Appendix B shows a random sample the free tweets. For this group (free tweets) it is not possible to distinguish between tweets coming from inside vehicles and pedestrians because the geo-tagged information recorded by mobile devices does not provide the necessary accuracy which is required for the separation between side-walk and mid-road. Accordingly, the study addresses the tweet count in three categories: all, check-in, and free tweets. In general, the study uses the final "all" count as the main outcome because the systematic filtering ensures a natural distribution of interaction with urban space by people, the other two (check-ins and free tweets) are mainly used for control purposes. Accordingly, if the predictability of these control variables shows significant variations, the matter would be further investigated. Figure 13 shows the general distribution of all geotagged tweets, Examples of collected geo-tagged Twitter feeds are presented in Appendix A and Appendix B.

Table 3. The process of collecting and filtering Twitter feed data

	Twitter Handles			Tweets			
	(1) Initial Twitter handles	(2) With geo-tagged data intact	(3) Final Twitter handles	(4) All	(5) Geo-tagged & within the boundary	Check-ins in relation with locations on the sidewalk	Free tweets
Famagusta	5560	1105	939	1559294	67861	45343	22518

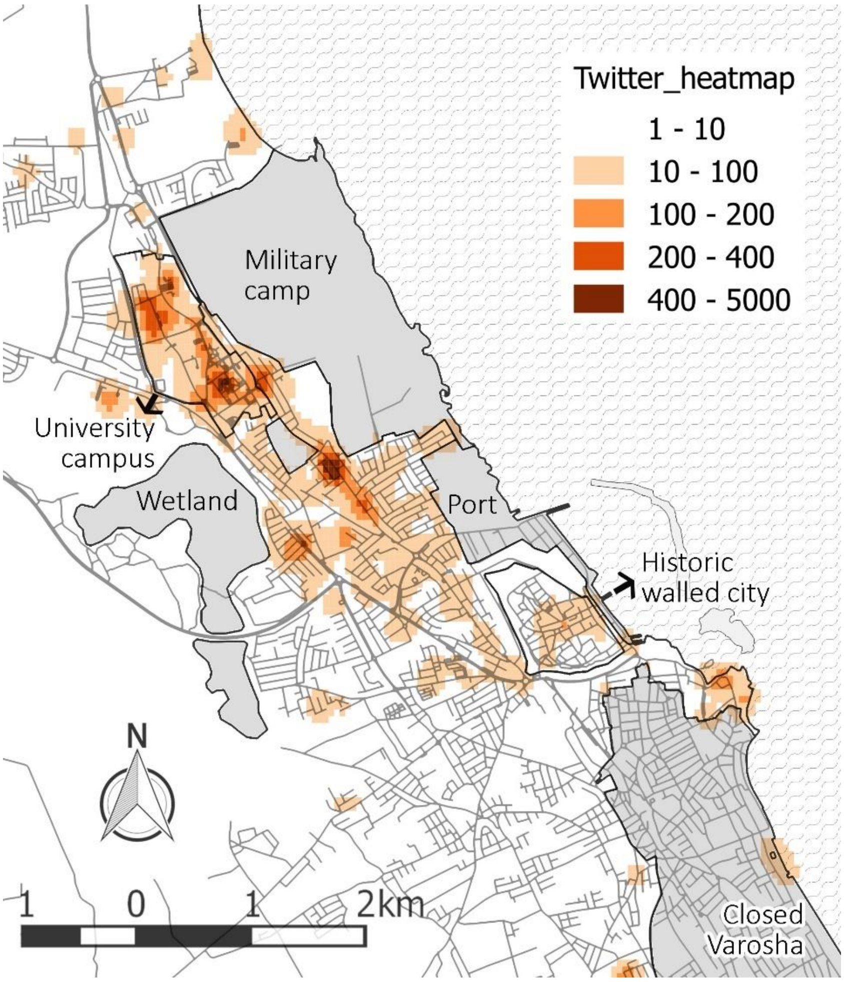


Figure 13. The distribution of all geo-tagged Twitter feeds throughout the city represented via heat-map

5.3.2 Second Layer: The Name-Generator, an Insight into People's Perception of Urban Public Space

The main logic behind the 2nd layer is to establish a reading method into the degree of connection between geo-tagged Twitter data and people's interaction with the urban network of spaces. This layer of data tries to explore the importance of social nodes from the perspective of people. One of the motivations behind this research was to explore the possibility of using social media as a source of data in areas in which the official census data is not widely available. Thus, this variable was designed as a control outcome to check the nature of geo-tagged Twitter data in relation to what people consider viable spaces for socio-spatial interactions. A name generator survey was designed to explore how people recall their interactions with urban spaces of the city. The Name generator survey tries to find the most attractive spaces from the standpoint of the users of the city, whether they were just spending time, sharing it on social media, or photographing it. This layer of data can be replaced in further studies by systematic observation. Accordingly, the name generator survey asks people to name (or mark) the followings:

- Their most favorite public places in the city that they spend time with their friends and socialize,
- Places which they share through social media,
- The places, which they took pictures.

The sample size was set based on the measurements of Israel (1992) addressing the minimum 95% confidence threshold with 5% error. Accordingly, a minimum sample size of 377 cases would meet the 95% confidence level given the population of Famagusta. Finally, 452 participants willingly took part and marked urban locations on the name-generator survey. Out of this number, 15 left the survey willingly, and 36 were eliminated due to insufficient answers. The places and their location were located on the GIS map. Out of 401 final answers, 1,922 clear places/locations were clearly identified. All locations recalled by the participants were then placed on the city map (Figure 14). A first glance of the raw data shows a pattern similar to the distribution of the geo-tagged Twitter data, the liner commercial street (Salamis) connects the university to the rest of the network. Public beaches of the city are clearly visible on the map. The historic core of the city shows itself as a place of possible activity. In its core, the first two layers are attempting to find Urban Point of Interests: POI (Gao et al., 2017) from the perspective of the actual participants and from the perspective of Twitter users.

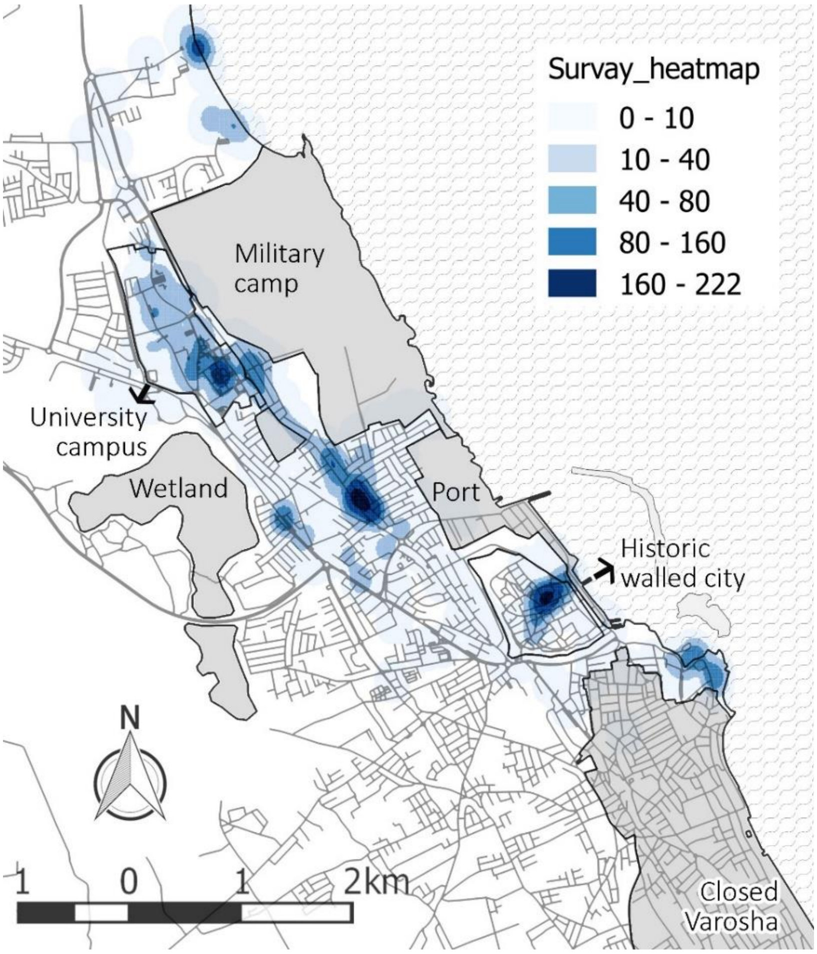


Figure 14. The location of places tagged through the survey represented via a heat-map.

5.3.3 Third Layer: Spatial Accessibility, Space Syntax, and Metric Centrality

Physical accessibility was measured via two methods: Angular, and Metric cost of travel. Firstly, the angular space syntax measures were selected because of the extended body of literature that supports its strong correlations with people movements in urban networks (see chapter 3).

Second: the street centrality measures we selected as a control variable group to represent pure Euclidian metric measurements. The theoretical framework and research question undertake the concept of distance. Although space syntax can provide these measurements, the dual nature of the represented graph that puts spaces as nods regardless of their volume, this necessitates involving a pure metric measurement for control purposes.

5.3.4 The Segment Map

The very definition of what institutes as an axis in the urban network is open to debate. The initial space syntax literature suggests any unobstructed line of sight or movement as an axis (Hillier & Hanson, 1984). Here, the study uses the road-center line as suggested by Turner (2007). The road-center line offers an equally significant outcome in analysis and it is better suited for integration with GIS. In this case, the road-center line offers the opportunity to count the geo-tagged data for each Space, when the unobstructed line of movement might not provide the accuracy required for addressing high volumes of geo-tagged data. The initial map was created based on the road-center line. The map was continued beyond the area of the study to minimize the 'edge effect' which is caused by the low integration measurements for spaces near the boundary of the map (Penn et al., 1998). The map was further converted into a refined segment map. This procedure breaks down the long lines in each intersection and shows stronger correlations with the natural movement of people (Steadman, 2004). In the segment map, each line between two intersections shows a slightly different value of integration/choice and increases the number of data entries which, in return, could improve the reliability of the statistical analysis. The final map of the city including 2888 segments was used for conducting the measurements. Table 4 shows the general descriptive statistics regarding the segment map.

Table 4. The segment map descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Angular Connectivity	2888	.0	8.2	2.804	1.0121
Connectivity	2888	1	9	4.00	1.061
Segment Length	2888	3.4	1510.0	92.832	81.7173
Valid N (listwise)	2888				

5.3.5 Space Syntax Measurements

Space syntax analysis of angular integration (to-movement) and choice (through-movement) on a dual graph with radii proxy limiters was conducted on the segment map of the city of Famagusta. The variables were calculated via UCL Depthmap X, and the outcome was integrated with other layers of data using QGIS software.

Accordingly, the integration was calculated in 11 different distances to provide an incremental point of reference for comparing levels of spatial analyses as suggested by Hillier (2009), the measurements were done in 5000m, 3000m, 2500m, 2000m, 1750m, 1500 m, 1250 m, 1000m, 750m 500m, and 250m (also see Lerman et al., 2014). Figure 15 shows local integration at 500m and choice at 500m.

The local integration demonstrates two locally accessible cores in Famagusta: the historic walled city and the university campus. The public can reach both spaces but only through limited gates; both spaces have definite borders. The walled city district of Famagusta is the historic center of the city. The historic core is very isolated in respect to global accessibility but is very accessible to pedestrians at the local level (walkable distance); this is caused by its limited access to the rest of the spatial network. Although the walled city has high-quality public spaces, it is not easily accessible from other parts of the city. Furthermore, the city has insufficient access to the sea, despite being a coastal area. Due to the enclosed military camps, the waterfront can only be accessed through two points at the far ends of the city. The local choice shows a similar pattern, but with more emphasis on the connections at the local level, accordingly, the connecting bridge between the historic walled city and city becomes a dominant feature on the choice analysis. Moreover, there seems to be a small area with high local Through-movement which was confirmed with the observation that this segment is being used by a residential neighborhood as the main local connection to the main street.

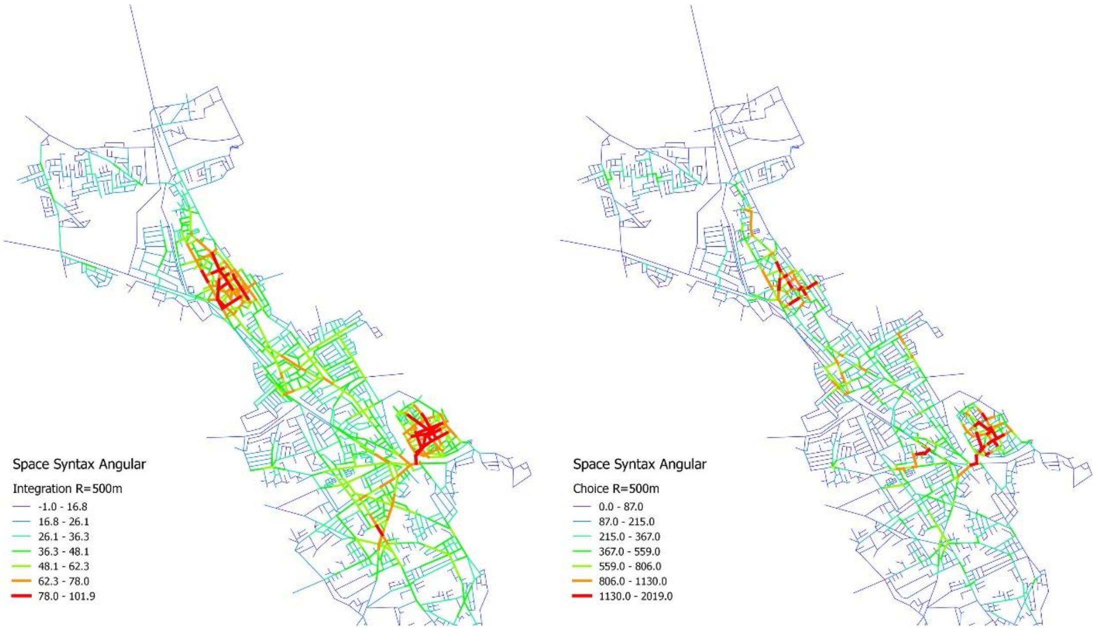


Figure 15. Space syntax local measurements left: integration at 500m at, right: choice at 500m

The global integration measurement shows the physical core and around the main arteries of the city. The spaces with high global integration in the case of Famagusta do not necessarily represent the social hubs and interactive urban spaces, but rather a mixture of traffic movements throughout the city. Similarly, Global choice puts more emphasis on two main vehicular axis of the city (Figure 16). The roundabout outside the historic core is visible as the main global to-movement and through-movement core; this happens because of the segregated nature of the city which separates the network into three main sections with their connection becoming highlighted in the network analysis. Furthermore, the low correlation coefficient between local and global integration suggests spatial segregation between local and global cores of the city (see Appendix E).

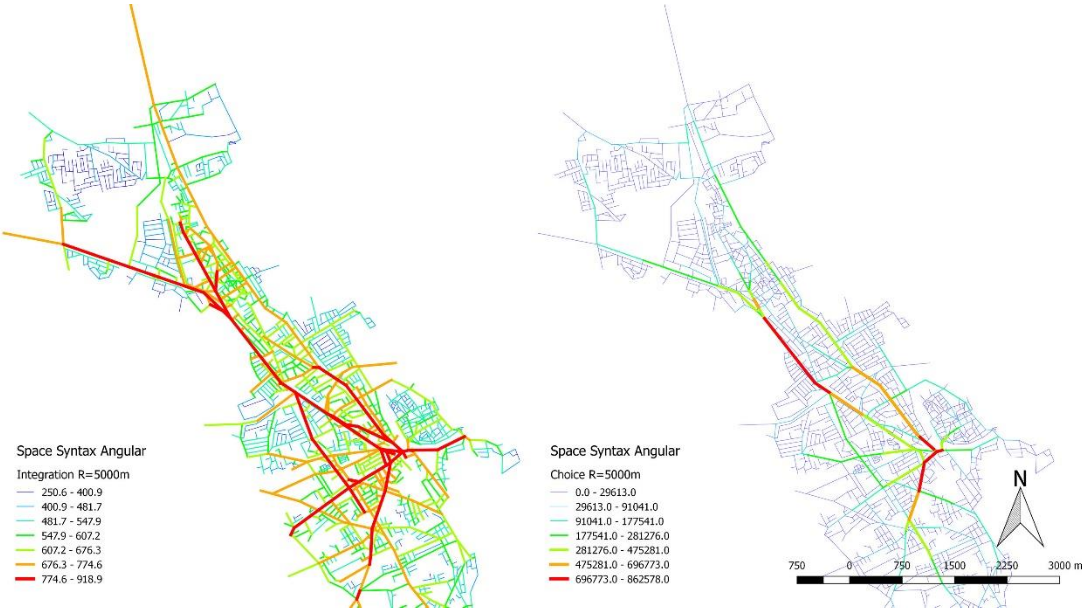


Figure 16. Space syntax local measurements, left: integration at 5000m, right: choice at 5000m

5.4 The Process of Overlaying the Three Layers Data

The process of data analysis begins with addressing the method for spatial overlaying of the three data layers. Three layers of data are three different families of data. In order to situate each data layer within its spatial context, and for enabling a comprehensive analysis between the different parts of the city, all data points were aggregated and superimposed on a hexagonal grid. The grid is composed of cells with 250m in diameter which correspond to the incremental increasing steps of proxy limiters for space syntax and centrality analysis (Figure 17). The hexagonal grid is a strong tool for exploring the correlation between local variables and statistical summarization of different datasets (Carr, Olsen, & White, 1992). The hexagonal grid allows a more natural comparison in cities without a clear grid, particularly when physical proximity is a key component (see Shelton, Poorthuis, & Zook, 2015). The 250 meters diameter was selected in line with the smallest proxy used in centrality and space syntax analyses (R=250) which increases incrementally with 250m steps.

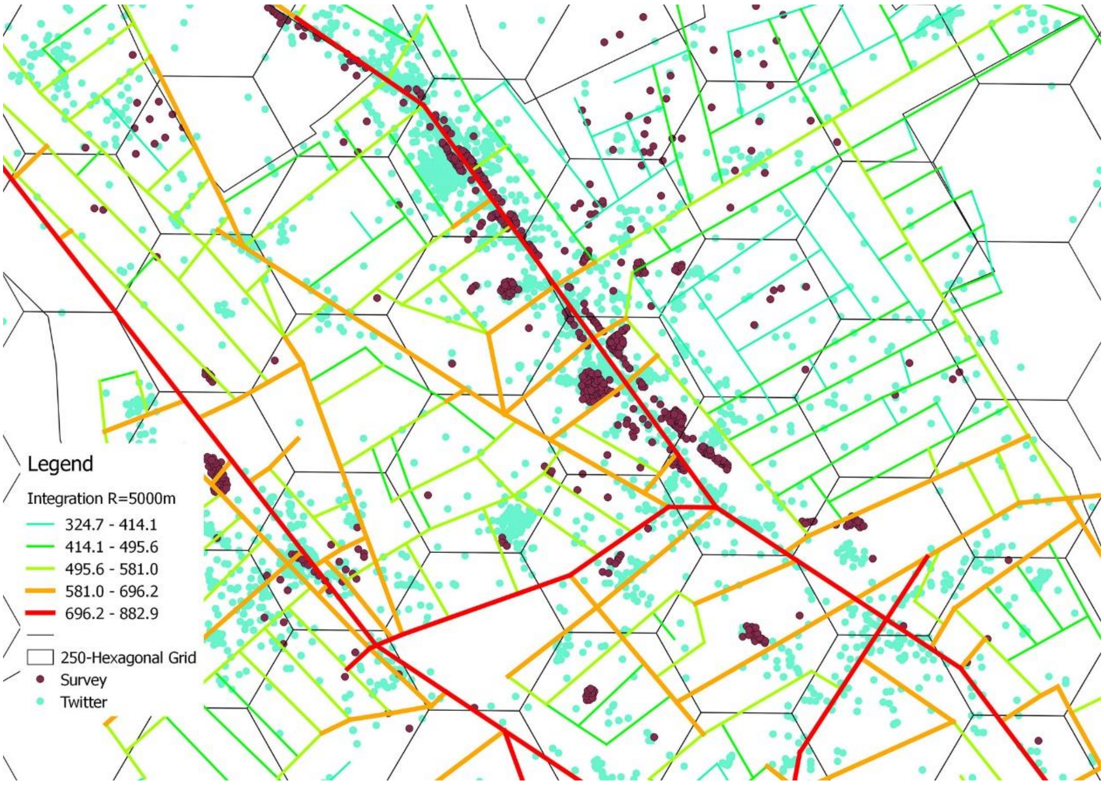


Figure 17. An example of the overlaying process via hexagonal grid

The placement of the hexagons on the map is an automated GIS procedure covering the axial map. Accordingly, a grid containing 415 cells was produced, 30 cells were manually removed at the periphery of the city, these cells contained insufficient data (for instance: a single segment passing through the corner of a hexagonal and no other data inside), the remaining 385 cells were used for the analysis. Each hexagonal map is addressed by a number and considered a case with different variables. Accordingly, the number of dots in each cell has been counted for each cell regarding the geo-tagged tweets and the name-generator survey. The space syntax and centrality measures were added to each cell as follows: the segments that were passing through cells borders were addressed to all those cells. Furthermore, the mean value of spaces that were assigned to each cell was added to each cell. All variables were aggregated in the final dataset. Table 5 shows the descriptive statics off all collected data. Layer 1: all geo-tagged tweets (check-in tweets, and free tweets for control), layer 2: the name generator survey, layer 3: 11 levels of Angular integration, 11 levels of angular choice (11 levels of metric closeness centrality, and 11 levels of betweenness centrality for control), for full descriptive See Appendix C. Descriptive maps were produced to show the average number of mentioned places in the city (Figure 18, Figure 19, & Figure 20), these figures provide an unprocessed reading of the city and how people perceive and use it by showing the distribution of clusters of accessibility and socio-spatial activities throughout the urban spaces.

Table 5. Descriptive statistics of different layers of data.

	Variable	N	Min	Max	Mean	Std. Deviation
Layer 1 DV	All Tweets	385	0	4880	160.91	547.5
	Check-in	385	0	3574	110	399
	Free tweets	385	0	1345	50.4	160.9
Layer 2 DV	Survey	385	0	337	6.7	26.6
Layer3 Main IV	CH 500	385	.0	771.9	121.473	136.2
	CH 5000	385	.0	316932	33528	47583
	INT 500	385	-1.0	77.4	24.654	14.8207
	INT 5000	385	97.0	719.3	416.473	138.7125
Layer 3 Control IV	CC 500	385	.001987	.00409	.00309	.00034
	CC 5000	385	.000272	.000490	.000371	.000048
	CB 500	385	.3	968.4	132.928	147.6028
	CB 5000	385	501	296330	33798	43255

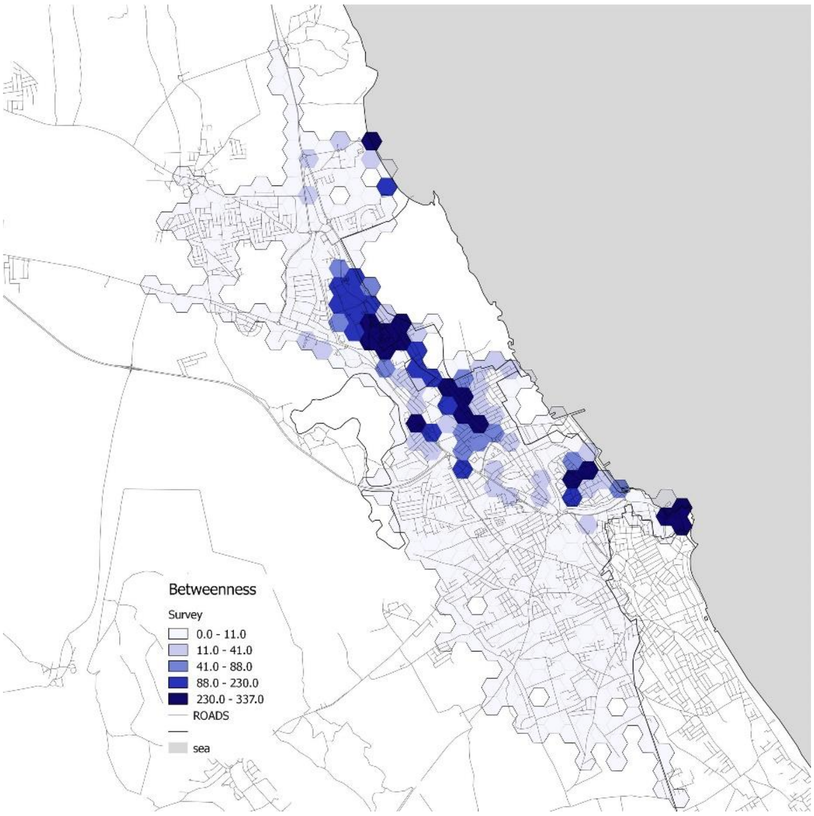


Figure 18. Distribution of places tagged via survey

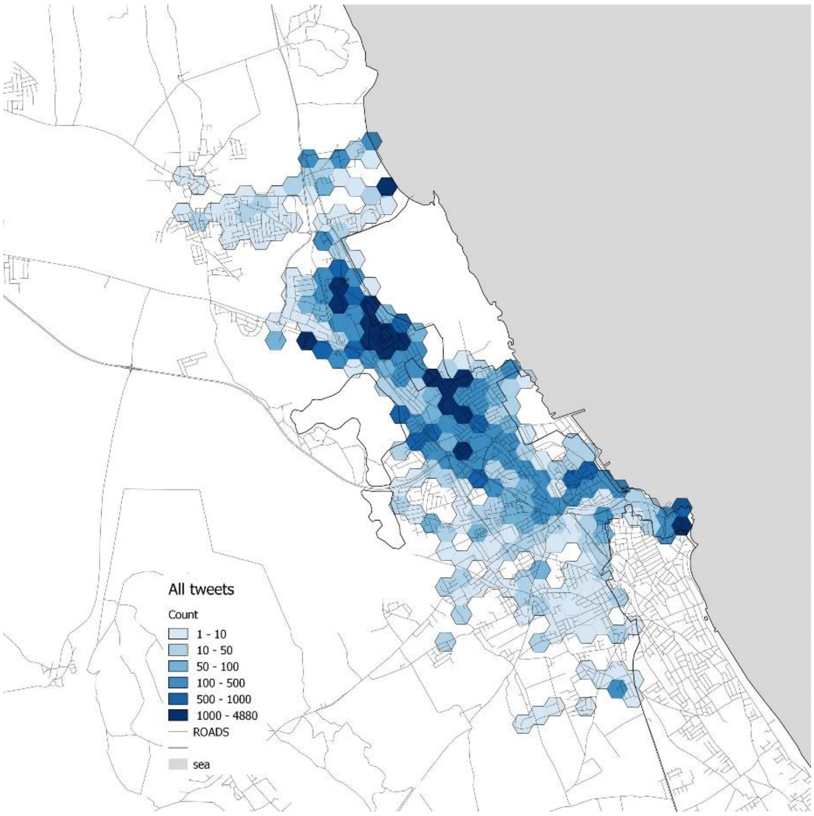


Figure 19. The spatial distribution of geo-tagged Twitter feeds superimposed on the grid

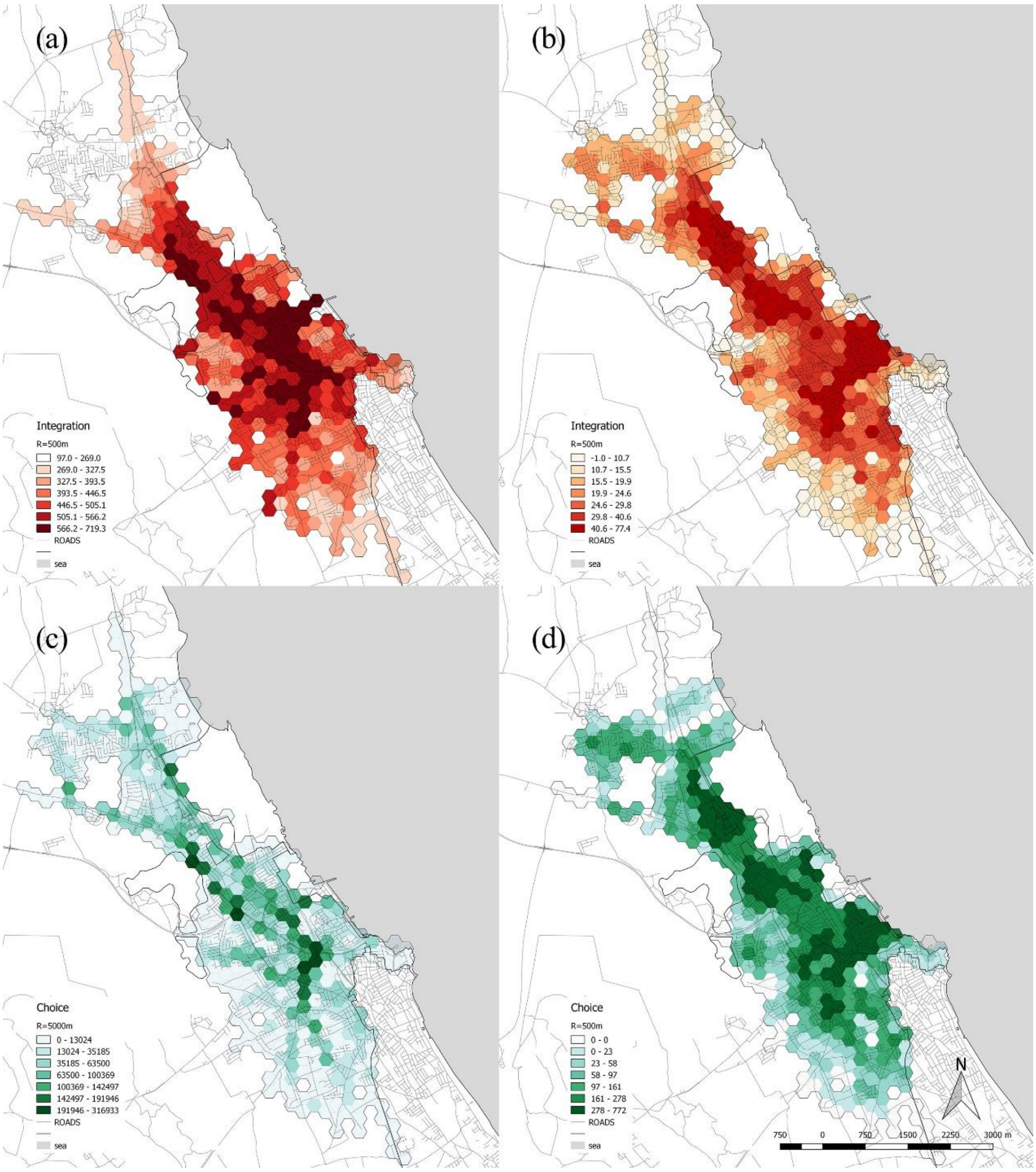


Figure 20. Distribution of space syntax angular measurement with metric proxy superimposed on the hexagonal grid: (a) global integration R=5000m, (b) local integration R=500m, (c) global choice R=5000m, (d) local choice R=500m

5.5 First Objective: Testing the Predictability of Geo-tagged Twitter Data via the Name-Generator Survey[3]

The Pearson correlation coefficient and regression analysis were perfumed exploring the predictability of geo-tagged data in illustrating people's interaction with urban spaces. The results illustrate the strong predictability of DV by the name generator survey (ß = 0.797, R^2 =0.63). The statistical significance strands at p<0.0000 indicating the meaningfulness of the correlation between the two layers of data. It can be strongly suggested that the geo-tagged Twitter feed can potentially render a clear image of the urban points of interaction if proceed properly. Furthermore, the very high predictability of the control groups: check-in tweets (ß = 0.768) and free tweets (ß = 0.784) suggests that both classifications could be used for addressing people's interaction with urban public spaces (Table 6). For instance, Shen and Karimi (2018) use the check-in tweets together with centrality measures in order to address the recent spatio-functional developments of Shanghai.

Table 6. Correlation coefficients between the first layer and second layer: exploring the reliability of geo-tagged Twitter feed

		Survey	All tweets	Check-ins	Free tweets
Survey	Pearson Correlation: ß	1	.797**	.768**	.784**
	p-value (sig.)		.000	.000	.000
All tweets	Pearson Correlation: ß		1	.990**	.945**
	p-value (sig.)			0.000	.000
Check-ins	Pearson Correlation: ß			1	.892**
	p-value (sig.)				.000

**. Correlation is significant at the 0.01 level (2-tailed).

Although the general correlation coefficient suggests that more than 63% of all geo-tagged Twitter feeds can be projected by the tagged spaces in the survey, it could be

[3] It should be mentioned that this study uses the 95% confidence interval (an alpha value of 0.05) as the significance as the minimum threshold.

argued that the geo-tagged data goes deeper into the detail of socio-spatial interaction. This mismatch could be caused by the natural limitations of traditional survey methods in engaging participants, furthermore, the hierarchical nature of memory might affect how people recall spatial elements (see McNamara, Hardy, & Hirtle, 1989). The Twitter data seems to go beyond some of these limitations by maximized the engagement with the spatial grid. Only 99 cells contain data points regarding the name generator survey (25%) compare to 281cells that return geo-tagged tweets (73%). The Twitter data includes a wider variety of spontaneous activities regarding urban space where the name generator survey is mostly bound to land-use, landmarks, and leisure activities.

5.6 Second Objective: Exploring the Predictability of Geo-tagged Twitter Feed Data via Space Syntax Measurements

The second objective stands at the heart of the current study because it is directly addressing the main research question and the two primary discussions in the literature review. However, before exploring the degree of predictability of DV through various levels of IV, two issues regarding the nature of DV must be addressed.

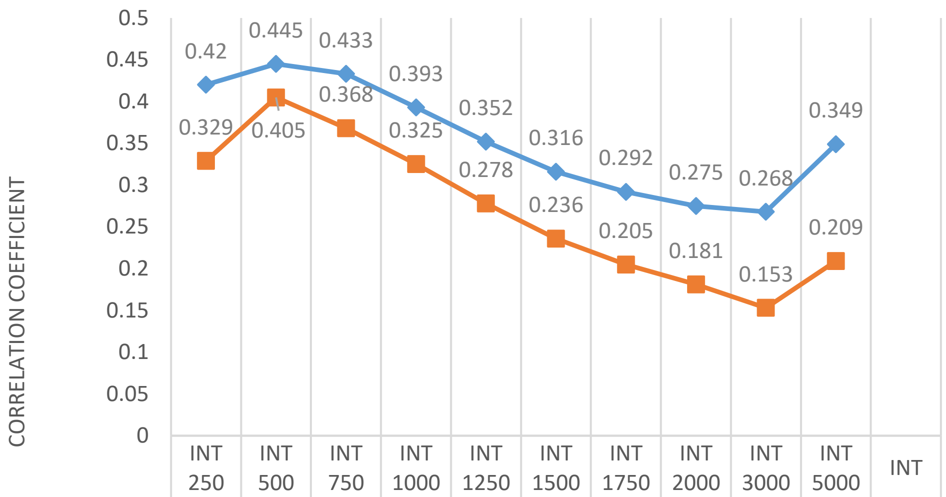
First: the distribution of the volume of spaces in the hexagonal grid is not uniforms (see Table 7). Cells include anywhere between 51m to 1510m of space assigned to them. Accordingly, cells with higher number/volume of spaces could potentially produce more tweets. This was confirmed by conducting a regression analysis that revealed that cells with higher spatial density have a slightly higher number of geo-tagged tweets ($ß = 0.25$ $P<0.000$). accordingly, to address this issue the number of geo-tagged tweets was divided by a unite of segment lengths for each cell (the study uses encounter per 100m of space length in line with Read (1999)).

Second: one of the concerns in addressing geo-tagged Twitter data is that the distribution of data is highly skewed, meaning that there are few cases toward the maximum and the majority of cells close to or equal to the minimum value (Table 7). Although the aggregation of tweets in a hexagonal grid somewhat softens the impact of skewness (compared with Table 5), however, the problem persists in the final dataset. Accordingly, the dependent variable was modified through a Log transform process using the natural Log of tweet-per-unit. A similar technique was used by Hillier et al. (1993) for normalizing pedestrian count data. The transformed DV is represented by DVt, but the original DV is also present on all statistical analysis as a precaution.

Table 7. Descriptive statistics regarding the distribution of DV and cumulative distribution of spaces in the hexagonal grid.

	N	Minimum	Maximum	Mean	Std. Deviation
Twitter	385	0	4880	160.91	547.560
Segment_ Length	385	51.3	1510.0	213.002	282.7380
Sum_ Segment _ Length	385	100	3030	1247.09	610.639
Valid N (listwise)	385				

The regression analysis was performed using geo-tagged Twitter data as the outcome variable (DV & DVt). The analysis was conducted in incremental steps for each proxy limiters of the space syntax measurements (the centrality measures are being used in further sub-chapters for control, and the regression analysis was used similarly). The correlation coefficient between different levels of independent variables representing the accessibility and the main dependent variables represented by Twitter data was conducted. The analysis was done separately for angular integration and angular choice (Figure 21 & Figure 22). The following two figures are representing some of the most critical outcomes of this dissertation.



	INT 250	INT 500	INT 750	INT 1000	INT 1250	INT 1500	INT 1750	INT 2000	INT 3000	INT 5000	INT
DVt	0.42	0.445	0.433	0.393	0.352	0.316	0.292	0.275	0.268	0.349	
Tweet count (raw)	0.329	0.405	0.368	0.325	0.278	0.236	0.205	0.181	0.153	0.209	

Figure 21. Predictability of DV & DVt via Space syntax angular integration in the incrementally increasing radial proxy, all presented correlations are significant at 0.01 level.

The Result shows a statistically significant correlation in various levels of accessibility for all distances (p<0.000). The correlation coefficient and the statistical significance rises with more local proxies of integration measurement. The correlation gradually increases to reach its maximum at the 500m reach of spaces. This result shows that local integration plays a significant role in people’s interaction with the public space of the city through social media. Moreover, the slightly less powerful but significant predictability of DVt by global integration should be taken into account. The global integration could be considered as the vehicular assisted accessibility to some extent, and it is still significant but shows less impact on the interactions with public space because some citizens use a combination of travel method within the city. Baran et al. (2008) show a similar dual correlation between pedestrian movement and both local and global integration. Jiang (2009) indicates local integration is the most significant predictor of human movement patterns. At 500m local accessibility, to-movement which indicates walkable and reachable destinations seems to be the significant factor in shaping socio-spatial interaction. The transformed DV shows improvement in the prediction of the outcome variable over the raw tweet count. This seems to be the same across all the space syntax measures. The increase in global integration should be taken into account for building a multiple regression statistical model. Accordingly, the low internal correlation between local and global measures (ß=.27) indicates that the nature of correlation is different on predicting DVt at global scale compared with local proxies (for all internal correlation see Appendix D).

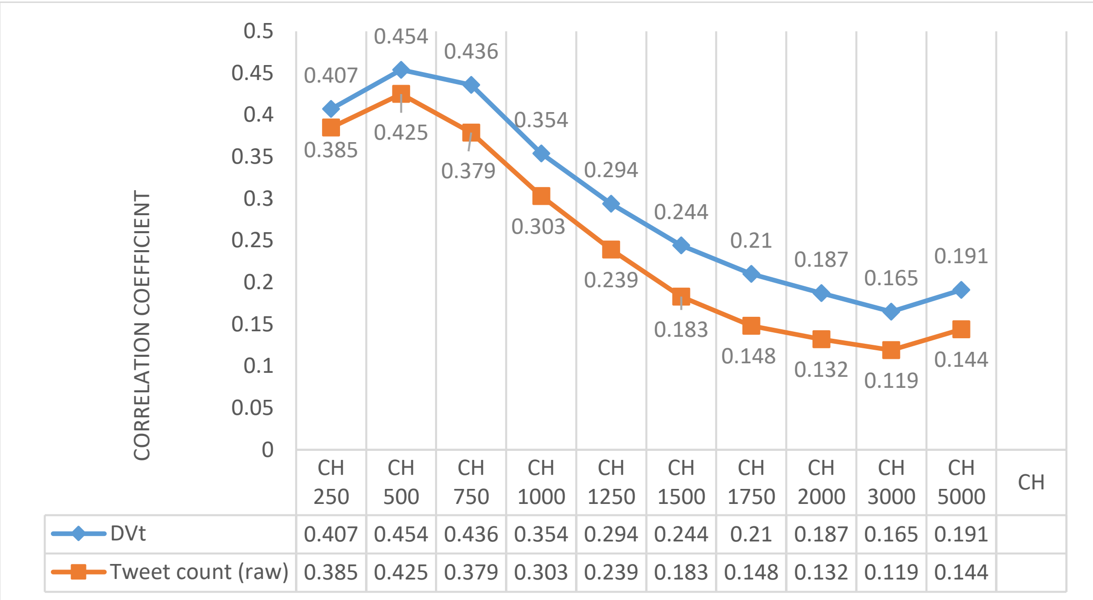


Figure 22. Predictability of DV & DVt via Space syntax angular choice in the incrementally increasing radial proxy, all presented correlations are significant at 0.01 level.

Angular choice shows a similar pattern of correlation reaching maximum significance at R=500m (ß = 0.0454) and slowly drops to a minimum at 3000m. In fact, the local choice seems to be the best predictor of geo-tagged data among all space syntax variables. The result indicates the importance of locality in the in-between space of the city. Here also a similar improvement in the prediction of transformed tweet count (DVt) is visible. Considering both analyses together it can be indicated local accessibility is critical in the formation process of geo-tagged social media data whether the space is used as a passage and/or a destination.

The correlation coefficient of this study is lower than Hillier's measurement for the city of London R^2=0.291 (Hillier et al., 1993), but in line with the meta-analysis by Sharmin and Kamruzzaman (2018) for both integration (between 0.173–0.238), and choice (between 0.391–0.561). However, the number of observations in this methodological approach is much higher due to the extended nature of the data. The traditional methods of observation for space syntax analysis often include counting people at a certain number of gates (Hillier et al., 1993; Turner, 2007; Jiang, 2009); it seems that the selection of said gates can influence the significance of correlation coefficient. The tweet count data used in this research has much fewer pragmatic limitations regarding data collection; it does engage a more substantial number of segments in the statistical analysis, and it is not bound to a specific time (time can be used to filter the data if necessary) or errors of human observation. It should be noted that controlling for DVt through check-in points, and free tweets did not cause any substantial change in the results.

In case of Famagusta, although the correlation is respectable throughout the city (Figure 21 & Figure 22), having a closer look at the data illustrates that the overall correlation is a combination of a variety of spatial entities with their unique characteristics. For instance, the geo-tagged tweet count in the two main arteries of the city shows significantly higher predictability through global integration. Salamis street (Figure 23: a& c) and Mustafa Kemal Blv (Figure 23: b& d) are surrounded by numerous cafes, restaurants, and retail shops; the central segments of these streets score high is global integration and return the highest number of tweets. Throughout the two main streets, the global integration can better predict the rate of tweets Figure 23: a& b). The analysis shows that despite the significance of local integration in larger scale, spaces with the highest tweet rate are most likely to correlate higher with global integration core of the city. According to Hillier (1999b), people choose their paths to either minimize the length of their commute or to maximize the efficiency of it. Hence it could be argued that spaces whit high local and global integration could provide both motives and are the significant points of socio-spatial interaction.

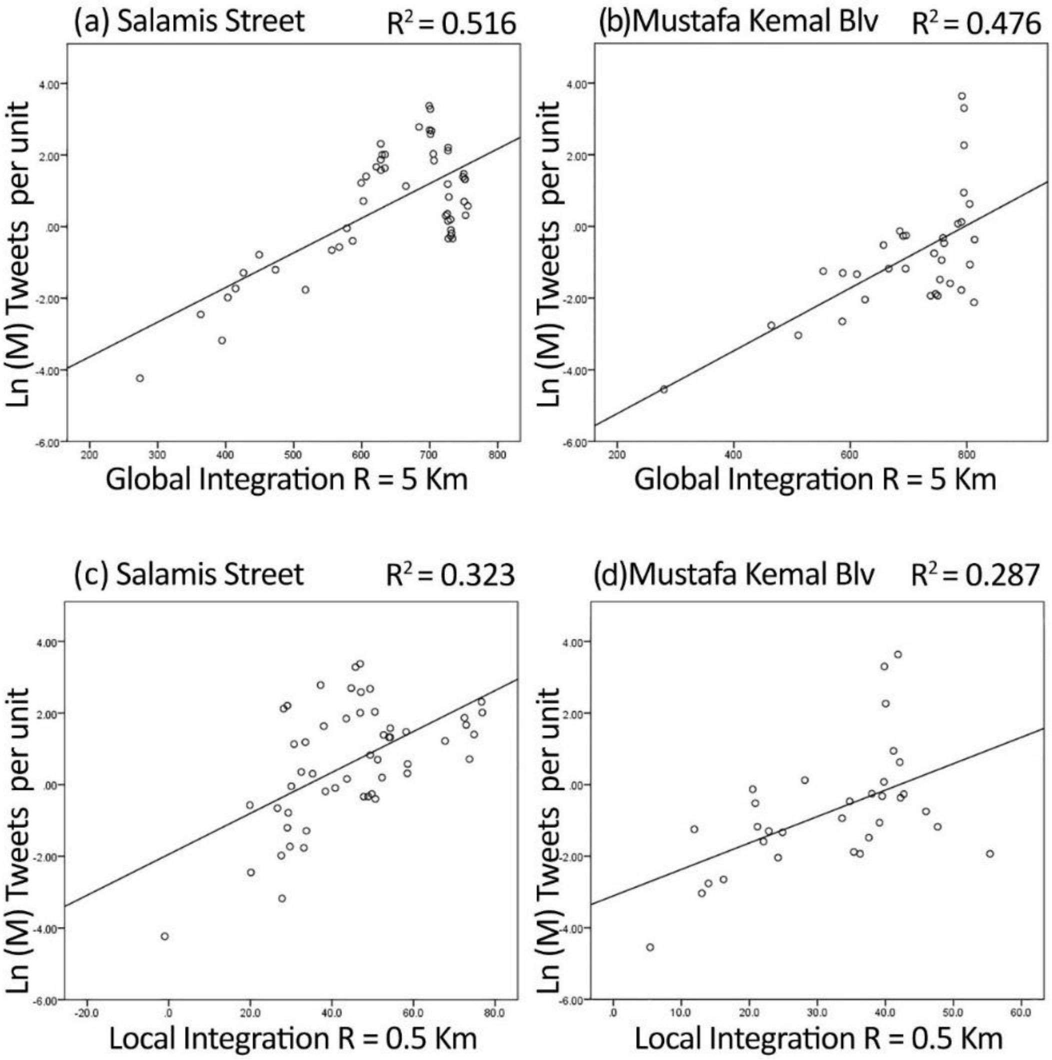


Figure 23. Global Integration through two main arteries of the city: Salamis street and Mustafa Kemal Blv.

5.6.1 Multivariate Predictions of Geo-Tagged Twitter Data

Furthermore, in both groups of IVs, local accessibility is the better predictors of outcome. Furthermore, global through-movements cannot take part in predicting the DVt when compared with spaces syntax integration value. Nevertheless, few observations demonstrate a great level of accessibility on both smaller local proxies (500m) and global scale at 5000m, This is visible through strong internal correlation among to-movement and through-movement measurements (see Appendix E, F, G&H). Accordingly, several multiple regression combinations were tested with control for multicollinearity between IVs.

The effects of internal correlation among IVs were tested by measuring the Variance Inflation Factor (VIF). This value tries to take the internal correlation between independent variables into account. VIF is calculated by the function of the correlation between IVs and is calculated by $1 / (1 - R^2)$, R represents the internal correlation coefficient between the independent variables targeted in the regression analysis. A general rule for addressing the possibility of multicollinearity using VIF is to consider values larger than 10 to have a high degree of multicollinearity, rendering the multiple regression obsolete. The $10 > VIF > 5$ is considered medium, and close to 1 is the lowest chance of multicollinearity (Chatterjee & Hadi, 2015, p. 236). The small VIF of 1.26 between Accessibility at 5000m (global) represented by Integration and local accessibility represented by choice at 500m shows that their prediction of DVt is representing two different types of interaction (Table 8). Accordingly, a multiple regression using the two influential IVs improved the predictability of DVt. The result is consistently controlled with the raw tweet count.

Table 8. The multivariate regression showing the predictability of the outcome using local choice and global integration (the best fit model)

Model	R	R^2	Adjusted R^2	VIF
b	.600[a]	.360	.357	1.26
c	.440[a]	.193	.189	1.27

a. Predictors: (Constant), INT_5000, CH_500, b. Dependent Variable: DVt, c. Dependent Variable: DV

5.7 Third Objective: Exploring the Potential Patterns of Socio-spatial Characteristics of Urban Spaces

The statistical significance of correlation coefficients across all IVs and further analysis of foreground spaces reveals that there are various types of socio-spatial interaction throughout the city. In these two sections, the study tries to explore the different patterns of socio-spatial interaction in the city of Famagusta. Accordingly, the two main predictors: global integration at 5000m and local choice at 500m, and the transformed dependent variable (DVt) were analyzed based on their respected spatial distribution. The distance from the mean value is set to be the determining factor of identifying patterns of interaction. Accordingly, the three variables were classified by using 1 and 2 standard deviations (SD: σ) away from the mean into three categories (Table 9).

Table 9. Exploring patterns of socio-spatial interactions and outliers based on their distance from the mean

The pattern of socio-spatial interaction	Outliers
1 standard deviation from the mean (68%)	2 standard deviations from the mean (95%)
Low: $X \leq \mu - \sigma$	Low: $X \leq \mu - 2\sigma$
Normal: $\mu - \sigma \leq X \leq \mu + \sigma$	Normal: $\mu - 2\sigma \leq X \leq \mu + 2\sigma$
High: $\mu + \sigma \leq X$	High: $\mu + 2\sigma \leq X$

Table 10. The identified types of spaces based on the one standard deviation away from the mean.

#	Cell's score across three variables		Spatial characteristics
Type1: 10 Cells (2.2%)	DVt	$> \mu + \sigma$	City center(s), including cafes, restaurants, and public spaces, where spaces have a high level of connection to the global network and walkable local access from residential areas.
	Local	$> \mu + \sigma$	
	Global	$> \mu + \sigma$	
Type2: 21 Cells (4.7%)	DVt	$> \mu + \sigma$	University campus and historical walled city, very well connected internally, not highly connected to the global network.
	Local	**$> \mu + \sigma$**	
	Global	**Normal**	
Type4: 26 Cells (5.8%)	DVt	$> \mu + \sigma$	Spaces around the main shopping street in the city, high global centrality, highly visible on Twitter, average local accessibility.
	Local	Normal	
	Global	$> \mu + \sigma$	
Type5: 20 Cells (4.4%)	DVt	$> \mu + \sigma$	Student accommodation spaces (inside and outside the campus), despite average accessibility these spaces show a high level of social media activity due to their social profile.
	Local	Normal	
	Global	Normal	
Type6: 7 Cells (1.6%)	DVt	$> \mu + \sigma$	Public beaches of the city are highly reported through Twitter despite deficient centrality measures in both local and global scale.
	Local	Normal	
	Global	$< \mu - \sigma$	
Type7: 13 Cells (2.9%)	DVt	Normal	A neighborhood with low-income families, although it is highly accessible in both local and global scale, shows very limited activity through social media.
	Local	$> \mu + \sigma$	
	Global	$> \mu + \sigma$	
Type8: 12 Cells (2.7%)	DVt	Normal	Residential spaces of the historic walled city score very high in local centrality measures, average global reach, and average tweet rate.
	Local	$> \mu + \sigma$	
	Global	Normal	
Type10: 40 Cells (8.9%)	DVt	Normal	Main traffic artery of the city has high global, average local, and average tweet rate. These spaces are not very well connected to their local surroundings, but carry the vehicular load of the city.
	Local	Normal	
	Global	$> \mu + \sigma$	
Type11: 172 Cells (38.2%)	DVt	Normal	Average across all variables, mostly residential spaces.
	Local	Normal	
	Global	Normal	
Type12: 57 Cells (12.7%)	DVt	Normal	A suburban nucleus, very limited global accessibility, average local accessibility, and tweet count.
	Local	Normal	
	Global	$< \mu - \sigma$	
Type14:	DVt	$< \mu - \sigma$	The main traffic access toward the historic walled city has very limited tweet count but very high local betweenness, and relatively high global access because it connects the two segregated parts of the grid.
	Local	$> \mu + \sigma$	
	Global	Normal	
Type: 17 34 Cells (7.6%)	DVt	$< \mu - \sigma$	Secondary traffic arteries and some spaces at the edge of the map show this combination.
	Local	Normal	
	Global	Normal	
Type:18 37 Cells (8.2%)	DVt	$< \mu - \sigma$	Main traffic lines connecting the city to the capital and other cities.
	Local	Normal	
	Global	$< \mu - \sigma$	

The first section focuses on the distribution of spaces within one standard deviation from the mean. 1 SD is used here to explore the possibilities in socio-spatial patterns of behavior among the main three variables. Next section would undertake to identification process of outliers' typologies by using two standard deviations (95% coefficient interval) that force the majority of the cells into one category leaving only a few extreme outliers (29 cells: 7.5%, marked in Figure 24). Accordingly, out of 27 possible combinations across the three variables, 9 did not exist due to the normal distribution of local choice, accordingly, there were no cases outside -1 SD of local through-movement. From the 18 remaining types, 13 were recognized and marked in the studied area[4]. The typology of these cells and their socio-spatial characteristics can be viewed in Table 10. Furthermore, Figure 24 shows the spatial distribution of these typologies throughout the city of Famagusta. Spaces with high centrality value are often home to vibrant and interactive urban spaces (Hillier, 1999a; Mehaffy, Porta, Rofe, & Salingaros, 2010). Likewise, Types 1, 2, and 4 (Table 10) are spaces that represent the public core of the urban network. The core of micro-economic transactions happens in and through these spaces. These types are containing the bigger portion of the extroverted foreground functions like cafes, food services, shops, etc. Naturally, these spaces can be read clearly via geo-tagged data. Furthermore, the campus is strongly represented in both layers of interactive data (Table 10, Type 2), but it scores average/low in the global accessibility both as a global in-between space and a global destination. The campus scores so highly in the local choice that pushes it into the outlier category (Table 10, Type 2). The global integration illustrates that the campus does not work as a global scale destination core for the city, but as one of

[4] The sequential naming of types is according to all possible types, the ones that were not observed in this case were left empty, this precaution was made in-case if these types were later observed in other cases. The identification number of typologies is consistent across all figures.

the main local nuclei of the urban spatial grid, the campus is highly reported through social media because of its' demographic profile, and because people use it intentionally. The campus is not a through-movement space at a larger scale, consequently, it provides a calm, and peaceful environment away from city traffic for its educational purposes. All campus spaces are accessible at a local walking distance; Mehaffy et al. (2010) also express similar findings for pedestrian accessibility of spaces at 400m. The historic walled city of Famagusta shows similar patterns of socio-spatial behavior, in-fact, both spaces are so highly locally accessible that they could be identified as outliers (local choice > $\mu + 2\sigma$, marked in Figure 24, Figure 25: type 8).

Type 5 cells contain spaces within the normal range of accessibility both locally and globally and are highly visible through social media, these spaces include four types: student accommodations, southern beaches, the general hospital, and clubs in connection with urban grid. These functions are not central functions and are naturally slightly segregated, but their nature is more interactive than their potential network accessibility. The student accommodations[5] for instant are moderately accessible both locally and globally. They show some characteristics similar to regular residential blocks (Type 10), except that they are comparatively highly reported on Twitter matching the tendency of younger people to be more active on social media.

[5] There are few other spaces with similar characteristics throughout the city. Such spaces are mainly attractive single functions like well-known restaurants, hotels, and the general hospital to the north of the campus.

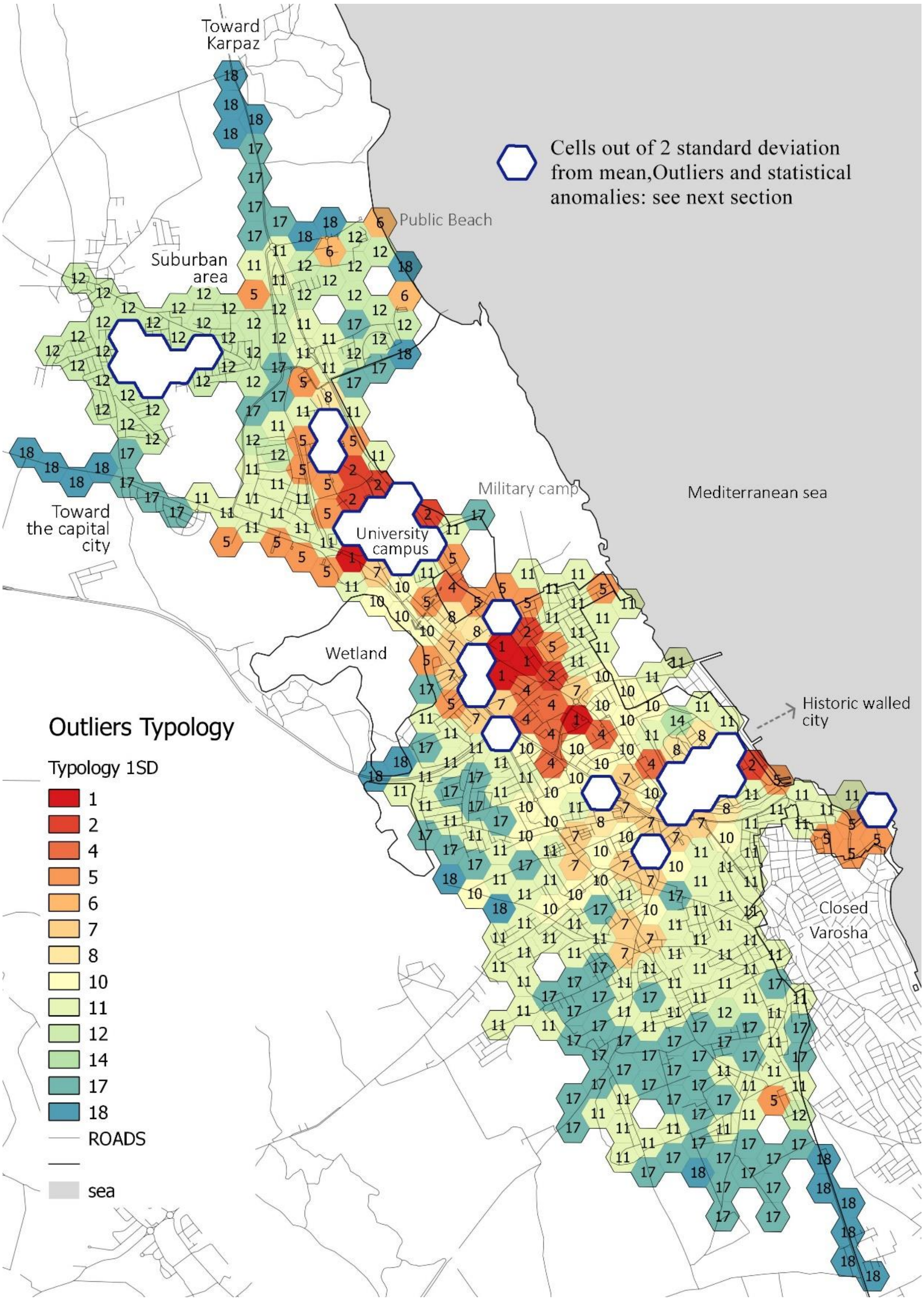


Figure 24. Visual representation of the spatial distribution of socio-spatial interaction typologies.

Type 6 represents the main public beaches in the northern side of Famagusta; these spaces score very low in both local and global accessibility, nevertheless, they are well reported through social media. Type 6 is a testament that functional attraction can affect the way people move and interact with the urban network. To the contrary, Type 7 shows very limited activity through social media though it has a similar integration score as Type 5. Type 7 at the southern part represent a low-income residential area with significant local and global accessibility but very limited representation through the go-tagged data.

Type 7 and 5 show similar characteristics in terms of space syntax measurements, but the demographic profile of the neighborhood seems to be the defining factor in terms of social media activities. These contextual differences within the network structure of the city are important in addressing the new types of data. Understanding the context is a critical point of research on this topic, and the specific profile of the case study should be considered (Graham & Dutton, 2014). Type 7 also consists of residential spaces around the central local/global nuclei of the city. These areas are often one-step behind the local/global foreground of the city and are usually target for increasing density due to their natural interaction with the cores of the city.

Type 11 cells include the most frequent spaces of the city; these spaces fall into the normal distribution across all three variables Type 11 is where the majority of low-rise intra-urban residential units are located. Both types show medium activities through social media. Type 10 is similar to 11, but it is slightly more globally accessible. Main inner-city traffic arteries are passing through these spaces, hence, giving it a slightly higher global integration score. Type 10 is low in tweet rate due to the lack of interactive functions in its close vicinity. Type 10 should be considered in planning and decision making because it could potentially become more like type 1&2. This type needs more local connections and supporting land-use development in order to become a more active hub of socio-spatial interaction.

Type 12 represents the suburban areas, normal/low local accessibility, and normal interactions through Twitter feeds, and very low global integration with the rest of the grid. Type 14 includes only one cell, interestingly; it embodies the main traffic access toward the historic core of the city. This cell represents a weak connection between two segregated sections of the city. Type 17 includes the area within the normal range of local/global accessibility but little or zero geo-tagged data, this type includes secondary traffic arteries and segments close to the edge of the city. Type 18 cells are the outgoing highways of the city, naturally low in accessibility and show almost no social-media activity.

5.8 Outliers, Having a Closer Look

Further investigation of the data shows several outliers in the dataset. Outliers could potentially influence the significance of statistical analysis, but this study tries to withstand the process of outlier cleaning. The outliers might reveal critical information about the socio-spatial patterns of correlation in the data and significant qualities of spaces (Hawkins, 1980). The outliers were detected using Euclidian distance of 2 standard deviations (see Table 9) or 95% confidence interval (Stevens, 2012). This approach pushes 92.5% of all cells across all three variables into the normal distribution. Twenty-nine cells were recognized as outliers in at least one of the three primary variables (Table 11). It is critical to investigate the outliers as they often indicate peculiar features of the network. Unlike the vibrant classification under 69% confidence interval, the outliers easily fit into 4 types (Table 11, Figure 25). No spaces with a multidimensional abnormal observation were detected in the case of Famagusta. Although such spaces might exist in larger cities, the future investigation is required. Among the three types of outliers in case of Famagusta, type 5 indicate spaces with an extremely high number of geo-tagged tweets. These spaces show normal/low global to-movement, and normal local through-movement, but are home to attractive functions. There are 2 cells showing these properties, one is located within the rare reachable seafront spaces close to the southern section of the city (Figure 26: a). The segregation between the urban spatial grid and the seafront shapes the character of these spaces (Figure 25 & Table 11). The second cell is located in the middle of the urban spatial network, it is home to numerous student cafes, restaurants, and bars, naturally, an extremely high number of geo-tagged tweets are associated with this cell (Figure 26: b). Hence, this part of the network can be considered an outlier as it shows an overwhelming quantity of activities, moreover, in the planning stages, it might be argued that some of these functions could be redistributed throughout the grid.

Table 11. The typology of outliers outside the 2 standard deviation away from the mean

#	Cell's score across three variables		Spatial characteristics
11: 421 Cells (92.5%)	DV_t	Normal	Normal across 3 variables.
	Local	Normal	
	Global	Normal	
Outlier 5: 10 Cells (2.5%)	DV_t	$> \mu + 2\sigma$	Spaces with extremely high visibility through Twitter despite their normal accessibility measures. Includes the public beach at the south section of the city and an area compacted with restaurant, cafes, and bars in the middle of the city.
	Local	Normal	
	Global	Normal	
Outlier 8: 13 Cells (3.4%)	DV_t	Normal	Historic walled city and some university campus, despite scoring very high on local accessibility; they show normal within the normal range.
	Local	$> \mu + 2\sigma$	
	Global	Normal	
Outlier 10: 3 Cells (0.7%)	DV_t	Normal	Traffic access with extremely high global access, all three are close to the topological joint connecting different parts of the grid together.
	Local	Normal	
	Global	$< \mu + 2\sigma$	
Outlier 14: 3 Cells (0.7%)	DV_t	Normal	The opposite of type 10, the central spaces of the suburban area in Tuzla, these spaces are the lowest in global accessibility but are normal through local/social-media activities.
	Local	Normal	
	Global	$>\mu + 2\sigma$	

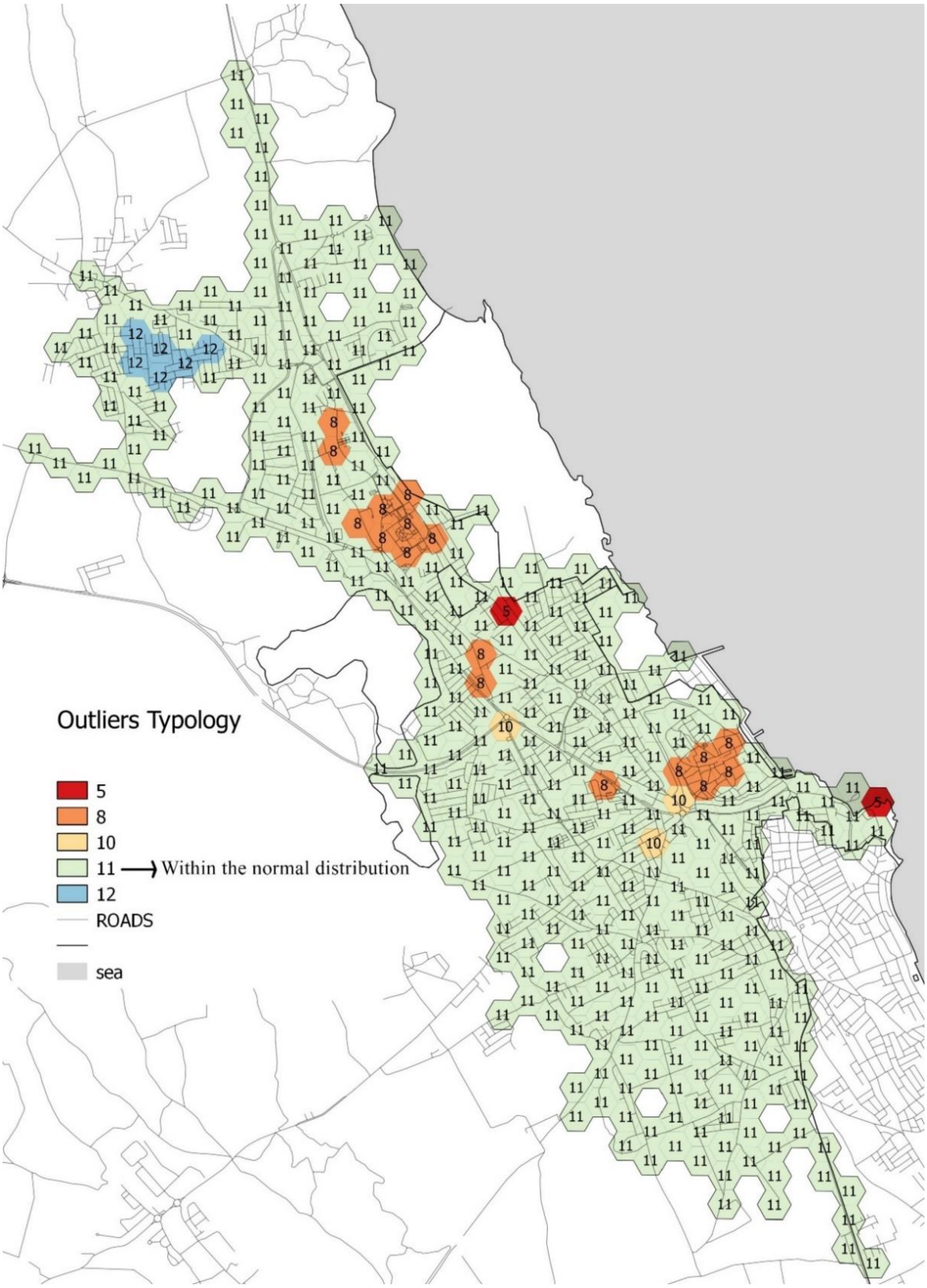


Figure 25. the distribution of outliers identified through filtering the data using the 2 standard deviation threshold

Type 8 includes two families of spaces in this case, the EMU campus, and the student dormitories inside it (Figure 26: c& d), and the historic walled city of Famagusta

(Figure 26: e). Both spaces show strong internal local accessibility, but they are not highly integrated with the urban grid at a global scale. The walled city is poorly connected to the rest of the city; there are only three lines of communication between the two grids. Similarly, the university is a closed system that interacts with the urban grid at a few limited points. The further effects of the campus space and walled city will be elaborated in detail in the following discussion sub-heading.

Type 10 outliers are the joint between different parts of the network, roundabouts, and spaces with extremely high global integration that are normal across other variables (Figure 26: f). These spaces are also potential candidates for land-use development and local connection. Type 14 is similar to what was identified within 1SD from mean, accordingly, this type is the center of a suburban neighborhood with extremely low accessibility to and from the urban grid at a global scale, these spaces show low/zero geo-tagged data despite their medium accessibility at the local level (Figure 26: g).

Figure 26. Examples of the outliers, type 5: palm beach (a), center of Salamis street (b), type 8: EMU campus (c), student dormitories (d), the walled city (e), type 10: major traffic junction (f), type 12: a suburban neighborhood (g)

5.9 Testing, Controlling and Repeating the Analyses

Using big data for urban research and social sciences is an emerging field of study. accordingly, certain precautions should be made to ensure the validity of the outcome. This study has tried to address this issue through data collection and data analysis. The data collection procedure illustrates the step by step process of data collection and data cleaning. The classification of geo-tagged Twitter data is an example of control measures that were embedded in the analysis. Here, the study tries to control, test, and replicate the study in three sections accordingly:

1. Controlling for the IVs by repeating the analysis via Euclidian metric accessibility via a primal graph which is clearer in defining distance proxies.
2. Testing the data aggregation and overlaying method (hexagonal grid) by proposing a data count at individual segment level.
3. Repeating the study in the city of Girne (Kyrenia) to explore whether the identified correlation coefficients were caused by the circumstances of the case (socio-spatial characteristics, and borders of the city of Famagusta).

5.9.1 Controlling for Metric Measurements of Accessibility

Additional to space syntax measurements, the study uses metric street centrality analysis as control variables in order to provide a point of reference for a pure metric reading of urban space. The same graph was used in the calculation of street centrality to minimize the variance between the control IVs and the main IVs. The only difference resides in using the intersection as the node for the spatial grid. Closeness Centrality: C_C, and Betweenness Centrality: C_B, were produced with similar metric proxy intervals (Figure 27). The data was superimposed with the same hexagonal grid system (Figure 28).

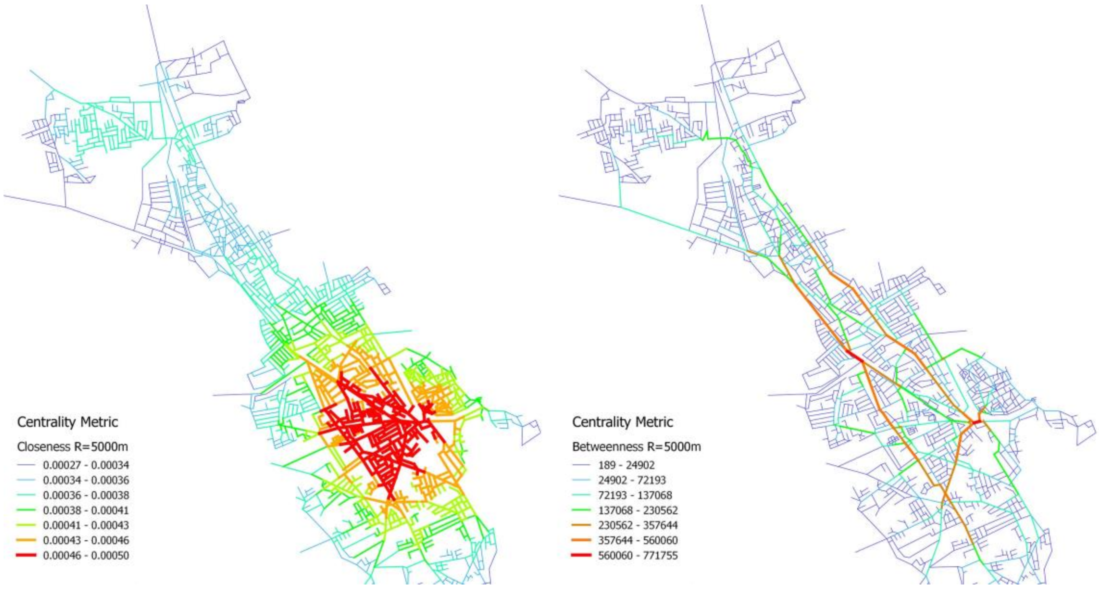


Figure 27. Metric Street centrality measures, (a) global closeness at R=5000m, (b) local closeness at R=500m.

Controlling for the physical metric accessibility via Euclidian Metric centrality shows rather a similar outcome especially considering betweenness centrality. The CB shows statistical significance in predicting the outcome variable (DVt) across the spectrum of metric proxy limiters. The correlation coefficient reaches its maximum at CB R=500 m (Figure 30). CC predicts DVt a little differently from other IVs, it shows a stronger correlation at middle distances (R=1500m) and reaches its maximum at the global level. Closeness centrality middle distances indicate that being close to the geographical center of the city could improve the possibility of socio-spatial interactions (Figure 29). Furthermore, constructing the socio-spatial outliers show similar outcomes when compared to angular measurements of space syntax.

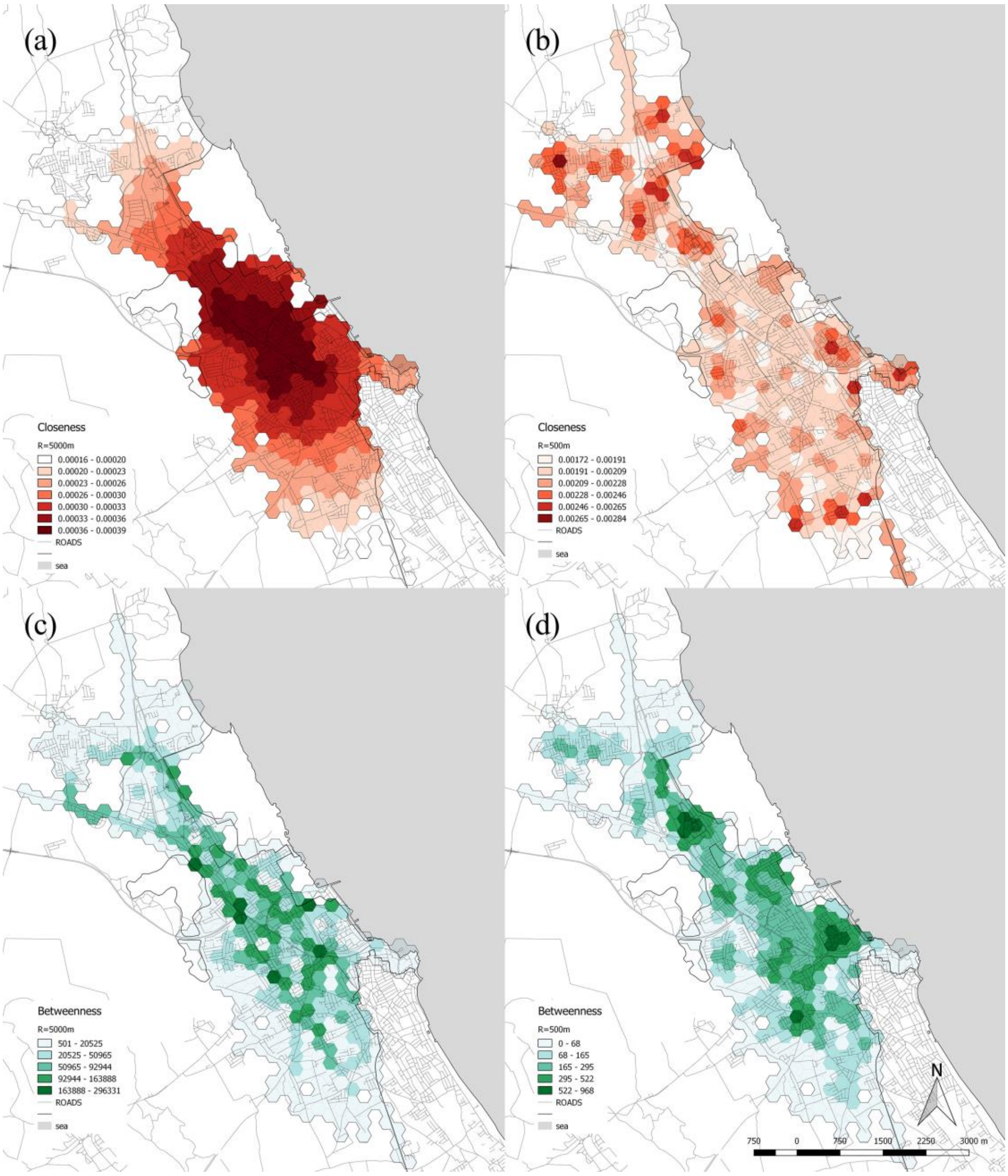


Figure 28. Distribution of metric street centrality measurement with metric proxy superimposed on hexagonal grid: (a) CC R=5000m, (b) CC R=500m, (c) CB R=5000m, (d) CB R=500m

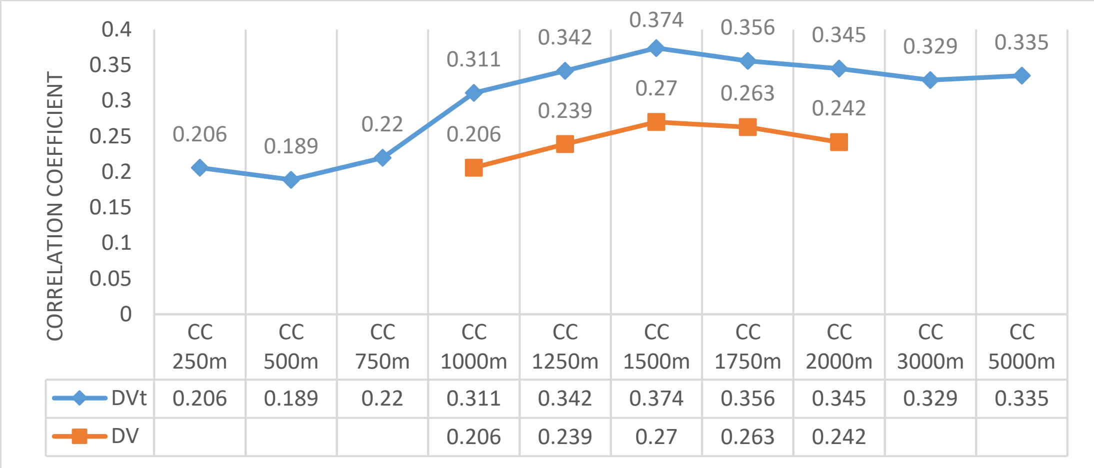


Figure 29. Predictability of DV & DVt via metric closeness centrality in incrementally increasing network proxy, all presented correlations are significant at 0.01 level.

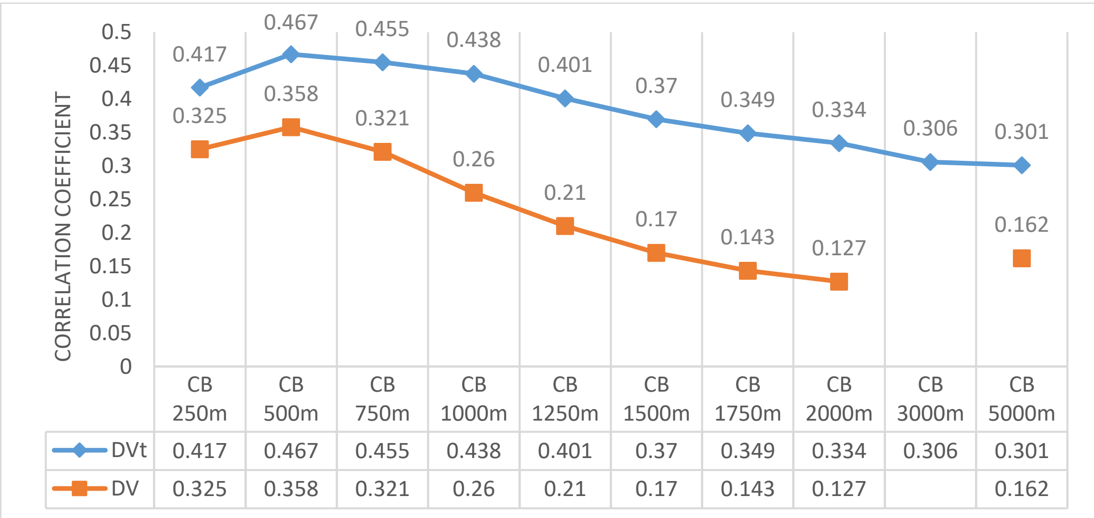


Figure 30. Predictability of DV & DVt via metric betweenness centrality in incrementally increasing network proxy, all presented correlations are significant at 0.01 level.

5.9.2 Testing the Reliability of Grid System through a Segment Base Overlay System

The hexagonal grid used in this technique helps the research to combine different methods and different data sets together, but as a part of scientific research method, the study aimed to repeat the analysis in a controlled manner from another way of approach in order to check the reliability of the data overlaying method. One of the points that this research is trying to make is to test the consistency of big-data and if it can be used for other purposes. Therefore, a segment base data entry was constructed in order to explore the correlation between the geo-tagged Twitter data points and special context of the city, each segment was given a separated entry. The margin of error in location accuracy on geo-tagged data was set to be maximum 30 meters as measured by Zandbergen and Barbeau (2011), therefore every tweet inside a 30 meters diameter from the center of the path was recorded as the number of Twitter feed count of that segment (Figure 31).

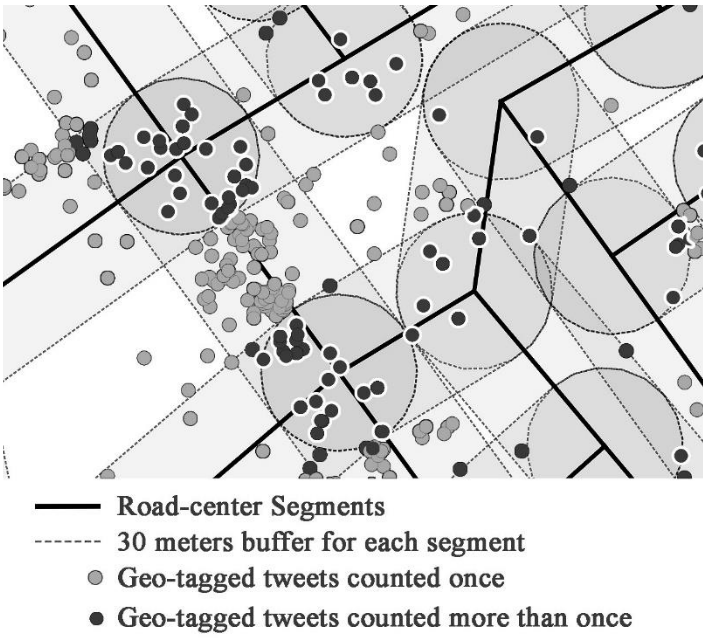


Figure 31. Counting Twitter data entry for each segment within a 30 meters diameter.

Accordingly, 1733 axis with significant data point were identified and the same Pearson analysis was conducted. The result shows similar findings with the hexagonal grid method. The general correlation coefficient increases with the local accessibility, and it reaches its maximum at 500 meters of distance (Table 12). The result repeats when checking for the control DV&DVt. Furthermore, similar patterns of outliers can be observed at the street level count. Both overlaying methods identify the local measurements as the most significant predictors of geo-tagged data. Similarly, public beaches, the city-center, walled city, traffic arteries, some university spaces, and the central axis of a low-income residential neighborhood (Piyale Paşa) are being recognized as the outliers (Figure 32). It could be argued that the hexagonal grid system is a reliable technique for conduction research on socio-spatial data, but it should be used with the consideration of scale. The aggregation of spaces in the grid method might improve the overall statistical correlations. Nevertheless, a space base data entry might be more useful when looking at individual spaces and their properties.

Table 12. Predictability of geo-tagged data through integration at street level.

Famagusta				IV: Angular integration with Radius limits									
				R=5000m	**R=3000m**	**R=2000m**	**R=1750m**	**R=1500m**	**R=1250m**	**R=1000m**	**R=750m**	**R=500m**	**R=250m**
DV: Natural logarithm of geo-tagged Twitter feeds per unit (meters)	Segments: N=1733	All tweets	R	.167**	.083**	.096**	.117**	.157**	.219**	.287**	.352**	.385**	.372**
			R2	.027	.006	.009	.013	.024	.047	.082	.123	.148	.138
			Sig.	.000	.001	.000	.000	.000	.000	.000	.000	.000	.000
		Check-in tweets	R	.142**	.069**	.081**	.103**	.144**	.210**	.281**	.348**	.383**	.363**
			R2	.020	.004	.006	.010	.020	.044	.078	.121	.146	.131
			Sig.	.000	.010	.002	.000	.000	.000	.000	.000	.000	.000
		Free tweets	R	.123**	.037	.058*	.083**	.124**	.191**	.265**	.342**	.390**	.392**
			R2	.015	.001	.003	.006	.015	.036	.070	.116	.152	.153
			Sig.	.000	.168	.031	.002	.000	.000	.000	.000	.000	.000

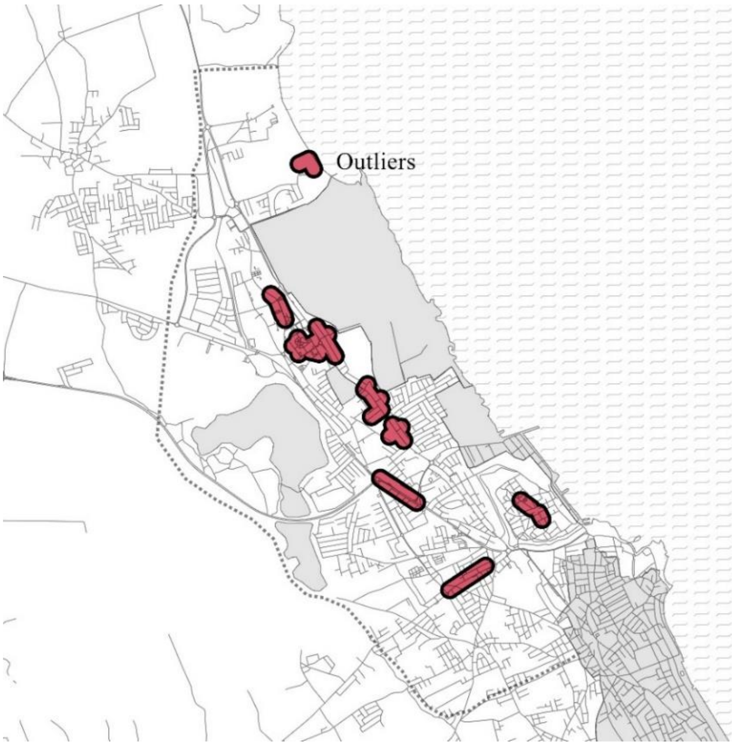


Figure 32. The location of outliers in segment level data entry

5.9.3 Re-checking the Methodology in the City of Girne (Kyrenia)

The study has tried to explore the reliability of the analysis by controlling for various data inputs and overlaying technique, but there is always the possibility of the data being influenced by the special circumstances of the case. This is at most importance especially because Famagusta is a peculiar city with unnatural borders, a university and no access to the waterfront. Accordingly, in this section, the study has been replicated in the city of Girne.

Girne: Also known as Kyrenia is the most important seaport and a coastal city in the northern coast of Cyprus. The city has a public and vital seafront, mainly the historic harbor which is one of the main destinations for pedestrians and micro-economic activities. Unlike Famagusta, Girne does not contain major inaccessible sections within the city. The city was selected to control for restrictions imposed on the study by the special characteristics of Famagusta which was the starting point of the study.

Due to the endless continuity of suburban development around the city a limitation was defined for the study (Figure 33). Accordingly, geo-tagged Twitter data and space syntax were collected for the city of Girne. Table 13 shows the systematic collection of Geo-tagged tweets for the city of Girne. Figure 33 shows the heat map of the distribution of the dependent variable throughout the city.

Table 13. The process of collecting and filtering tweets

	Twitter Handles			Tweets			
	(1) Initial Twitter handles	(2) With geo-tagged data intact	(3) Final Twitter handles	(4) All collected tweets	(7) All Geo-tagged & within the Boundary	Check-ins in relation with locations on the sidewalk	Free tweets
GIRNE	6711	891	762	1132604	27152	16125	11027

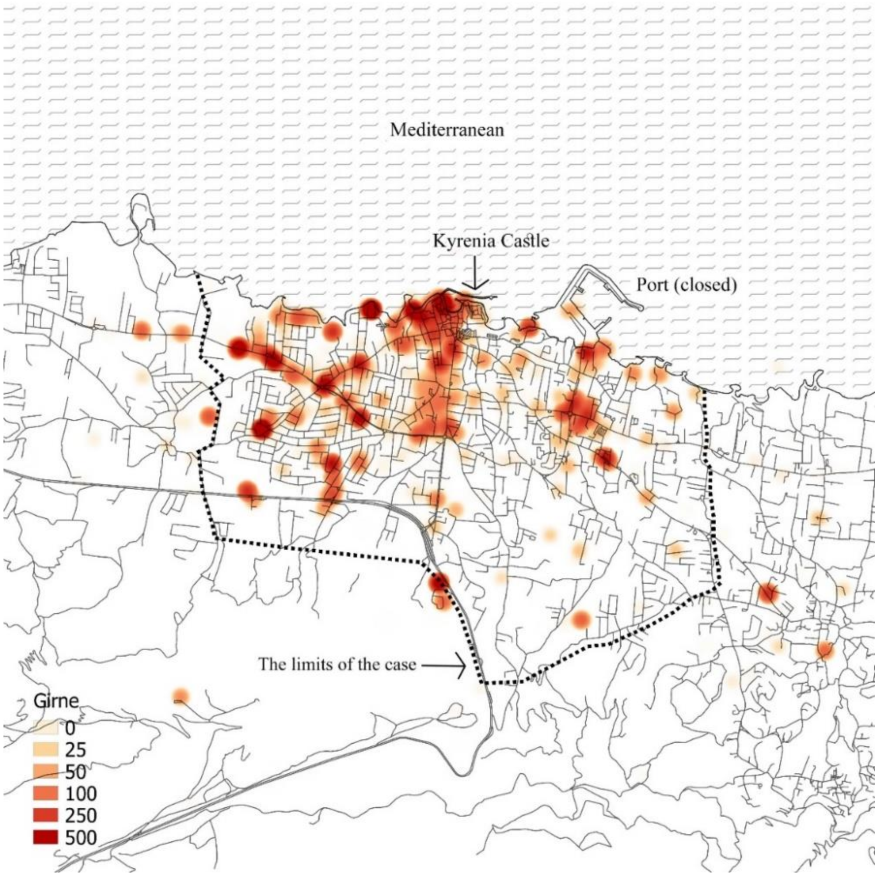


Figure 33. The heat-map of geo-tagged tweets throughout the city of Girne

The data was processed using the same hexagonal grid system (Figure 35, Figure 36 & Figure 37). In contrast to Famagusta Girne shows a strong core which persists through both local and global integration. The integration core is located in close relation with the historic harbor which is a destination for leisure activities and pedestrian movement. The mean length of segments is smaller and more frequent despite having a smaller population (Table 14). The city is more compact and functions are located much closer to each other. Due to its location, the city has not been affected by the division of the Island unlike the other two major cities (Famagusta and Nicosia); keeping a natural and organic development pattern which can be clearly observed when comparing the mean integration value between the two cities (Table 14 & Figure 34).

Table 14. The descriptive statistics of angular integration in local/global level in the city of Girne (Famagusta is repeated for comparison).

#	Cases	Segments	Segment Length		Local Integration 500m		Global Integration 5000m	
			Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
1	Famagusta	2888	92.8	81.7	33.8	19.1	449.3	158.7
2	Girne	4213	56.3	39.3	55.1	32.4	548.1	129.8

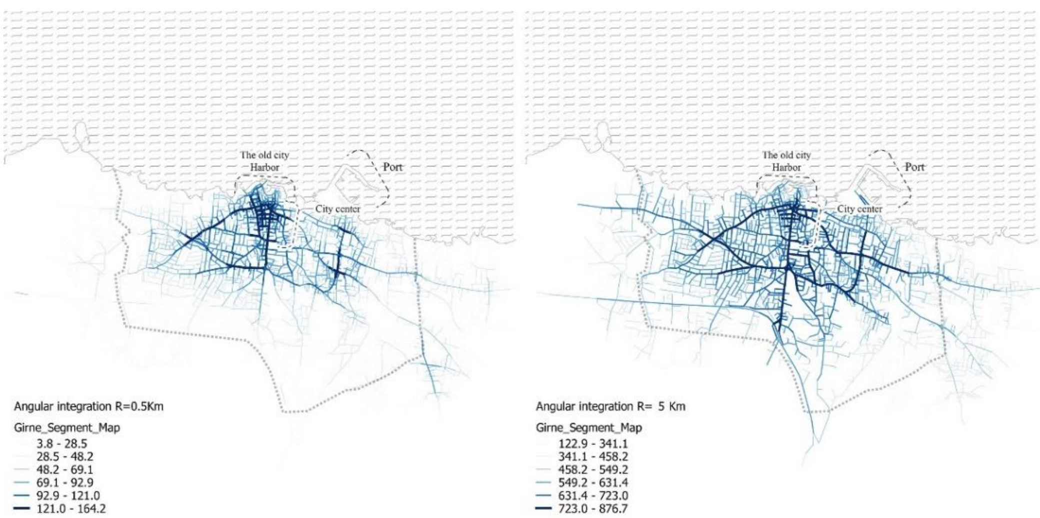


Figure 34. The angular integration or Girne through segment map, right: local at R=500m, left: global at R=5000m

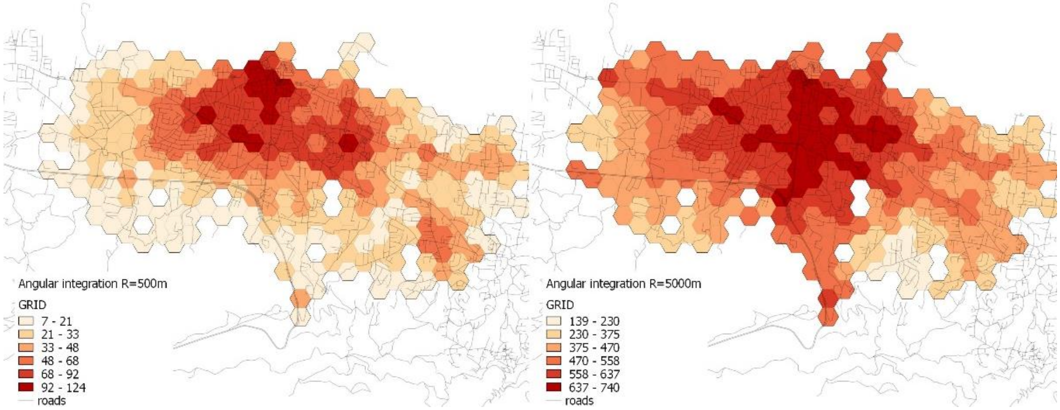


Figure 35. Angular integration map of Girne represented on the 250m hexagonal grid.

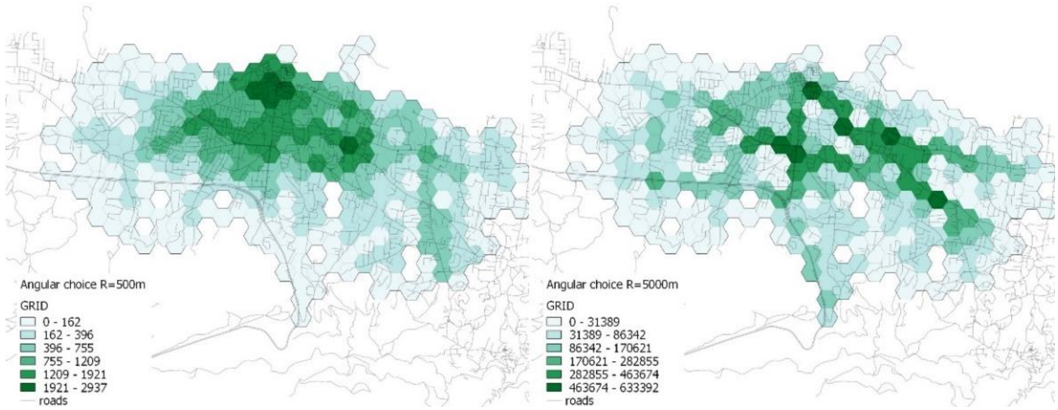


Figure 36. Angular choice map of Girne represented on the 250m hexagonal grid.

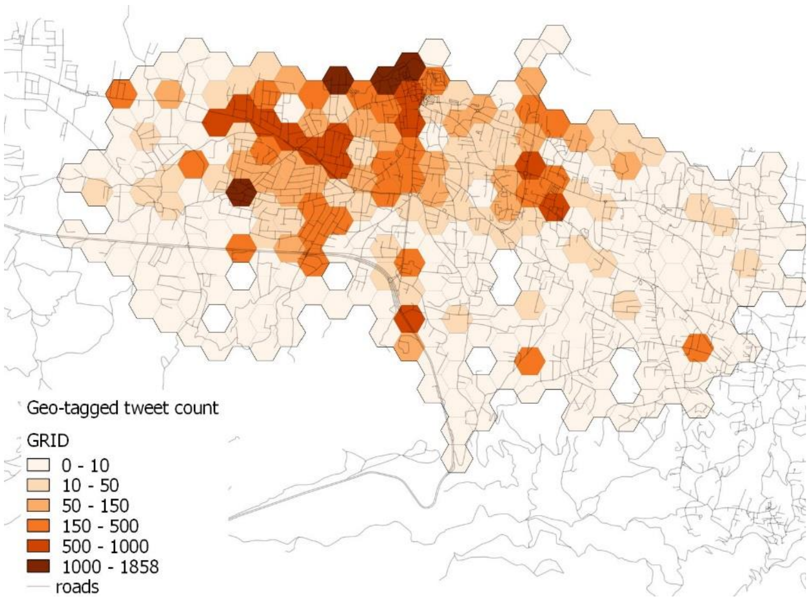


Figure 37. Distribution of geo-tagged tweets throughout the city of Girne represented on the hexagonal grid

In general, Girne shows a similar incline in correlation coefficient in more local proxies. The predictability of Twitter data is much stronger at the local level for both integration and choice measures. However, the incline is much shallower and the predictability of geo-tagged data remains relatively stable and high throughout all levels of accessibility (Table 15 & Table 16). The internal correlation between space syntax value is much higher in Girne when compared with Famagusta. The city is highly intelligible due to this phenomenon. The city has a uniform shape and a strong core with both high local and global values. The repetition of the method confirms that the local accessible destination could be the best proctor of socio-spatial interaction with urban space.

Table 15. The predictability of geo-tagged Twitter data via different levels of angular integration

DV: Natural logarithm of geo-tagged Twitter feeds per unit (meters)	N=277		IV: Angular integration with Radius limits									
			R= 5000 m	**R= 3000 m**	**R= 2000 m**	**R= 1750 m**	**R= 1500 m**	**R= 1250 m**	**R= 1000 m**	**R= 750 m**	**R= 500 m**	**R= 250 m**
	All tweets	R	.465**	.524**	.567**	.570**	.574**	.583**	.591**	.598**	.614**	.508**
		Sig	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Check-in	R	.474**	.518**	.544**	.543**	.545**	.553**	.560**	.568**	.587**	.506**
		Sig	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Free	R	.384**	.436**	.476**	.481**	.486**	.501**	.518**	.538**	.573**	.593**
		Sig	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 16. The predictability of geo-tagged Twitter data via different levels of angular choice

DV: Natural logarithm of geo-tagged Twitter feeds per unit (meters)	N=277		IV: Angular choice with Radius limits									
			R= 5000 m	**R= 3000 m**	**R= 2000 m**	**R= 1750 m**	**R= 1500 m**	**R= 1250 m**	**R= 1000 m**	**R= 750 m**	**R= 500 m**	**R= 250 m**
	All tweets	R	.277**	.352**	.427**	.447**	.471**	.496**	.518**	.549**	.596**	.601**
		Sig	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Check-in	R	.295**	.350**	.418**	.436**	.458**	.481**	.499**	.527**	.574**	.581**
		Sig	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Free	R	.197*	.258**	.337**	.362**	.392**	.428**	.467**	.520**	.585**	.604**
		Sig	.012	.001	.000	.000	.000	.000	.000	.000	.000	.000

In terms of socio-spatial pattern, all identified patterns within 1 standard deviation also exist in Girne with 93% normal cases and 7% outliers (Figure 38). When compared with Famagusta, the high local integration throughout the network shows more spaces with potential for increasing socio-spatial interactions. A new type of outlier is observed in Girne (Figure 39: Type 7) which includes a major traffic junction with extremely high global and local accessibility but very limited tweet count, this outlier further shows the general correlations among variables might not be sufficient enough for explain how the urban network works. Type 12 shows a neighborhood with extremely low global integration while maintaining a normal local integration and geo-tagged data (Figure 39). Accordingly, it should be noted that although the general correlation is promising, each case must be considered with thorough contextual consideration.

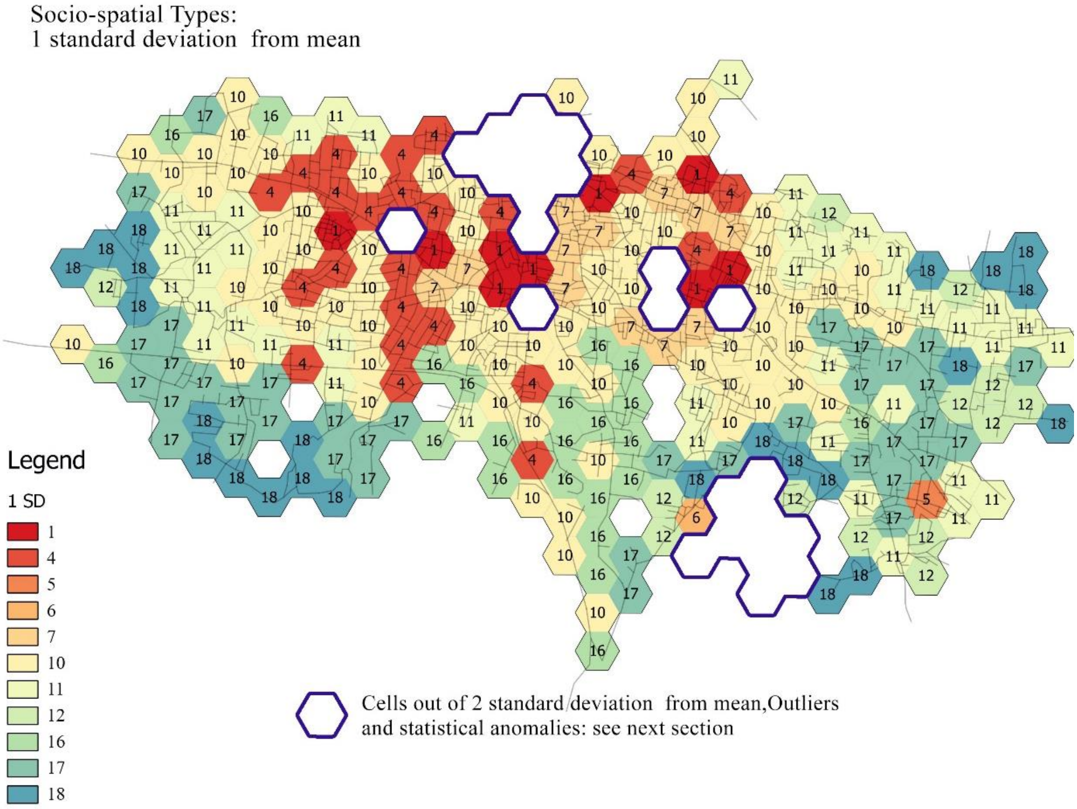


Figure 38. Distribution of socio-spatial patterns considering 2 standard deviations away from the mean in the city of Girne

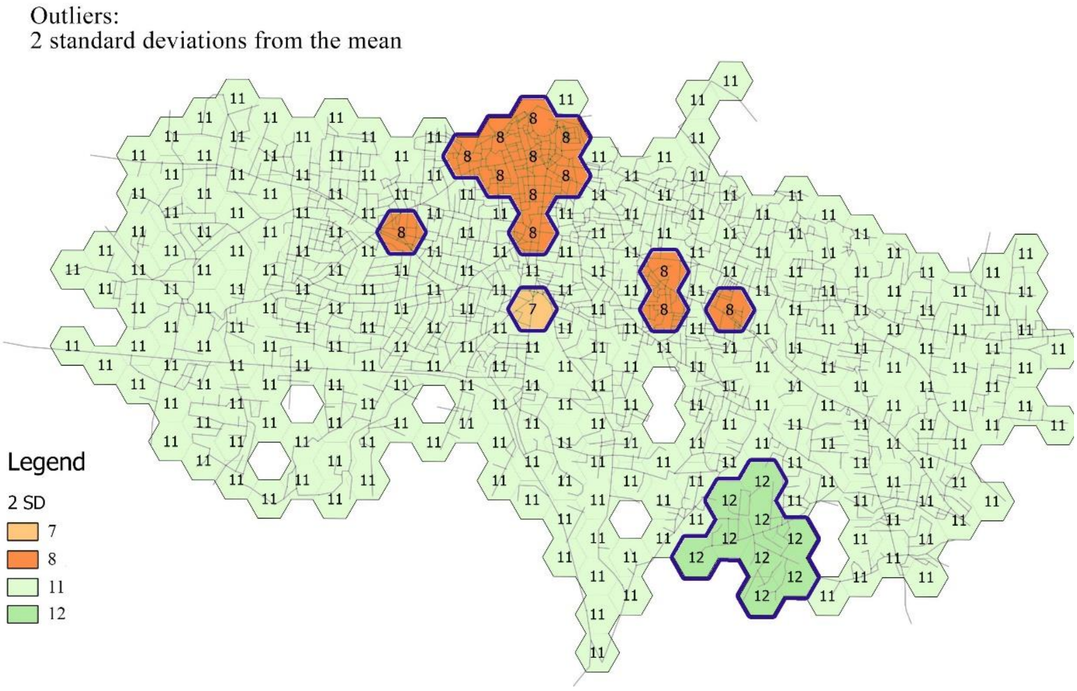


Figure 39. Distribution of outlier considering 2 standard deviations away from mean in the city of Girne

The foreground spaces of the city were also checked and compared with Famagusta. In Girne, Ecevit Street shows a similar behavior (Figure 40: a&c), but Ziya Rızkı Street has a different nature (Figure 40: b&d). Ziya Rızkı is mainly a pedestrian path with only one line for cars which is mainly used to service local businesses. Ziya Rızkı Street is one of the popular pastime destinations of the city and it is located at the heart of the historic core of the city in which high local integration is an inherent characteristic of the space. Accordingly, it shows a much stronger correlation with local measurements. The higher correlation in the main streets can be supported by the idea of "dual structure" presented by Hillier, accordingly the foreground activities of the city (micro-economy) are following the near-universal rule of accessibility, but the background residential activities are always affected by the contextual features of the city (Hillier, 2012).

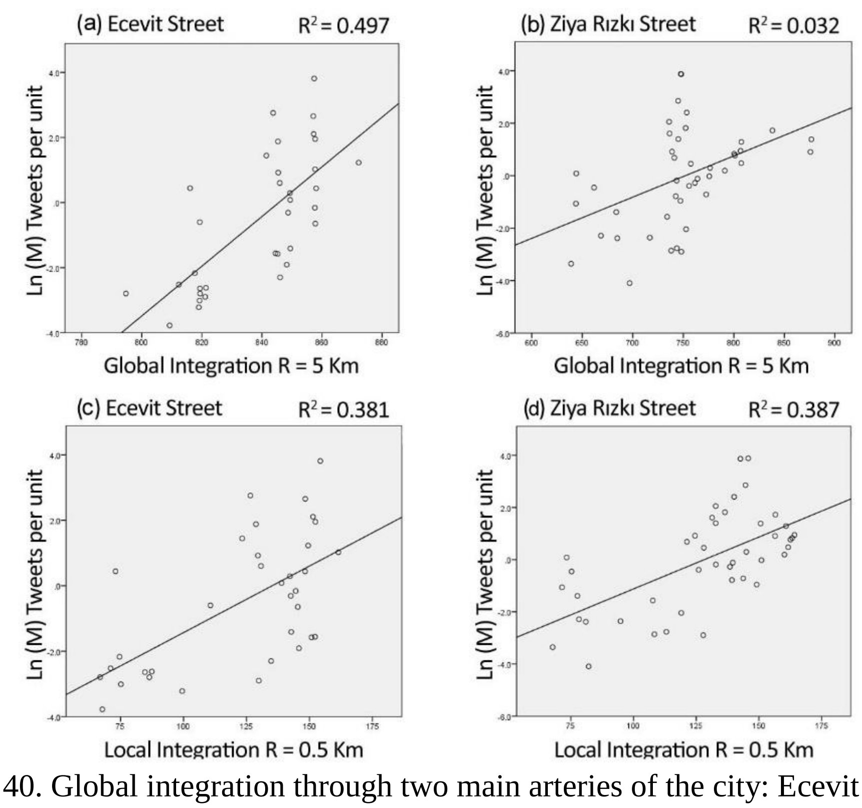


Figure 40. Global integration through two main arteries of the city: Ecevit Street: a&c and Ziya Rızkı street b&d.

The study was further repeated in the northern part of Nicosia, the general correlations show similar socio-spatial patterns, the detailed analysis can be seen the related conference proceedings where the findings were presented (Iranmnesh & Atun, 2017)

5.10 Discussion

People's interactions throughout social media within the context of the urban spatial grid is an inherent part of today's urban life, nevertheless, these interactions can only exist and are understood within the spatial context of their production (Couclelis, 2004). The social content of urban form -as a new emerging entity- could open up new doors for policy making and development plans by addressing the potentials and shortcomings of socio-spatial characteristics of urban spaces. In the case of Famagusta, the natural shape of the city and its borders influence how the social content mediates the spatial structure of the city. In general, the findings of this study show the advantage of local accessibility over global accessibility in the process of forming socio-spatial interactions. It could be argued that the city in general, needs to be more locally accessible and at the same time, support a core or multiple cores that are globally accessible. The issue in analyzing spaces with high global accessibility is the fact that some of these spaces are very well accessible at the local level as well, hence, the possibility of multicollinearity must be taken into account. The overall analysis indicates that the local accessibility is relatively more important, but to provide a more detailed analysis, the search for different typologies of spaces and outliers is necessary. Accordingly, the various behavioral patterns that come to light in respect of outliers are critical components of any study on this subject.

The powerful correlation between people's recall of urban spaces and the geo-tagged Twitter feed data illustrates the applicability of utilizing the Twitter feed data in leading research on socio-spatial characteristics of urban space. However, the extent of this reliability can be questioned. It has been argued here that the geo-tagged Twitter feed as a source of socio-spatial data opens a new perspective in reading peoples' usage, connection and interaction with the network of urban public spaces by providing a more detailed and comprehensive outcome when compared with a traditional name generator survey. The result indicates that people tend to recall the significant and well-known nodes of the city; furthermore, the majority of marked spaces through the survey are related to leisure activities. The Twitter data, on the other hand, includes a wider variety of urban interaction, for instance, fan clubs, local nodes, barbershops, office, and work-related activities, educational activities, and much more can be classified within these data sets.

However, the social-media data should be used with caution, the filtering process must be clearly defined and contextual preferences of the case-study should be taken into account. Nevertheless, geo-tagged Twitter data come with its' caveats. The data might be biased due to some intervening factors, for instance, the free internet access provided by some commercial services. This study tried to control for this by filtering and rechecking the check-in data that might be influenced by such services, the results express very little to no effect in the case of Famagusta. Moreover, Using Twitter data for spatial analysis come with its limitations, for instance, the social profile of different parts of the city might affect the production of social media data. Various studies suggest the necessity of addressing the issue of user demographics of Twitter. Clearly, the users of Twitter do not represent the general population. At this time, the user profile of social media might contain age and socio-economic biases (Lloyd & Cheshire, 2017; Longley & Adnan, 2016). In this case study, the Piyale Paşa neighborhood (Table 10: 7) is a significant example of this phenomenon, the area shows a moderate local and high global accessibility but very limited geo-tagged tweets, this neighborhood consists of lower-income families that might not have any representation in the data collection. It should be mentioned that the data collection of this research includes people with access to smartphones and the internet; it might be subjected to age, income, or social restriction to some extent. Although the ever-increasing penetration of smartphone and internet might change this in the coming decades. Nevertheless, it is not possible to advocate that this target group represent the entire population of the city, although it proves a very good sample size. However, repeating the analysis excluding this neighborhood (Piyale Paşa) does not change the correlation coefficient significantly (at 500m R^2=.156 compare to R^2=.161). Nevertheless, it could be argued that if the data existed at the same rate compare to the rest of the city; the correlation coefficient might improve significantly. Accordingly, the contextual, socio-economical, and demographic characteristics of urban spaces must be carefully monitored while using the new layer of data for reading urban interactions.

Moreover, replicating the analysis with the survey data shows a similar outcome. Here the correlation coefficient is repeated by using the survey data as the DV& DVt and is predicted via space syntax measurements. The similarity between the correlation coefficient supports the argument regarding the usability of the geo-tagged Twitter data as the main outcome variable (Figure 41 & Figure 42).

The general outcome of the study indicates that the local accessibility is the best predictor of socio-spatial interactions. The result repeats itself across spaces with high local to-movement and through-movement. Moreover, the results are similar when controlling for metric distance, overlaying method, and case study. Within the combination of the variables that this study undertook; there are various spaces with socio-spatial characteristics that are not fitting the general correlation pattern between accessibility and Twitter interactions. For instance, further observation of data suggests that some segments of the map can be better predicted via global instigation, and/or by a combination of both local and global measurements. Accordingly, the classification of data based on the two IVs suggested by the best fit multiple regression model shows a vibrant structure beneath the distribution of these layers.

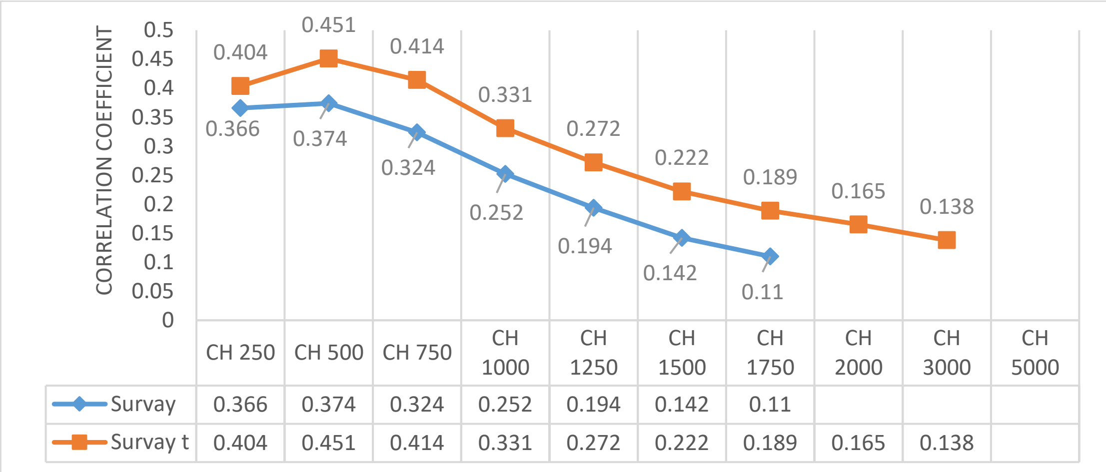


Figure 41. The correlation between angular choice measures and the name generator survey, the results are significant at 0.01

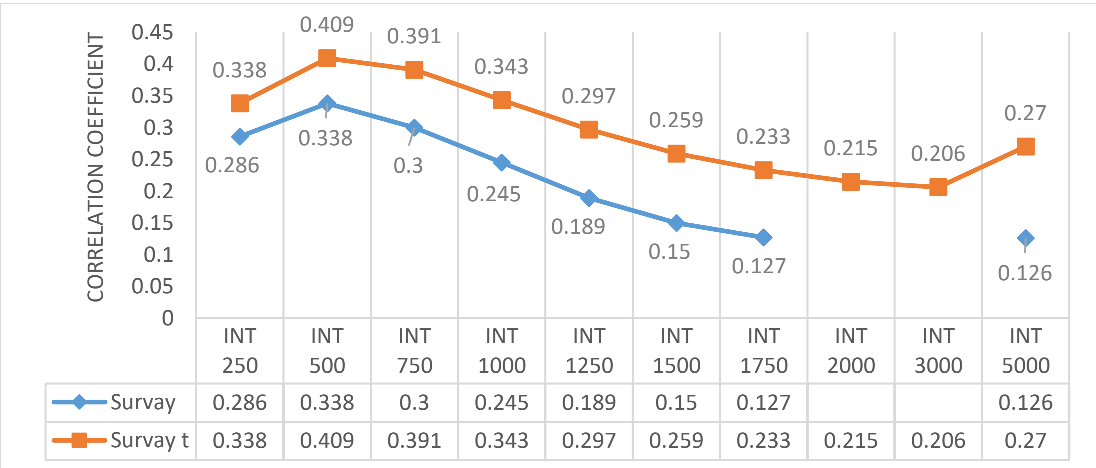


Figure 42. The correlation between angular integration measures and the name generator survey, the results are significant at 0.01

Undoubtedly, the features of Famagusta play a role in the formation of its socio-spatial interactions. Some of these outliers are the result of the city boundaries and its linear form. Accordingly, these outliers should be understood within their context. Although similar spaces might be found in other cases, the characteristics of each city must be addressed accordingly. In Famagusta, the military borders affect the socio-spatial network of the city by blocking the paths leading towards the coastal line and in the south by limiting the existing grid, bringing the 'edge effect' -as a reality of the network and not a data collection limitation- close to the main streets of the city. Moreover, the lack of access to the seafront has a significant impact on the socio-spatial interaction within the city. The long-distance travel that is required to reach the seashore has created an imbalance in the patterns of global accessibility. The high number of people tweeting from the beaches with the lowest level of accessibility shows that attractive functions can potentially undermine accessibility as a critical variable. This becomes much clearer when the results are compared with Kyrenia, in the second case vibrant waterfront activities represent the hearth of both local and global grid of the city. in the case of Kyrenia a large body of geo-tagged data represents interaction with seafront which is an integrated part of the urban grid.

Furthermore, besides the military borders which are rigid and unreachable, the city has two other semi-gated areas, the historic walled city, and the university campus (Table 11: Type 5). Although these spaces are reachable by both locals and students, they are not very well connected to the urban spatial network, both have borders around them and are accessible only from specific points. Both locations are very well connected internally and show lower levels of global accessibility, furthermore, both spaces return a high number of tweets. Although the history and spatial form of these two spaces are unlike, they show similar socio-spatial characteristics. Both spaces have been built to be self-sufficient internally for a small population, with residential areas, retail shops, public spaces, and recreational activities. We must note that the university campus shows a stronger interaction with respect to Twitter data because the foremost users of the space are younger and have a more active online life. These parts of the urban network highlight the importance of local accessibility when compared with global accessibility. Thus, it could be argued that despite low global accessibility, urban spaces could maintain a high level of socio-spatial interactions if they provide high local accessibility to everyday functions.

Thirdly, the core of the socio-spatial interactions in the city follows the logic of space syntax -most accessible spaces from any other part of the network- and, naturally, home to a variety of recreational activities. In contrast, the research found segments with higher levels of global accessibility within the same proximal distance, which do not contain significant socio-spatial interactions. These spaces are the primary traffic nodes of the city with little connection to their surroundings. High global accessibility might not be enough for the formation of these types of spaces, and being locally accessible is a necessity for the natural formation of socio-spatial interactions.

Famagusta can be categories as a college town according to Gumprecht (2009) because it is a city in which more than 20% of the population is enrolled in a 4-year undergraduate program. Parts of this type can be traced by to the dialectical development process of the city and the campus in recent history. The campus was initially established with no planning intentions to integrate with the city of Famagusta, a leftover town in a post conflicting area. Thus, it has a well-integrated core for local pedestrian movements. Nevertheless, over time, the campus has acted as an attraction pole shifting the development of the city towards the university due to the limits/borders of the city in the south, east, and west, it has been transformed into a form of “campus as a city”. It is not yet highly integrated with the city at the larger scale (5000m), nevertheless, the development process of the city is enveloping the spatial structure of the campus over time.

The analysis of outliers also renders promising results, the outlier spaces are including waterfront spaces that are very spatially inaccessible on both local and global scale but heavily reported through social media. These spaces also contain a good portion of reported social interactions. There is also the new dormitory section of the university, although it is one of the most populated areas and has been mentioned through social media, it is having low integration value in both local and global level. The university stadium has a similar characteristic. university cultural center, clubs, and beach club are also activity driven functions that attract many students regardless of their spatial status. It is evident from the data that local accessibility has a significant positive role in explaining the Twitter feed data, but spaces with less spatial accessibility might be highly visible through Twitter data because they are being well connected in a social network. Accordingly, despite the results being in favor of the second argument (first law of geography), there are spaces that are showing the validity of the first argument in favor of de-territorialization/de-localization of urban space. Thus, the three following point could be made:

- The inaccessible space of the grid that score low in local and/or global measurements can be reported as a highly interactive space just as the result of their attractive and vibrant functionality. The network cost of travel in these cases can be compromised by the reputation and attractiveness of the land-use functions.
- Highly interactive points in the grid can change how people chose their path in the network, this happens at both local and global scale.

- The quality and image of the path might affect how people move through space, accordingly, people might select a less integrated path if it offers higher spatial quality Koschinsky, Talen, Alfonzo, and Lee (2017).

These points correspond with both discussions in the literature, in fact, it could be debated that both arguments stand true to some extent. Although the effects of physical proximity are clear and strong, the attraction points outside the accessibility range indicate that physical proximity is not an absolute necessity for the formation of socio-spatial interactions. Returning to the concept of the networked society, it can be argued that the natural complexity of urban space arises with the development of digital communication. Although the network society occupies the space in respect to the physical proximity, the complex patterns of spaces that were identified here suggests a slow emerging expansion upon those physical layers that are caused by the properties of new networks.

The second part of the discussion highlights the methodological aspects of the study. The general correlation between the integration measurements and Twitter data shows the importance of spatial accessibility regarding how people interact with the city. Arguably, not considering the land-use is one of the significant limitations of space syntax (Ratti, 2004), and although W. G. Hansen (1959); Hillier and Penn (2004) and many others argue that the degree of accessibility eventually shapes the land-use, our findings suggest that this is not always the case. Regarding Famagusta, the space syntax logic works for the urban core and can explain some of the socio-spatial interaction, but it does not show consistency in all parts of the urban spatial network. Therefore, we suggest that using social media data can enhance the interpretation of space syntax measurements because it is a real representation of citizens interacting with the spatial network of the city. The benefit of considering social media data in urban studies could be more significant in their practical and developmental aspects. Exploring the spatial network in reference to its actual users' interactions adds another layer of visibility to our existing understanding of cities (Taylor & Schroeder, 2015). For instance, the spaces with high global accessibility that are not visible through social media could be considered for developing more public functions and more local accessibility. The quality of these spaces should be further analyzed as it might affect their natural accessibility (Foltete & Piombini, 2007). The bordered parts of the city might need more connection with the grid in order to increase the global accessibility to those spaces (see Era, 2012). In the case of Famagusta, redefining the borders and facilitating the access to the waterfront should be a priority. The result shows that attractive public functions can improve the interaction with urban space regardless of the degree of accessibility. Therefore, even in areas such as the historic walled city, the more public function might attract more people and in return support the preservation of the space. The methodology might be highly beneficial in public transportation studies by identifying the potential destinations and route alternatives for possible development.

It should be argued that although the land-use is not directly considered in this study, the overall logic of space syntax and centrality measures indicates that they are both sides of the same coin and coevolve together as the natural process of urban development (Hillier, 1996; Hillier, 2012; Hillier & Penn, 2004; H.-K. Kim & Sohn, 2002; Penn & Turner, 2004). Accordingly, this study does not ignore the effect of land-use; rather we consider it the essential quality of the spatial grid that co-evolves and co-exists with the degree of integration, choice, and centrality.

5.11 Utilization of the Research for Planning and Development

The outcome of this study indicates a verity of socio-spatial typologies of spaces regarding accessibility and geo-tagged data (social media). Some of these cases show anomalies that need to be addressed as emerging urban issues; these outliers must be taken into consideration for planning; Outliers are significant to this research as they show spaces that are not following the regression model. For instance, Type 10 (Figure 24) shows spaces that are expected to show high interactive functionality where none exists in reality. Accordingly, these spaces should be considered in land-use development. Some of these outliers show and identify untapped potentials of the urban spatial network. They illustrate the potential capacity of spaces for socio-spatial interaction. Regarding the empirical applications, the method could be used for both identifying problems and discovering hidden potentials of the urban grid. The process of problem detection, problem diagnostics, problem-solving could be seen in a new light considering the new interaction layer of the city.

The outliers could be further categorized into two groups, first, spaces with high tweet count that have low integration score, second, spaces with limited tweet count that show high integration score. The circumstances are different, but they show that highly interactive spaces through social media could exist, regardless of their accessibility at a local and/or global scale. At the same time, highly accessible spaces throughout the city might not be interactive through social media. Some of these spaces show promising qualities for becoming vital public space.

The data suggests different levels of Correlations under different circumstances. Outliers, in this case, could also illustrate the potential capacities of spaces for socio-spatial interaction. Some of these spaces have high visibility through social media. Although the circumstances are different, they show that highly interactive spaces through social media could exist regardless of their accessibility in the local and/or global scale. Some of these spaces show promising qualities for becoming a vital public space, therefore, for the planning stage increasing local and global accessibility could increase the possibility of socio-spatial interactions. Another type of outliers that can be explored are spaces with high local, and global accessibility and a low number of socio-spatial interactions. These spaces express and unused potential that can provide the potential for city planning and revitalization. Evidently, analyzing the data from social media should be conducted at various scales; seeking patterns of significant relations in the data is critical. It could be argued that the general correlation in ‘big data’ should not be overestimated. In this case, the outliers are rendering important realities of the city. Even throughout the normal distribution, the analysis might find interesting socio-spatial behavioral patterns.

The results points to a stronger correlation between the distribution of geo-tagged tweets and global/local accessibility in the foreground spaces of the city. Different observations showed that both local and global indicators could provide high predictability of the geo-tagged data. Accordingly, the distribution of micro-economic activities at the foreground spaces can render vital spaces at the local level, global level, or a combination of both. It is better to use a combination of local and global measures for addressing the possibility of socio-spatial interaction because spaces that are locally accessible (Figure 24: Type14) might not be globally integrated enough to support such interactions.

Chapter 6

CONCLUSION

The rise of social media and virtual connections has created a new interactive layer in the existing structure of urban life. The new ways of interaction in space have created another inherent layer on top of the existing network structure of the city. In order to answer the research question, it must be mentioned that there are two main arguments about this topic. One argues that the new social media has isolated individuals and created a space-free network structure, and the second argues that the new social media is amplifying the existing socio-spatial structure of the urban form. I argue that the answer is more complicated. Accordingly, a different combination of these two at various levels can create various socio-spatial interaction patterns. Therefore, making a general assumption outside the context is not logical.

Social media has enabled citizens of the contemporary world to take more control over their social relations, and at the same time, offers more choices for interactions. Readings on the topic suggest that a new form of communication has strengthened people’s involvement in urban space.

Urban networks are a complex structure of interwoven layers of interaction and spatial entities that co-evolve together. Urban public spaces as nodes of interactions are integrated parts of this complex system. Cities abound with diversity and a variety of choices throughout history. They can offer opportunities for everybody only when everybody participates in their development, and digital communication is providing this possibility more and more.

Social media, by providing these opportunities, has changed the role of today’s urban residents from the consumers or transformers of information into the creators of information. This change creates large datasets of interaction with other social actors and with spaces of cities. This so-called ‘big data’ is the by-product of social media, and because they are of the same nature, it can be utilized to explore the new reality of urban space together with social media.

Integration of the big data into urban analytical studies shows promising results. Mobile digital communication devices in the hands of the majority of the population have given a new face to urban space. People share their thoughts and simultaneously connect them to the real time and space of the urban form. This so-called “big data” opens up many new possibilities for research on urban structure. Especially in public spaces, it gives appropriate information about what people really do while they are using social media. This new layer of data, in-line with the increasing complexity of urban space, provides new opportunities for reading cities.

This research has tried to explore the relationship between socio-spatial interactions through social media and physical accessibility to urban space. Thus, as new tools of communication change the way people interact with each other and with urban space, new methodological approaches become more indispensable. The city of today is evolving with new communication mediums, and citizens are recording and sharing their activities in space. This new production, that is usually referred to as ‘big data,’ could be used in order to gain a better understanding of the socio-spatial interactions of urban space. The 'big data' requires new methods of collection and new analytical methods that could adequately represent its complex and evolving nature. 'Big data' shows promising results in the exploration of more complex problems that urban life faces today. Our research result suggests that even in areas where detailed official census data are unreachable, exploring big data could open the possibility of new research. However, the size of 'big data' should be considered within its relative context. This research has attempted to explore new possibilities by looking at urban space from the window of 'social media' and the way it interacts with the spatial network of a city. The study aimed to explore the effects of social media on the different degrees of accessibility to urban space and to see if virtual connections, which are not bounded by distance, have affected the way people access and use the physical space, which has proximal limitations. Exploring new possibilities in combination with other analytical methods with 'big data' was a concern in conducting this research. It seems that although the effects of the rising network society are visible when looking at it on the smaller scale of everyday life, physical proximity still plays an important role in the way people interact with the city. The general result of this research shows that even the interactions through social media increase within more locally-accessible spaces in the city. On the other hand, we suggest that the "outliers" of the data should be taken into consideration as they might provide insight into planning and development. There are activity-driven spaces that are heavily-reported through social media but are not easily accessible through the urban network. Our findings show that local accessibility is not a necessary factor for the creation of socio-spatial interactions through social media. It seems that although local accessibility is accommodating to the creation of socio-spatial interactions, the virtual connections could attract people to less accessible areas when the related activity is favored. This finding shows that although the general significance in data can explain the importance of local accessibility, it is essential to explore the data on a smaller scale. In this case, the outliers in the dataset provided an understanding of the potential for socio-spatial interactions in the city. By looking closer at the data, the study was able to identify various types of patterns that could not be explained by the statistical analysis. These types could be used for planning, development, and marketing. The methodological approach of this research could be further elaborated by exploring other contexts. Perhaps a further reading of urban space by this method in other cities would provide more insights into these issues.

The study tried to combine different layers of data collection and analysis to provide a comprehensive understanding of the subject. The research used the traditional name-generator survey, Twitter data, and space syntax analysis to address the objectives. Movement by choice and movement via integration were used on nine levels starting from 250m at the local level with incidentally increasing steps toward global scales.

This dissertation has tried to explore the degree of reliability and/or the difference between the geo-tagged social media data and the real urban space. The results indicate a strong correlation between these data and the real interactive points of interest in the urban grid. The social media data cannot be self-explanatory; they require additional supportive methods and analytical tools. The data can be used to understand how society interacts with space and to better understand urban socio-spatial interactions.

Furthermore, the current study suggests that the social media data (in this case geo-tagged Twitter data) can be used to understand patterns of socio-spatial behavior in public spaces. The results demonstrate that these data provide a more detailed understanding of urban space as complex networks of socio-spatial relations that are acting both as a whole and as connected individuals. The study uses the outliers in the dataset to dive deeper into the discussion instead of eliminating them. These outliers could provide insight into emerging patterns of socio-spatial behaviors in the city. The outliers can explain the potential and weaknesses of urban space regarding social interactions. They can also be utilized as a guideline for planning and development. The result implies the importance of both local and global accessibility in the formation of socio-spatial interactions in urban space, but the local measures appear to be more effective. However, the answers seem to be more complicated than the general correlation. Further exploration of data revealed various types of socio-spatial patterns in the case study. Thirteen types of spaces were identified based on their local and global accessibility and the transformed tweet count. Our findings express the importance of addressing the socio-spatial typology of space with regard to its context. Each unique type of space could provide insight into emerging patterns of socio-spatial behavior in the city. This typology can be used to explore the potential and weaknesses of urban space regarding social-spatial interactions. They can also be utilized as a guideline for development and planning.

This research tried to explore the effects of social media and mobile devices on the socio-spatial interactions of urban life. The research question was rather challenging and designing a proper methodological approach was critical. The findings support the following ideas:

- Local accessibility is critical in the formation of socio-spatial interactions in urban space. Even though, many theories suggest the distance-less (free) nature of digital communication might have de-territorialized the urban space and undermined the importance of physical proximity, the result indicates the slight importance of local accessibility compared to global accessibility.

- One of the points of this research was to explore the reliability of big data in conducting research on urban spaces. The findings of this study suggest that there is a strong correlation between this data and people's interaction with the urban space. It could be argued that in areas in which the official data is scarce, the social media data can be used if filtered properly.
- Our finding shows that besides the general importance of local accessibility there are spaces (outliers) that can be explained by the effects of distance-free digital communication. Certain trends and activities can reach a large audience through the medium of digital communication. Accordingly, the socio-spatial typologies of urban spaces must be addressed according to the characteristics of the case study.

REFERENCES

Ahmed, A., Hong, L., & Smola, A. J. (2013). *Hierarchical geographical modeling of user locations from social media posts.* Paper presented at the Proceedings of the 22nd international conference on World Wide Web.

Alexander, C. (1964). *Notes on the synthesis of form*. London: Oxford University press

Alexander, C. (1977). *A pattern language: towns, buildings, construction*: Oxford university press.

Alexander, C. (2002). *The nature of order: the process of creating life*: Taylor & Francis.

Allen, P. M. (2012). *Cities and regions as self-organizing systems: models of complexity*: Routledge.

Anderson, C. (2004). The End of Theory: The Data Deluge Makes the Scientific Method Obsolete. *GeografiskaAnnaler: Series B, Human Geography, 86*(1), 33-34.

Anderson, C. (2008). The end of theory: The data deluge makes the scientific method obsolete: Wired.

Ang, L. M., & Seng, K. P. (2016). Big Sensor Data Applications in Urban Environments. *Big Data Research*.

Arribas-Bel, D. (2014). Accidental, open and everywhere: Emerging data sources for the understanding of cities. *Applied Geography, 49*, 45-53.

Axhausen, K. W., & Kowald, M. (2015). *Social networks and travel behaviour*: Ashgate Publishing, Ltd.

Bafna, S. (2003). Space syntax: A brief introduction to its logic and analytical techniques. *Environment and Behavior, 35*(1), 17-29.

Baran, P. K., Rodríguez, D. A., & Khattak, A. J. (2008). Space syntax and walking in a new urbanist and suburban neighbourhoods. *Journal of Urban Design, 13*(1), 5-28.

Batty, M. (2009). Accessibility: in search of a unified theory: SAGE Publications Sage UK: London, England.

Batty, M. (2012). Building a science of cities. *Cities, 29*, S9-S16.

Batty, M. (2017). Space Syntax and Spatial Interaction: Comparisons, Integrations, Applications.

Bentley, I. (1985). *Responsive environments: A manual for designers*: Routledge.

Bhat, C., Handy, S., Kockelman, K., Mahmassani, H., Chen, Q., & Weston, L. (2000). *Development of an urban accessibility index: Literature review*. Retrieved from

Bontcheva, K., & Rout, D. (2014). Making sense of social media streams through semantics: a survey. *Semantic Web, 5*(5), 373-403.

Boyd, D., & Crawford, K. (2012). Critical Questions for Big Data. *Information, Communication & Society, 15*(5), 662-679.

Breiger, R. (1974). The Duality of Persons and Groups. *Social forces, 53*, 181-190.

Brenner, N., & Schmid, C. (2014). The 'Urban Age' in Question. *International Journal of Urban and Regional Research, 38*(3), 731-755. doi:10.1111/1468-2427.12115

Bruns, A., Burgess, J. E., Crawford, K., & Shaw, F. (2012). # qldfloods and@ QPSMedia: Crisis communication on Twitter in the 2011 south east Queensland floods.

Burt, R. (2011). *Structural Holes in virtual worlds*. Chicago: University of chicago press.

Carmona, M. (2010). *Public places, urban spaces: the dimensions of urban design*: Routledge.

Carpio, G. G. (2016). Racial projections: cyberspace, public space, and the digital divide. *Information, Communication & Society*, 1-17.

Carr, D. B., Olsen, A. R., & White, D. (1992). Hexagon mosaic maps for display of univariate and bivariate geographical data. *Cartography and Geographic Information Systems, 19*(4), 228-236.

Cairncross, F. (2001). The Death of Distance: How the Communications Revolution Is Changing Our Lives. *Harvard Business School Press*.

Carr , S., Francis, M., Rivlin, L. G., & Stone , A. M. (1993). *Public Space (Cambridge Series in Environment and Behavior)*. Cambridge: Cambridge University Press.

Cass, N., Shove, E., & Urry, J. (2005). Social exclusion, mobility and access1. *The sociological review, 53*(3), 539-555.

Castells, M. (1989). *The informational city: Information technology, economic restructuring, and the urban-regional process*: Blackwell Oxford.

Castells, M. (1996). *The Information Age: Economy, Society and Culture Volume 1: The Rise of the Network Society. 2nd ed.* Oxford: Wiley Blackwell.

Castells, M. (1998). *The Information Age: Economy, Society and Culture Volume 3: End of Millennium*. Oxford: Wiley Blackwell.

Castells, M. (2000a). Materials for an exploratory theory of the network society1. *The British journal of sociology, 51*(1), 5-24.

Castells, M. (2000b). Toward a sociology of the network society. *Contemporary sociology, 29*(5), 693-699.

Castells, M. (2008). Afterword. In J. E. Katz (Ed.), *Handbook of mobile communication studies* (pp. 447-451): The MIT Press.

Castells, M., & Cardoso, G. (2006). *The network society: From knowledge to policy*: Johns Hopkins Center for Transatlantic Relations Washington, DC.

Chambers, D. (2006). *New Social Ties, Contemporary Connections in a Fragmented Society*. London: Palgrave Macmillan.

Chatterjee, S., & Hadi, A. S. (2015). *Regression analysis by example*: John Wiley & Sons.

Cheng, Z., Caverlee, J., Lee, K., & Sui, D. Z. (2011). Exploring Millions of Footprints in Location Sharing Services.

Cho, E., Myers, S. A., & Leskovec, J. (2011). *Friendship and mobility: user movement in location-based social networks.* Paper presented at the Proceedings of the 17th ACM SIGKDD international conference on Knowledge discovery and data mining.

Cint. (2018). Which social media do you use? Retrieved from https://www.statista.com/statistics/570098/distribution-of-social-media-used-turkey/

Couclelis, H. (2004). The construction of the digital city. *Environment and Planning B: Planning and design, 31*(1), 5-19.

Crampton, J. W., Graham, M., Poorthuis, A., Shelton, T., Stephens, M., Wilson, M. W., & Zook, M. (2013). Beyond the geotag: situating 'big data' and leveraging the potential of the geoweb. *Cartography and Geographic Information Science, 40*(2), 130-139. doi:10.1080/15230406.2013.777137

Crooks, A., Croitoru, A., Jenkins, A., Mahabir, R., Agouris, P., & Stefanidis, A. (2016). User-generated big data and urban morphology. *Built Environment, 42*(3), 396-414.

Crucitti, P., Latora, V., & Porta, S. (2006). Centrality measures in spatial networks of urban streets. *Physical Review E, 73*(3), 036125.

Dana, B., & Kate, C. (2012). ‘Critical Questions for Big Data’. *Information, Communication and Society, 15*, 5.

De Mauro, A., Greco, M., & Grimaldi, M. (2016). A formal definition of Big Data based on its essential features. *Library Review, 65*(3), 122-135.

Doratli, N., Hoskar, S. Ö., Vehbi, B. O., & Fasli, M. (2007). Revitalizing a declining historic urban quarter—The walled city of Famagusta, North Cyprus. *Journal of Architectural and Planning Research*, 65-88.

Era, R. T. (2012). Improving pedestrian accessibility to public space through space syntax analysis. *Environmental planning laboratory (LABPLAM), Department of urbanism and spatial planning*, 16.

Feld, S. (1981). The Focused Organization of Social Ties. *American Journal of sociology, 86*, 1015-1035.

Foltete, J.-C., & Piombini, A. (2007). Urban layout, landscape features and pedestrian usage. *Landscape and Urban Planning, 81*(3), 225-234.

Ford, G. B. (1913). The city scientific. *Engineering Record, 67*, 551-552.

Foth, M., & Hearn, G. (2007). Networked Individualism of Urban Residents: Discovering the communicative ecology in inner-city apartment buildings. *Communication & Society, 10*(5), 749-772.

Freeman, L. C. (1978). Centrality in social networks conceptual clarification. *Social networks, 1*(3), 215-239.

Gao, S., Janowicz, K., & Couclelis, H. (2017). Extracting urban functional regions from points of interest and human activities on location-based social networks. *Transactions in GIS, 21*(3), 446-467.

García-Palomares, J. C., Salas-Olmedo, M. H., Moya-Gómez, B., Condeço-Melhorado, A., & Gutiérrez, J. (2018). City dynamics through Twitter:

Relationships between land use and spatiotemporal demographics. *Cities, 72*, 310-319.

Gehl , J. (2011). *Life Between Buildings: Using Public Space* (J. Koch, Trans.). Washington: Island Press.

George, G., Haas, M. R., & Pentland, A. (2014). Big data and management. *Academy of Management Journal, 57*(2), 321-326.

Giddens, A. (1991). *Modernity and Self-identity: Self and Society in the Late Modern Age*. Stanford,: CA: Stanford University Press.

Giddens, A. (1994). *NowHere: space, time, and modernity*: Univ of California Press.

Goffman, E. (1963). *Behavior in public places: Notes on the social organization of gatherings*: Free Press New York.

Gold, M. K. (2012). *Debates in the digital humanities*: U of Minnesota Press.

Graham, M., & Dutton, W. H. (2014). *Society and the internet: How networks of information and communication are changing our lives*: OUP Oxford.

Graham, M., & Shelton, T. (2013). Geography and the future of big data, big data and the future of geography. *Dialogues in Human Geography, 3*(3), 255-261.

Granovetter, M. (1983). The strength of weak ties: A network theory revisited. *Sociological theory*, 201-233.

Gruzd, A., Jacobson, J., Wellman, B., & Mai, P. H. (2017). *Social Media and Society: Introduction to the Special Issue:* SAGE Publications Sage CA: Los Angeles, CA.

Guley, K., & Abbasoglu, M. S. Proposal for the Revitalisation of the Walled City Famagusta.

Gumprecht, B. (2009). *The American college town*: University of Massachusetts Press.

Hall, P. (2002). *Cities of Tomorrow*. Oxford: Wiley Blackwell.

Hampton, K., Sessions, L., Her, E. J., & Rainie, L. (2009). Social isolation and new technology. *Pew Internet & American Life Project, 4*.

Hampton, K., & Wellman, B. (2001). Long Distance Community in the Network Society Contact and Support Beyond Netville. *American Behavioral Scientist, 45*(3), 476-495.

Hansen, D., Shneiderman, B., & Smith, M. A. (2010). *Analyzing social media networks with NodeXL: Insights from a connected world*: Morgan Kaufmann.

Hansen, W. G. (1959). How accessibility shapes land use. *Journal of the American Institute of Planners, 25*(2), 73-76.

Hao, J., Zhu, J., & Zhong, R. (2015). The rise of big data on urban studies and planning practices in China: Review and open research issues. *Journal of Urban Management, 4*(2), 92-124.

Hawkins, D. M. (1980). *Identification of outliers* (Vol. 11): Springer.

Hillier, B. (1996). *Space is the Machine: A Configurational Theory of Architecture*. Cambridge: Press Syndicate.

Hillier, B. (1999a). Centrality as a process: accounting for attraction inequalities in deformed grids. *urban design International, 4*(3-4), 107-127.

Hillier, B. (1999b). The hidden geometry of deformed grids: or, why space syntax works, when it looks as though it shouldn't. *Environment and Planning B: Planning and design, 26*(2), 169-191.

Hillier, B. (2009). *Spatial sustainability in cities: organic patterns and sustainable forms*.

Hillier, B. (2012). Studying Cities to Learn about Minds: Some Possible Implications of Space Syntax for Spatial Cognition. *Environment and Planning B: Planning and design, 39*(1), 12-32. doi:doi:10.1068/b34047t

Hillier, B., & Hanson, J. (1984). *The Social Logic of Space*. Cambridge Cambridge University Press.

Hillier, B., & Iida, S. (2005). *Network and psychological effects in urban movement.* Paper presented at the International Conference on Spatial Information Theory.

Hillier, B., & Penn, A. (2004). Rejoinder to carlo ratti. *Environment and Planning B: Planning and design, 31*(4), 501-511.

Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1993). Natural movement: or, configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and design, 20*(1), 29-66.

Hillier, B., & Schwander, C. (2012). Compositional and urban form effects on centres in Greater London.

Huang, Y., Guo, D., Kasakoff, A., & Grieve, J. (2015). Understanding US regional linguistic variation with Twitter data analysis. *Computers, Environment and Urban Systems*.

Iranmnesh, A., & Atun, R. A. (2017). *Exploring patterns of socio-spatial interaction in the public spaces of city through Big Data.* Paper presented at the ISUF 2017 XXIV International Conference on City and Territory in the Globalization Age, Valencia.

Irwin, M. D., & Hughes, H. L. (1992). Centrality and the structure of urban interaction: measures, concepts, and applications. *Social forces, 71*(1), 17-51.

Israel, G. D. (1992). Determining sample size.

Jiang, B. (2009). Ranking spaces for predicting human movement in an urban environment. *International Journal of Geographical Information Science, 23*(7), 823-837.

ITU. (2013). *World in 2013, ICT facts and figures* Retrieved from Geneva, Switzerland

Jacobs, J. (1961). *The Death and Life of Great American Cities*. New York: Vintage Books, Random hous

Jiang, B., & Claramunt, C. (2004). A structural approach to the model generalization of an urban street network. *GeoInformatica*, *8*(2), 157-171.

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of Social Media. *Business horizons, 53*(1), 59-68.

Kenyon, S., Lyons, G., & Rafferty, J. (2002). Transport and social exclusion: investigating the possibility of promoting inclusion through virtual mobility. *Journal of Transport Geography, 10*(3), 207-219.

Kim, H.-K., & Sohn, D. W. (2002). An analysis of the relationship between land use density of office buildings and urban street configuration: Case studies of two areas in Seoul by space syntax analysis. *Cities, 19*(6), 409-418.

Kim, Y. O., & Penn, A. (2004). Linking the spatial syntax of cognitive maps to the spatial syntax of the environment. *Environment and Behavior, 36*(4), 483-504.

Kitchin, R. (2013). Big data and human geography Opportunities, challenges and risks. *Dialogues in Human Geography, 3*(3), 262-267.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal, 79*(1), 1-14.

Klauser, F. R., & Albrechtslund, A. (2014). From self-tracking to smart urban infrastructures: Towards an interdisciplinary research agenda on Big Data. *Surveillance & Society, 12*(2), 273.

Kotzias, D., Lappas, T., & Gunopulos, D. (2014). *Addressing the Sparsity of Location Information on Twitter.* Paper presented at the EDBT/ICDT Workshops.

Kotzias, D., Lappas, T., & Gunopulos, D. (2015). Home is where your friends are: Utilizing the social graph to locate twitter users in a city. *Information Systems*.

Kraut, R., Patterson, M., Lundmark, V., Kiesler, S., Mukophadhyay, T., & Scherlis, W. (1998). Internet paradox: A social technology that reduces social involvement and psychological well-being? *American psychologist, 53*(9), 1017.

Koschinsky, J., Talen, E., Alfonzo, M., & Lee, S. (2017). How walkable is Walker's paradise? *Environment and Planning B: Urban Analytics and City Science, 44*(2), 343-363.

Kumar, S., Morstatter, F., & Liu, H. (2014). *Twitter data analytics*: Springer.

Lansley, G., & Longley, P. A. (2016). The geography of Twitter topics in London. *Computers, Environment and Urban Systems, 58*, 85-96.

Law, S., Chiaradia, A., & Schwander, C. (2012). *Towards a multimodal space syntax analysis: A case study of the London street and underground network.* Paper presented at the Published in Proceedings of the 8th International Space Syntax Symposium, Santiago de Chile, Chile.

Lazer, D., Pentland, A. S., Adamic, L., Aral, S., Barabasi, A. L., Brewer, D., . . . Gutmann, M. (2009). Life in the network: the coming age of computational social science. *Science (New York, NY), 323*(5915), 721.

Lee, R., Wakamiya, S., & Sumiya, K. (2013). Urban area characterization based on crowd behavioral lifelogs over Twitter. *Personal and ubiquitous computing, 17*(4), 605-620.

LeGates, R., Nicholas , T. J., & Kingston, R. (2009). Spatial thinking and scientific urban planning. *Environment and Planning B: Planning and design, 36*, 763-768.

Lerman, Y., Rofè, Y., & Omer, I. (2014). Using space syntax to model pedestrian movement in urban transportation planning. *Geographical Analysis, 46*(4), 392-410.

Leszczynski, A. (2012). Situating the geoweb in political economy. *Progress in human geography, 36*(1), 72-89.

Liu, C. (2015). Worldwide internet and mobile users: emarketer's updated estimates for 2015. *eMarketer, Tech. Rep.*

Lloyd, A., & Cheshire, J. (2017). Deriving retail centre locations and catchments from geo-tagged Twitter data. *Computers, Environment and Urban Systems, 61*, 108-118.

Lofland, L. H. (1998). *The public realm: Exploring the city's quintessential social territory*: Transaction Publishers.

Longley, P. A., & Adnan, M. (2016). Geo-temporal Twitter demographics. *International Journal of Geographical Information Science, 30*(2), 369-389.

Lynch, K. (1960). *The image of the city* (Vol. 11): MIT press.

Madanipour, A. (2007). *Designing the City of Reason: Foundations and Frameworks*. New York: Routledg.

Mahmoudi Farahani, L. (2016). The value of the sense of community and neighbouring. *Housing, Theory and Society, 33*(3), 357-376.

Malecki, E. J. (2014). Connecting the fragments: Looking at the connected city in 2050. *Applied Geography, 49*, 12-17.

Marin, A., & Wellman, B. (2011). Social Network Analysis: An introduction. In J. Scott & P. J. Carrington (Eds.), *The SAGE Handbook of Social Network Analysis* (pp. 11-25): SAGE.

McNamara, T. P., Hardy, J. K., & Hirtle, S. C. (1989). Subjective hierarchies in spatial memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*(2), 211.

Mehaffy, M., Porta, S., Rofe, Y., & Salingaros, N. (2010). Urban nuclei and the geometry of streets: The ‘emergent neighborhoods’ model. *urban design International, 15*(1), 22-46.

Moreno Pires, S., Magee, L., & Holden, M. (2017). Learning from community indicators movements: towards a citizen-powered urban data revolution. *Environment and Planning C: Politics and Space*, 2399654417691512.

Morstatter, F., Pfeffer, J., Liu, H., & Carley, K. M. (2013). *Is the Sample Good Enough? Comparing Data from Twitter's Streaming API with Twitter's Firehose.* Paper presented at the ICWSM.

Moughtin, C. (1992). *Urban Design, Street and Square*. Oxford: Architectural Press.

Önal, Ş., Dağli, U., & Doratli, N. (1999). The urban problems of Gazimagusa (Famagusta) and proposals for the future. *Cities, 16*(5), 333-351.

Penn, A., Hillier, B., Banister, D., & Xu, J. (1998). Configurational modelling of urban movement networks. *Environment and Planning B: Planning and design, 25*(1), 59-84.

Penn, A., & Turner, A. (2004). Movement-generated land-use agglomeration: simulation experiments on the drivers of fine-scale land-use patterning. *urban design International, 9*(2), 81-96.

Peponis, J., Hadjinikolaou, E., Livieratos, C., & Fatouros, D. (1989). The spatial core of urban culture. *Ekistics*, 43-55.

Porta, S., Crucitti, P., & Latora, V. (2006). The network analysis of urban streets: a primal approach. *Environment and Planning B: Planning and design, 33*(5), 705-725.

Putnam, R. D. (2001). *Bowling alone: The collapse and revival of American community*: Simon and Schuster.

Rainie, L., & Wellman, B. (2012a). *Networked : the new social operating system*. Cambridge: MIT Press.

Rainie, L., & Wellman, B. (2012b). *Networked: The new social operating system*: Mit Press.

Ratti, C. (2004). Space syntax: some inconsistencies. *Environment and Planning B: Planning and design, 31*(4), 487-499.

Read, S. (1999). Space syntax and the Dutch city. *Environment and Planning B: Planning and design, 26*(2), 251-264.

Rheingold, H. (2000). *The virtual community: Homesteading on the electronic frontier*: MIT press.

Rivers, C. M., & Lewis, B. L. (2014). Ethical research standards in a world of big data. *F1000Research, 3*.

Ruths, D., & Pfeffer, J. (2014). Social media for large studies of behavior. *Science, 346*(6213), 1063-1064.

Salingaros, N. A. (2005). *Principles of Urban Structure*. Amesterdam: Techne Press.

Sarkar, C., Webster, C., Pryor, M., Tang, D., Melbourne, S., Zhang, X., & Jianzheng, L. (2015). Exploring associations between urban green, street design and walking: Results from the Greater London boroughs. *Landscape and Urban Planning, 143*, 112-125.

Scellato, S., Noulas, A., Lambiotte, R., & Mascolo, C. (2011). Socio-spatial properties of online location-based social networks. *ICWSM, 11*, 329-336.

Seresinhe, C. I., Moat, H. S., & Preis, T. (2017). Quantifying scenic areas using crowdsourced data. *Environment and Planning B: Urban Analytics and City Science*, 0265813516687302.

Sharmin, S., & Kamruzzaman, M. (2018). Meta-analysis of the relationships between space syntax measures and pedestrian movement. *Transport Reviews, 38*(4), 524-550.

Shelton, T., Poorthuis, A., & Zook, M. (2015). Social media and the city: Rethinking urban socio-spatial inequality using user-generated geographic information. *Landscape and Urban Planning, 142*, 198-211.

Sheltona, T., Poorthuisb, A., & Zookb, M. (2015). Social media and the city: Rethinking urban socio-spatial inequalityusing user-generated geographic information. *Landscape and Urban Planning*.

Shen, Y., & Karimi, K. (2016). Urban function connectivity: Characterisation of functional urban streets with social media check-in data. *Cities, 55*, 9-21.

Shen, Y., & Karimi, K. (2018). Urban evolution as a spatio-functional interaction process: the case of central Shanghai. *Journal of Urban Design, 23*(1), 42-70.

Simmel, G. (1976). The Metropolis and Mental Life *The Sociology of Georg Simmel*. New York: Free Press.

Steadman, P. (2004). Developments in space syntax: SAGE Publications Sage UK: London, England.

Stevens, J. P. (2012). *Applied multivariate statistics for the social sciences*: Routledge.

Summers, L., & Johnson, S. D. (2017). Does the configuration of the street network influence where outdoor serious violence takes place? Using space syntax to test crime pattern theory. *Journal of quantitative criminology, 33*(2), 397-420.

Taylor, L., & Schroeder, R. (2015). Is bigger better? The emergence of big data as a tool for international development policy. *GeoJournal, 80*(4), 503-518.

Thulin, E., & Vilhelmson, B. (2007). Mobiles everywhere Youth, the mobile phone, and changes in everyday practice. *Nordic Jurnal of Youth Research, 15*(3), 235-253.

Tobler, W. R. (1970). A computer movie simulating urban growth in the Detroit region. *Economic geography, 46*(sup1), 234-240.

Townsend, A. M. (2000). Life in the real-time city: Mobile telephones and urban metabolism. *Journal of urban technology*, *7*(2), 85-104.

Turner, A. (2007). From axial to road-centre lines: a new representation for space syntax and a new model of route choice for transport network analysis. *Environment and Planning B: Planning and design, 34*(3), 539-555.

Twitter Privacy Policy. (2018). Retrieved from https://twitter.com/en/privacy

UN. (2018). *World Urbanization Prospects 2018*. Retrieved from https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

Urry, J. (2003). Social networks, travel and talk1. *The British journal of sociology, 54*(2), 155-175.

Van Dijk, J. (2012). *The network society*: Sage Publications.

Vanky, A. P. (2017). *To and fro: digital data-driven analyses of pedestrian mobility in urban spaces.* Massachusetts Institute of Technology.

Wang, H., Chin, A., & Wang, H. (2011). *Interplay between social selection and social influence on physical proximity in friendship formation.* Paper presented at the SRS 2011 workshop.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications* (Vol. 8): Cambridge university press.

Weiler, A., Grossniklaus, M., & Scholl, M. H. (2015). Situation monitoring of urban areas using social media data streams. *Information Systems*.

Wellman, B. (2018). The network community: An introduction *Networks in the global village* (pp. 1-47): Routledge.

Wellman, B., & Frank, K. (2001). *Network Capital in multi-level World: Getting Support in Personal Communications*. chicago.

Wellman, B., & Haythornthwaite, C. (2002). *The Internet in Everyday Life*. Berlin: Blackwell Publishing.

Whyte, W. H. (1980). *Socail life of small urban spaces*. New York: PROJECT FOR PUBLIC SPACES.

Wyly, E. (2014). The new quantitative revolution. *Dialogues in Human Geography, 14*(1), 26–38.

Yoon, S., Elhadad, N., & Bakken, S. (2013). A practical approach for content mining of Tweets. *American journal of preventive medicine, 45*(1), 122-129.

Yuan, Y., Raubal, M., & Liu, Y. (2012). Correlating mobile phone usage and travel behavior–A case study of Harbin, China. *Computers, Environment and Urban Systems, 36*(2), 118-130.

Zachary, N. P. (2012). *The Connected City: How Networks are Shaping the Modern Metropolis*. Oxon: Routledge.

Zandbergen, P. A., & Barbeau, S. J. (2011). Positional accuracy of assisted gps data from high-sensitivity gps-enabled mobile phones. *Journal of Navigation, 64*(03), 381-399.

Zhan, X., Ukkusuri, S. V., & Zhu, F. (2014). Inferring urban land use using large-scale social media check-in data. *Networks and Spatial Economics, 14*(3-4), 647-667.

APPENDICES

Appendix A: A Sample of Check-in Geo-tagged Twitter Feed Data

Twitter Handle	Tweet	Tweet Date	Latitude	Longitude	Language	Place
ID_C1	I'm at Kybele in Famagusta, Cyprus w/ @denizzakilli @emircanakilli	3/9/2018 23:11	35.16128214	33.91235746	en	Cyprus
ID_C2	I'm at The Palm House Cafe & Restaurant in Gazimagusa, Famagusta	2/13/2018 13:51	35.12131401	33.95672392	en	Cyprus
ID_C3	I'm at Oza Coffee in Famagusta,	3/8/2018 21:22	35.14040082	33.91570395	en	Cyprus
ID_C4	I'm at Basket2 Restaurant & Cafe in Famagusta, Ammochostos	9/18/2017 15:27	35.14156429	33.91354491	en	Cyprus
ID_C5	I'm at Eastern Mediterranean University in Famagusta	9/24/2017 5:26	35.14157762	33.90889307	en	Cyprus
ID_C6	I'm at Departmant Of Electrical & Electronic Engineering in famagusta	9/29/2017 7:09	35.14442531	33.90778182	en	Cyprus
ID_C7	I'm at Coffeemania - @kcoffeemania in Gazimagusa, Ammochostos	10/22/2016 20:00	35.1373007	33.92019544	und	Cyprus
ID_C8	I'm at Palm Beach in Famagusta,	10/25/2016 19:54	35.12072162	33.95589636	en	Cyprus
ID_C9	I'm at Ehl-i Keyf in Gazimagusa, Cyprus	10/28/2016 21:07	35.14292397	33.9139262	tr	Cyprus
ID_C10	I'm at Costa Coffee in Gazimagusa, Ammochostos	7/27/2017 19:02	35.133521	33.923663	und	Cyprus
ID_C11	I'm at David People in Magusa,	7/27/2017 20:35	35.133672	33.923646	und	Cyprus
ID_C12	I'm at Aralik Sonu Ocakbasi in Famagusta,	7/28/2017 1:10	35.13508681	33.92152985	tr	Cyprus
ID_C13	I'm at Glapsides Beach in Famagusta, KKTC	9/28/2017 19:51	35.16042644	33.9135667	en	Cyprus
ID_C14	I'm at David People in Magusa,	10/3/2017 17:16	35.13331222	33.92372872	und	Cyprus
ID_C15	I'm at Ekor Premier in Gazimagusa, Cyprus	10/6/2017 12:41	35.12731294	33.92372477	und	Cyprus
ID_C16	I'm at Walnuts Coffee Bar & Grill in Famagusta,	10/14/2017 20:16	35.14279111	33.91425847	en	Cyprus
ID_C17	I'm at Ehl-i Keyf in Gazimagusa, Cyprus	10/21/2017 22:57	35.14292397	33.9139262	tr	Cyprus
ID_C18	I'm at BOO'M Club in Gazimagusa	10/22/2017 0:04	35.11978806	33.94556459	tr	Cyprus
ID_C19	I'm at Barcode in Famagusta,	10/31/2017 22:17	35.14308277	33.91387202	en	Cyprus
ID_C20	I'm at Ati's Cafe & Bar in Famagusta	11/4/2017 13:34	35.12062966	33.9560597	en	Cyprus
ID_C21	I'm at Gloria Jean's Coffees in Gazimagusa,	11/5/2017 21:47	35.13264785	33.92448181	en	Cyprus
ID_C22	I'm at Apachill Pub & Bar & Nargila in Famagusta,	11/26/2017 21:28	35.13751028	33.92004722	en	Cyprus
ID_C23	I'm at Ekor Premier in Gazimagusa, Cyprus	12/14/2017 11:44	35.12731294	33.92372477	und	Cyprus
ID_C24	I'm at Gloria Jean's Coffees in Gazimagusa,	1/6/2018 22:40	35.13264785	33.92448181	en	Cyprus
ID_C25	I'm at Petek Pastahanesi in Famagusta, Ammochostos	1/12/2018 20:07	35.12582883	33.94384695	tl	Cyprus
ID_C26	I'm at Jamie's Bistro & Lounge in Famagusta	2/10/2018 19:49	35.14392672	33.91333793	en	Cyprus
ID_C27	I'm at Gerrard's Irish Pub in Gazimagusa	2/14/2018 19:32	35.13431248	33.92326868	und	Cyprus
ID_C28	I'm at Barcode in Famagusta,	2/14/2018 20:09	35.14311513	33.91398607	en	Cyprus
ID_C29	I'm at Arkin Palm Beach Hotel in	2/23/2018 20:05	35.11948551	33.95824835	tr	Cyprus

Appendix B: A Sample of Free Geo-tagged Twitter Feed Data

Twitter Handle	Tweet	Tweet Date	Latitude	Longitude	Language	Place
ID_F1	Bu Gece KARAOKE Gecesine Haz?rm?y?z ?????????????? Ark?n Palm Beach Hotel Kumsal'? Saat :?	7/5/2017 15:45	35.11948208	33.95817435	tr	Cyprus
ID_F2	Beach Wedd?ng @ Ark?n Palm Beach Hotel ???? @ Arkin Palm Beach Hotel https://t.co/bWPIMsnalF	7/28/2017 19:42	35.11948208	33.95817435	tr	Cyprus
ID_F3	31 Temmuz Pazartesi Gecesi Kumsalda '' SPLIT '' Sinema Keyfi ??in Rezervasyon: Ye?im Koreli?	7/29/2017 23:00	35.11948208	33.95817435	tr	Cyprus
ID_F4	Sabaha yolcuyuz insallah ?? (@ Hazal's ?? in Magusa)	1/21/2017 21:07	35.14103706	33.91366747	tr	Cyprus
ID_F5	:((((((((@ Faculty Of Business And Economics w/ 9 others)	3/20/2013 11:31	35.14140119	33.91045097	en	
ID_F6	Quiz time.. (@ Faculty Of Business And Economics w/ 2 others)	5/3/2013 6:18	35.14140119	33.91045097	en	
ID_F7	Denize.......	6/9/2013 8:40	35.1419754	33.90815735	tr	
ID_F8	Haydi denize denize denizee birdaha	6/12/2013 11:50	35.1419754	33.90815735	tr	
ID_F9	Cok sicak yaniyoruz..	10/10/2013 14:49	35.1493009	33.905672	tr	
ID_F10	?? @ Palm Beach Sahil	1/25/2016 8:49	35.11886053	33.95793942	tl	
ID_F11	Just posted a photo @ Palm Beach Sahil	5/22/2016 14:58	35.11884554	33.9579191	en	Cyprus
ID_F12	#summer is #coming #cyprus #Famagusta @ Palm Beach Sahil	4/25/2015 14:45	35.11866948	33.95808709	tl	
ID_F13	?? @ Palm Beach Sahil	4/17/2015 20:05	35.11866948	33.95808709	tl	
ID_F14	?rfan (@ Magusa Kaleici | Famagusta Old Town, Walled City in Famagusta, KKTC	4/23/2017 15:55	35.12451314	33.9408466	und	Cyprus
ID_F15	?? @ Kaleici, Famagusta, Cyprus	3/30/2016 23:35	35.125	33.9417	und	Cyprus
ID_F16	Az ?nce bir fotograf payla?t? @ Magusa	7/28/2014 21:16	35.12703748	33.93314483	tr	
ID_F17	I just became the mayor of Othello Kalesi	3/10/2013 16:58	35.12598272	33.94382517	en	
ID_F18	8 March Woman?s Day?? (@ The People's i	3/8/2018 21:37	35.12464097	33.94464814	en	Cyprus
ID_F19	Erkeklere tavsiyem; o d?vmeler sizi kurtarm	7/10/2017 16:15	35.16139236	33.91286696	tr	Cyprus

Appendix C: Descriptive Statistics of All Variables Assigned to the Hexagonal Grid

		N	Minimum	Maximum	Mean	Std. Deviation
DV	Twitter	385	0	4880	160.91	547.560
	Check-ins	385	0	3574	110.42	399.029
	Free points	385	0	1345	50.49	160.971
DV	Survey	385	.0	337.0	6.722	26.6432
	INT_250	385	-1.0	56.9	11.736	7.2007
IV	INT_500	385	-1.0	77.4	24.654	14.8207
	INT_750	385	-1.0	110.8	40.722	25.2160
	INT_1000	385	8.4	161.6	60.180	36.2154
	INT_1250	385	10.9	236.5	82.219	48.6740
	INT_1500	385	19.8	303.7	106.401	61.3896
	INT_1750	385	23.7	355.3	131.961	74.1894
	INT_2000	385	27.3	395.3	158.768	85.9325
	INT_3000	385	47.9	555.9	261.684	120.5549
	INT_5000	385	97.0	719.3	416.473	138.7125
	CH_250	385	.0	102.4	15.535	18.8355
IV	CH_500	385	.0	771.9	121.473	136.2653
	CH_750	385	.0	1934.1	386.349	407.7729
	CH_1000	385	.0	5921.1	854.969	912.9112
	CH_1250	385	.0	13306.2	1591.332	1768.2030
	CH_1500	385	.0	24504.4	2646.872	3062.6618
	CH_1750	385	.0	38017.3	4029.180	4842.2649
	CH_2000	385	.0	53199.9	5695.525	7087.1951
	CH_3000	385	.0	137026.4	14406.731	19151.9618
	CH_5000	385	.0	316932.8	33528.976	47583.8879
	CC_250m	385	.0019867499879327	.0176819132112851	.006216386421019	.001270992183382
IV	CC_500m	385	.0019867499879327	.0040983562754240	.003091930849691	.000345252837697
	CC_750m	385	.0017206427667737	.0030218822342386	.002073585297757	.000180537476549
	CC_1000m	385	.0011783995846256	.0021187036874371	.001527125543819	.000156891996729
	CC_1250m	385	.0009521344397055	.0015948515937411	.001213727429419	.000122895780691
	CC_1500m	385	.0008303634897912	.0012849435500381	.001009606448108	.000091548200789
	CC_1750m	385	.0007143755967478	.0011663491417409	.000868297474146	.000078574767341
	CC_2000m	385	.0006047169844034	.0010983764098549	.000764280321486	.000074356606429
	CC_3000m	385	.0004388853255646	.0006733284981673	.000533815323390	.000049508469175
	CC_5000m	385	.0002724422834412	.0004905394215071	.000371836393208	.000048170434409
	CB_250m	385	.0	139.7	21.315	22.9453
	CB_500m	385	.3	968.4	132.928	147.6028
IV	CB_750m	385	.3	2183.3	397.212	411.7888
	CB_1000m	385	3.3	5594.3	882.954	918.5639
	CB_1250m	385	15.3	13226.7	1663.818	1813.8173
	CB_1500m	385	24.7	25494.1	2814.480	3203.4712
	CB_1750m	385	36.2	40999.7	4312.983	5059.1506
	CB_2000m	385	77.0	58325.6	6121.227	7305.0667
	CB_3000m	385	252.9	136846.8	15313.191	18847.3680
	CB_5000m	385	501.0	296330.6	33798.121	43255.8934
	Valid N (listwise)	385				

Appendix D: Correlation Coefficient Between Twitter Data and All Independent Variables

q	INT_250	INT_500	INT_750	INT_1000	INT_1250	INT_1500	INT_1750	INT_2000	INT_3000	INT_5000	INT
Ln_tweets_per_unit	.420**	.445**	.433**	.393**	.352**	.316**	.292**	.275**	.268**	.349**	.142*
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.019
Twitter	.329**	.405**	.368**	.325**	.278**	.236**	.205**	.181**	.153**	.209**	.110*
	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.033

	CH_250	CH_500	CH_750	CH_1000	CH_1250	CH_1500	CH_1750	CH_2000	CH_3000	CH_5000	CH
Ln_tweets_per_unit	.407**	.454**	.436**	.354**	.294**	.244**	.210**	.187**	.165**	.191**	.142*
	.000	.000	.000	.000	.000	.000	.000	.002	.006	.002	.018
Twitter	.385**	.425**	.379**	.303**	.239**	.183**	.148**	.132*	.119*	.144**	.119*
	.000	.000	.000	.000	.000	.000	.004	.010	.021	.005	.021

	CC_250m	CC_500m	CC_750m	CC_1000m	CC_1250m	CC_1500m	CC_1750m	CC_2000m	CC_3000m	CC_5000m	CC_N
Ln_tweets_per_unit	.128*	.004	.019	.181**	.210**	.236**	.207**	.186**	.145*	.069	.411**
	.034	.942	.753	.003	.000	.000	.001	.002	.016	.254	.000
Twitter	.008	.021	.086	.194**	.243**	.291**	.295**	.270**	.174**	.006	.216**
	.875	.690	.095	.000	.000	.000	.000	.000	.001	.911	.000

	CB_250m	CB_500m	CB_750m	CB_1000m	CB_1250m	CB_1500m	CB_1750m	CB_2000m	CB_3000m	CB_5000m	CB_N
Ln_tweets_per_unit	.326**	.381**	.390**	.339**	.288**	.249**	.221**	.203**	.172**	.196**	.138*
	.000	.000	.000	.000	.000	.000	.000	.001	.004	.001	.022
Twitter	.351**	.386**	.348**	.285**	.233**	.191**	.162**	.145**	.128*	.179**	.156**
	.000	.000	.000	.000	.000	.000	.002	.005	.013	.000	.002

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix E: Internal Correlation of Space Syntax Angular Integration at Different Proxies

		INT_250	INT_500	INT_750	INT_1000	INT_1250	INT_1500	INT_1750	INT_2000	INT_3000	INT_5000	INT
INT_250	ß	1	.823**	.755**	.673**	.605**	.551**	.517**	.494**	.421**	.358**	.044
	Sig.		.000	.000	.000	.000	.000	.000	.000	.000	.000	.390
INT_500	ß	.823**	1	.966**	.895**	.825**	.768**	.730**	.699**	.615**	.566**	.257**
	Sig.	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
INT_750	ß	.755**	.966**	1	.973**	.924**	.875**	.837**	.804**	.718**	.674**	.364**
	Sig.	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000
INT_1000	ß	.673**	.895**	.973**	1	.984**	.951**	.918**	.888**	.803**	.756**	.463**
	Sig.	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
INT_1250	ß	.605**	.825**	.924**	.984**	1	.989**	.967**	.943**	.869**	.815**	.525**
	Sig.	.000	.000	.000	.000		0.000	.000	.000	.000	.000	.000
INT_1500	ß	.551**	.768**	.875**	.951**	.989**	1	.993**	.978**	.915**	.855**	.562**
	Sig.	.000	.000	.000	.000	0.000		0.000	.000	.000	.000	.000
INT_1750	ß	.517**	.730**	.837**	.918**	.967**	.993**	1	.995**	.946**	.881**	.579**
	Sig.	.000	.000	.000	.000	.000	0.000		0.000	.000	.000	.000
INT_2000	ß	.494**	.699**	.804**	.888**	.943**	.978**	.995**	1	.966**	.902**	.595**
	Sig.	.000	.000	.000	.000	.000	.000	0.000		.000	.000	.000
INT_3000	ß	.421**	.615**	.718**	.803**	.869**	.915**	.946**	.966**	1	.954**	.629**
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
INT_5000	ß	.358**	.566**	.674**	.756**	.815**	.855**	.881**	.902**	.954**	1	.728**
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
INT	ß	.044	.257**	.364**	.463**	.525**	.562**	.579**	.595**	.629**	.728**	1
	Sig.	.390	.000	.000	.000	.000	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix F: Internal Correlation of Space Syntax Choice at Different Proxies

q		CH_250	CH_500	CH_750	CH_1000	CH_1250	CH_1500	CH_1750	CH_2000	CH_3000	CH_5000	CH
CH_250	ß	1	.919**	.790**	.646**	.533**	.452**	.397**	.358**	.291**	.244**	.166**
	Sig.		.000	.000	.000	.000	.000	.000	.000	.000	.000	.001
CH_500	ß	.919**	1	.943**	.828**	.723**	.641**	.581**	.538**	.461**	.400**	.284**
	Sig.	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
CH_750	ß	.790**	.943**	1	.960**	.891**	.822**	.765**	.721**	.638**	.563**	.418**
	Sig.	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000
CH_1000	ß	.646**	.828**	.960**	1	.979**	.936**	.892**	.853**	.773**	.683**	.516**
	Sig.	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
CH_1250	ß	.533**	.723**	.891**	.979**	1	.987**	.960**	.932**	.864**	.764**	.582**
	Sig.	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000
CH_1500	ß	.452**	.641**	.822**	.936**	.987**	1	.992**	.976**	.923**	.816**	.624**
	Sig.	.000	.000	.000	.000	.000		0.000	.000	.000	.000	.000
CH_1750	ß	.397**	.581**	.765**	.892**	.960**	.992**	1	.995**	.959**	.853**	.657**
	Sig.	.000	.000	.000	.000	.000	0.000		0.000	.000	.000	.000
CH_2000	ß	.358**	.538**	.721**	.853**	.932**	.976**	.995**	1	.978**	.874**	.675**
	Sig.	.000	.000	.000	.000	.000	.000	0.000		.000	.000	.000
CH_3000	ß	.291**	.461**	.638**	.773**	.864**	.923**	.959**	.978**	1	.931**	.740**
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
CH_5000	ß	.244**	.400**	.563**	.683**	.764**	.816**	.853**	.874**	.931**	1	.900**
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
CH	ß	.166**	.284**	.418**	.516**	.582**	.624**	.657**	.675**	.740**	.900**	1
	Sig.	.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix G: Internal Correlation of Closeness Centrality (C_C) at Different Network Proxies

		CC_250m	CC_500m	CC_750m	CC_1000m	CC_1250m	CC_1500m	CC_1750m	CC_2000m	CC_3000m	CC_5000m	CC_N
CC_250m	ß	1	.575**	.033	.239**	.254**	.226**	.156**	.210**	.225**	.217**	.198**
	Sig.		.000	.526	.000	.000	.000	.002	.000	.000	.000	.000
CC_500m	ß	.575**	1	.532**	.419**	.376**	.304**	.190**	.227**	.163**	.092	.018
	Sig.	.000		.000	.000	.000	.000	.000	.000	.001	.073	.730
CC_750m	ß	.033	.532**	1	.625**	.441**	.326**	.223**	.144**	.021	-.174**	-.243**
	Sig.	.526	.000		.000	.000	.000	.000	.005	.687	.001	.000
CC_1000m	ß	.239**	.419**	.625**	1	.914**	.736**	.551**	.448**	.315**	.081	.063
	Sig.	.000	.000	.000		.000	.000	.000	.000	.000	.118	.224
CC_1250m	ß	.254**	.376**	.441**	.914**	1	.897**	.697**	.579**	.423**	.124*	.124*
	Sig.	.000	.000	.000	.000		.000	.000	.000	.000	.016	.016
CC_1500m	ß	.226**	.304**	.326**	.736**	.897**	1	.908**	.800**	.566**	.132*	.111*
	Sig.	.000	.000	.000	.000	.000		.000	.000	.000	.010	.031
CC_1750m	ß	.156**	.190**	.223**	.551**	.697**	.908**	1	.953**	.666**	.170**	.092
	Sig.	.002	.000	.000	.000	.000	.000		.000	.000	.001	.075
CC_2000m	ß	.210**	.227**	.144**	.448**	.579**	.800**	.953**	1	.745**	.244**	.119*
	Sig.	.000	.000	.005	.000	.000	.000	.000		.000	.000	.021
CC_3000m	ß	.225**	.163**	.021	.315**	.423**	.566**	.666**	.745**	1	.624**	.380**
	Sig.	.000	.001	.687	.000	.000	.000	.000	.000		.000	.000
CC_5000m	ß	.217**	.092	-.174**	.081	.124*	.132*	.170**	.244**	.624**	1	.768**
	Sig.	.000	.073	.001	.118	.016	.010	.001	.000	.000		.000
CC_N	ß	.198**	.018	-.243**	.063	.124*	.111*	.092	.119*	.380**	.768**	1
	Sig.	.000	.730	.000	.224	.016	.031	.075	.021	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix H: Internal Correlation of Betweenness Centrality (C_B) at Different Network Proxies

w		CB_250m	CB_500m	CB_750m	CB_1000m	CB_1250m	CB_1500m	CB_1750m	CB_2000m	CB_3000m	CB_5000m	CB_N
CB_250m	ß	1	.955**	.856**	.715**	.601**	.528**	.480**	.448**	.372**	.291**	.174**
	Sig.		.000	.000	.000	.000	.000	.000	.000	.000	.000	.001
CB_500m	ß	.955**	1	.947**	.823**	.712**	.638**	.589**	.554**	.472**	.380**	.234**
	Sig.	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
CB_750m	ß	.856**	.947**	1	.955**	.880**	.817**	.769**	.734**	.648**	.535**	.340**
	Sig.	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000
CB_1000m	ß	.715**	.823**	.955**	1	.978**	.937**	.900**	.869**	.785**	.661**	.436**
	Sig.	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
CB_1250m	ß	.601**	.712**	.880**	.978**	1	.987**	.963**	.940**	.867**	.734**	.492**
	Sig.	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000
CB_1500m	ß	.528**	.638**	.817**	.937**	.987**	1	.993**	.980**	.923**	.784**	.533**
	Sig.	.000	.000	.000	.000	.000		0.000	.000	.000	.000	.000
CB_1750m	ß	.480**	.589**	.769**	.900**	.963**	.993**	1	.996**	.955**	.821**	.569**
	Sig.	.000	.000	.000	.000	.000	0.000		0.000	.000	.000	.000
CB_2000m	ß	.448**	.554**	.734**	.869**	.940**	.980**	.996**	1	.974**	.846**	.597**
	Sig.	.000	.000	.000	.000	.000	.000	0.000		.000	.000	.000
CB_3000m	ß	.372**	.472**	.648**	.785**	.867**	.923**	.955**	.974**	1	.917**	.698**
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
CB_5000m	ß	.291**	.380**	.535**	.661**	.734**	.784**	.821**	.846**	.917**	1	.911**
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
CB_N	ß	.174**	.234**	.340**	.436**	.492**	.533**	.569**	.597**	.698**	.911**	1
	Sig.	.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).