The Impact of Mobile Touch Screen Device Use on Musculoskeletal Disorder: Risk Assessment Modeling and Verification

Ali S. Milad Elghomati

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Prof. Dr. Ali Hakan Ulusoy
Director

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

Prof. Dr. Gökhan İzbırak
Chair, Department of Industrial Engineering

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 Industrial Engineering.

Prof. Dr. Orhan Korhan
Supervisor

Examining Committee

1. Prof. Dr. Emin Kahya
2. Prof. Dr. Orhan Korhan
3. Prof. Dr. Serap Ulusam Seçkiner
4. Prof. Dr. Qasim Zeeshan
5. Assoc. Prof. Dr. Ender Angın

ABSTRACT

Background. Touch screen interface is a technology that is applied to almost all mobile devices. Their intensive and repetitive touch screen may pose a significant problem, which creates ergonomic pains on musculoskeletal disorders. Purpose. This research aims to study the impact of using Mobile Touch Screen Devices (MTSDs) on the human musculoskeletal system and assess the pain interference with the ability to work. Methods. Cornell musculoskeletal discomfort questionnaire was given to 544 participants (71% males and 29% females) at the Eastern Mediterranean University. Association rules mining technique is applied to illustrate the correlation and logistic regression to identify the significant risk factors. Subsequently, the sample data was tested using five different machine learning models; the support vector machine, the long-short-term memory neural, the back-propagation, radial basis function and the ensemble bagged tree to offer predictive accuracy. Results**.** Most musculoskeletal disorders were reported in the neck region and lower back (64.3% and 55.3%) respectively, followed by upper back (44.3%), and the right shoulder (37.5%). Analysis of association rules showed positive correlation between the lower back and the neck (support = 44%, confidence = 77%). The discomforts were at the neck, shoulders, upper and lower back. The findings reveal that both sitting and behind a desk performing a task while sitting result in significant risk factors of physical discomfort. Additionally, the results found that the results found that the ensemble bagged tree has the highest accuracy in prediction. The ensemble bagged tree achieved the highest scores of all of the metrics (91%, 94.3 %, 96.1%, and 95.2% for accuracy, macro-precision, macro-recall, and macro-averaged F1-score) and outperformed other models. Conclusions. The ensemble bagged tree predicted the interference of the pain in the muscle performance ability for the users. Moreover, the discomfort level was the highest in the neck and lower back areas.

Keywords: association rules; musculoskeletal disorders; risk assessment modeling; radial basis function; touch screen

ÖZ

Arka fon. Dokunmatik ekran arayüzü, hemen hemen tüm mobil cihazlara uygulanan bir teknolojidir. Yoğun ve tekrarlayan dokunmatik ekranları, kas-iskelet sistemi rahatsızlıklarında ergonomik ağrılar yaratan önemli bir sorun oluşturabilir. Amaç. Bu araştırma, Mobil Dokunmatik Ekran Cihazlarının (MTSD'ler) insan kas-iskelet sistemi üzerindeki etkisini incelemeyi ve çalışma yeteneği ile ağrı etkileşimini değerlendirmeyi amaçlamaktadır. Yöntemler. Doğu Akdeniz Üniversitesi'nde 544 katılımcıya (%71 erkek ve %29 kadın) Cornell kas-iskelet rahatsızlık anketi uygulandı. Önemli risk faktörlerini belirlemek için korelasyon ve lojistik regresyonu göstermek için birliktelik kuralları madenciliği tekniği uygulanır. Ardından, örnek veriler beş farklı makine öğrenimi modeli kullanılarak test edildi; destek vektör makinesi, uzun-kısa süreli bellek siniri, geri yayılım, radyal temel işlevi ve tahmin doğruluğu sunmak için topluluk torbalı ağaç. Sonuçlar. En çok kas-iskelet sistemi rahatsızlıkları boyun bölgesinde ve alt sırtta (%64.3 ve %55.3) rapor edilmiştir, bunu sırt üstü (%44,3) ve sağ omuz (%37.5) izlemiştir. Birliktelik kurallarının analizi, alt sırt ve boyun arasında pozitif korelasyon gösterdi (destek = %44, güven = %77). Rahatsızlıklar boyun, omuzlar, üst ve alt sırttaydı. Bulgular, hem oturmanın hem de masanın arkasında otururken bir görevi yerine getirmenin fiziksel rahatsızlık için önemli risk faktörleriyle sonuçlandığını ortaya koymaktadır. Ek olarak, sonuçlar, toplu torbalı ağacın tahminde en yüksek doğruluğa sahip olduğunu bulmuştur. Toplu torbalı ağaç, tüm metriklerin en yüksek puanlarını elde etti (%91, %94.3, %96.1 ve doğruluk, makro-hassasiyet, makro-hatırlama ve makro-ortalamalı F1 puanı için) ve diğer modellerden daha iyi performans gösterdi. Sonuçlar. Topluluk torbalı ağaç, ağrının kullanıcılar için kas performans kabiliyetine müdahalesini öngördü. Ayrıca rahatsızlık düzeyi en yüksek boyun ve bel bölgesindeydi.

Anahtar Kelimeler: birliktelik kuralları; kas-iskelet sistemi bozukluğu; risk değerlendirme modellemesi; radyal temel fonksiyonu; dokunmatik ekra

DEDICATION

To my wife and children, your presence in my life has distinctively made me succeed in my study.

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Chapter 1

INTRODUCTION

1.1 Background of the Study

Touch screen interface has been the technology of virtually all devices especially telecommunication mobile gadgets. These mobile gadgets, over two decades now have becomes a necessary possession of everyone irrespective of age, race, religion, gender and colour or creed. The highest proportion of use the technologies devices among users are the touchscreen devices (KORHAN & ELGHOMATİ, 2019) . Most of this advanced interface requires the stylus or finger touch hence there are mostly regarded as a Mobile Touchscreen Device (MTSDs). In fact, many people are in possession of more than one of these devices; we can simply infer that mobile touchscreen device has become a norm in the day-to-day activities of millions of people world over. Buttressing this inference is the report of Gustafsson et al. (2018); Mackay and Weidlich (2014); Poushter (2016); Toh et al. (2017) that put the figures of the users in Sweden and Australia to be 80% of the (ages 9-79 years) and 89% of the (ages 18-75 years) population respectively. For , 87% teenager of US population between 18 – 34 years, 79% of ages between 12 – 15 years for the UK, 93% and 95% among adults of ages 18 and 34 respectively and the categories goes on and on. Without over-emphasizing, MTSDs have become essential devices among different categories of people in the world.

MTSDs gained this wide acceptance and usage due to their ability to enhance the delivery of some activities efficiently and effectively. They are used for sending and receiving instant messages, calls, emails, and for assessing the internet. These and many advantages of mobile touch screen devices have resulted in huge potential social, mental and behavioural effects. However, mobile touch screen devices have also been associated with some negative effects especially on the social relationships, depression and sleep quality as reported by Demirci et al. (2015); Seo et al. (2016), and these consequently have resulted in the increase in the potential physical distortions or frails usually counted among the musculoskeletal disorder. Hakala et al. (2006); Harris et al. (2015); Siu et al. (2009); Torsheim et al. (2010) opined that the use of these high-tech devices is associated with musculoskeletal symptoms of in some related studies. Mobile touch screen devices have created a shift from the conventional keyboard, traditional desktops and laptops to virtual keyboards of varying sizes thereby altering the strength of relationships between key activation force and typing force. The latter is highly related to the key activation force (J. H. Kim et al., 2014). This replacement can be adduced to twists in the musculoskeletal exposures leading to discomforts is some essential muscles of the users.

1.2 Statement of Problems

Several methods have been employed to study and proffer solution to the musculoskeletal problems due to mobile touch screen devise usage. Berolo et al. (2011) examined the symptoms among mobile hand-held device users and their relationship to the devise use with most participants reporting pains in at least one part of the body especially in the right hand at the base of the thumb. However, the continuous use required by these devices of repetitive movements from our hands (e.g. wrists and arms) for use leads to muscular effort and musculoskeletal disorder, such as neck and shoulder (H.-J. Kim & Kim, 2015; Shim, 2012). Multiple touches may result in joint excursions and tap through the increased in the use of the flexed thumb and the decreased efficiency at the wrist joints (Asakawa et al., 2017; Gustafsson et al., 2018; H. Kim & Song, 2014; Trudeau et al., 2012). Furthermore, the use of touchscreen smartphones leads to loading over fingers and thumbs especially when performing on the phones with high speed and high repetition rates (Y. F. Xie et al., 2016). These musculoskeletal exposures include the posture, posture variables examine include angles of head, neck, cranio-cervical, shoulder, distal upper extremity (elbow, wrist, fingers and thumb) flexion/extension, head and neck gravitation demand as well as posture and movement variability. Once distortions set in, some of the following symptoms could be perceived and noticed (i) include self-reported pain, (ii) discomfort at the neck/shoulder (iii) back and upper extremities (upper arm, forearm, wrist, fingers, and thumb). These can be measured by motion analysis systems, video or photograph analysis and the range of motion meters or electro goniometers (Toh et al., 2017).

These could be well explained through the muscle activity variables through the process of electromyography (EMG). Figure 1 demonstrates the EMG clearly by giving those muscles exposures that are greatly affected by the use of these MTSDs as the upper trapezius, cervical extensors and distal upper extremity (e.g. wrist, finger or thumb flexors/extensors).

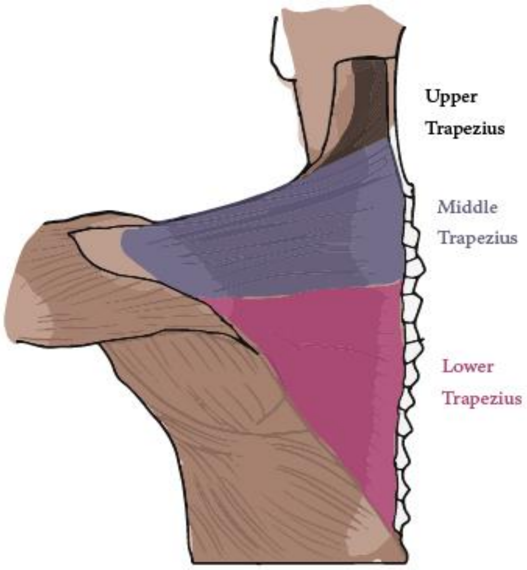

Figure 1. Muscles exposures of upper limb

By employing visual analogue scale (VAS), numeric or loo point rating scale and body map or questions these symptoms can be measured.

1.3 Motivation to Solve the Problem

Due to the limitation of the previous study that focuses on using mobile touchscreen devices and its effect on musculoskeletal disorders. There is a lack of information about the effect of using mobile touchscreen devices on musculoskeletal disorders. Finding significant effect of using mobile touchscreen devices on musculoskeletal disorders will be important as a guideline to use these devices in the future to reduce the risk on people. Implications for smartphone users include the need to select a phone which fits their hand size, especially if they intend doing intensive text entering. Smartphone users and designers should be aware that hand size influences thumb kinematics and muscle activity and thus manufacturers should consider offering phones in different sizes to suit the range of user hand sizes. Indeed many smartphones manufacture now offer smartphones in different sizes. Although there are several studies that have been focused on the relationship between using mobile touchscreen devices and musculoskeletal disorder, still there is limited evidence that mobile touch screen device usage has an effect on musculoskeletal system (Toh et al., 2017).

1.4 Aim of the Study

This research aims to study the impact of using mobile touchscreen devices (tablet computers and smartphones) on the human musculoskeletal system, and identifying significant factors that lead to pain and discomfort in which body regions during mobile touchscreen devices use. Specifically, the study is aimed at evaluating and confirming if and to what extent dose the use of touch-screen smartphones relate to the experience of musculoskeletal pains among the users of such devices. In this respect, risk assessment modeling and verification which shows the significant risk factors that contribute to the experience of physical discomfort among mobile touch screen devices users is determined. Additionally to machine learning (ML) algorithms predict the impact pain or discomfort of mobile touch screen devices use on different body regions and defined the risk levels that interfered with the ability to perform daily activities. Also association rule mining approach to extract interesting correlations and patterns.

1.5 Scope and Significance of the Problem

There is a few knowledge about the activation level of muscles from the neck and upper extremities among touchscreen smartphones users. Moreover, there is no indication of the level of muscle activation differs among users using touchscreen smartphones. This research is provided for the readers who are interested in revealing and obtaining information related to the impact mobile touchscreen device on the musculoskeletal disorder. The end result will help to identify the participants who are under the risk musculoskeletal distortions with the use of a mobile touchscreen device on musculoskeletal and predict if there will be an interference to the users' daily activities performance that can lead to absenteeism because of pain in their various body parts. This study will focus only on Eastern Mediterranean University (EMU) student's which may limit the generalization of the result. According to previous studies, the relationships between MTSDs and musculoskeletal are expected to be positive. In this context a logistic regression model was applied, to reveal the risk factors of musculoskeletal disorders among users of mobile touch screen devices, would be developed by assessing and analyzing questions about musculoskeletal about pain or discomfort occurrence, severity, and interfere with ability to daily activities in18 body parts during last week on the use of the mobile touch screen devices. Then will be applied machine learning technic to classifying risk levels for interference with the ability to perform daily activities. Association rules mining technique was applied to illustrate the correlation.

Chapter 2

LITERATURE REVIEW

This chapter previews the relevant studies in the literature about the musculoskeletal disorder and the effects of using touch screen devices, such as mobile phones and tablets and presents the gap in the literature. The perceptions and opinions of the previous researchers will be presented in relation with our aims in the current study.

This chapter will be narrative of literature according to the pertinent aspects:

i) Researches regarding the usage of using touch screen devices (smartphone and tablet) for daily activities for university students;

ii) Studies concerning multitasking of handheld devices (i.e. gaming, texting, and calls tasks);

iii) Studies concerning the description of the risk factors and types of musculoskeletal disorders;

iv) Studies regarding the advantages and disadvantages of touch screen devices;

v) Studies regarding Artificial Neural Networks (ANNs) and the advantages and disadvantages.

2.1 Users of Mobile Touch Screen Devices

Due to the information and technology revolution witnessed in the twenty-first century, and with the trends of the modern era, there has been a wide usage of mobile touch screen devices among people. This has also led to a rapid development in the technology field, especially smartphones. Today smartphones have become touchscreen only. Those devices such as smartphones, tablets, gaming consoles, etc. are handheld devices that made our lives easier and more interconnected. Thus, these devices have become more common among young people.

A recent study showed that more than three-quarters of the population between the ages 18 to 44 years have their mobile touch screen devices such as smartphones with them almost all the time on day, with only two hours of their waking day spent without their devices in hand (Neupane et al., 2017) .They are also used as a supporting tool for education especially for the university students. This has led to addiction of using such devices. Some of the consequences of this addiction includes irresistibility and lack of self-control when using mobile touch screen devices (Toh et al., 2019).

Berolo et al. (2011), found that 98% of participants (students, administrative, and faculty members) in a Canadian University use mobile devices for 4.65 hours a day. As a result, the development of tech and rising growth of mobile touch screen use has become of negative effect on the hands and upper extremities of the participants. So et al. (2017) conducted a study about the time consumed for daily use of mobiles. The study found that 90% of the participants reported daily use of smartphones, 31% of which spend 1-2 hours a day while 19% reach 2-4 h/day.

In the past years, the number of computer users has dramatically fallen compared to the rising number of mobile touch screen devices users worldwide because of their versatility and abundance of applications (Y. F. Xie et al., 2016).The total amount of smartphone sales alone is estimated to be over 837 million gadgets in 2013 (Favell, 2014). Moreover, a worldwide growth rate of 26% has been predicted for devices such as tablets and smartphones in the period between 2012 and 2016. This is because of the features of mobiles that are suitable for the users, such as portability and availability with the users all the time (Guiry et al., 2014).

Touchscreen technology has been generated approximately $16 billion in revenues in 2012. And according to the study firm ID Tech EX, the touch screen widest spread is expected to increase three times by 2022 (Thiele Cathleen, 2013,Oct 03). This widespread of the use of mobile touchscreen devices will have an increase in the risks of musculoskeletal disorders due to the increasing number of usage hours for the users, especially the university students.

A systematic review of ergonomic and stress-related literature by Toh et al. (2017) highlighted the need for scholars to investigate the relationship between the increasingly number of touch screen mobile device users and the surge in the number of occurrences of musculoskeletal disorders. The constant surf for the social media and the use of smartphones for the academic purposes may hurt the muscles because of the repetitive usage of the muscle and the improper ways of seating while using the mobiles.

2.2 Features and Services Offered by Technology of MTSD

Mobile touchscreen devices are now becoming very popular among people including smartphones and tablets. The users of these devices are no longer solely restricted to conventional computers for completing daily work activities because mobile devices provide a range of functions in the form of mobile applications (apps) always available at all times. Therefore, we can no longer assume that users of mobile devices are still in a stationary state (seated or standing) or physically restricted by any other activity (such as carrying objects or opening the door).

The use of mobile devices has become prevalent among college students. Because of the small size, they are now made sufficiently portable to use "on the go " when they stand, sit and walk. Which makes them widely used for different tasks and all of these require the use of fingers or thumbs most often. Furthermore, these devices are surface area providing the user with a large display screen with few a number of physical keys (Karlson et al., 2005). Because of their versatility and abundance of applications, the majority of keypad phone products has been replaced by smartphones (Y. F. Xie et al., 2016). Thus, the mobile touch screen devices, such as tablets and smartphones, have become used essential for our future lives (Chiang & Liu, 2016). We use these devices in public and private spaces, such as homes, cars, offices, schools, restaurants, shops, museums, hotels, airports, trains.

The use of mobile touch screen devices is one of the options that could allow users to connect the internet. Therefore, the reason why touchscreen tablets are popular might be a range of advantages, which include ease of use, portability, speed, ergonomics, and lightweight (Baker et al., 2016). Recently, touch screen technology is omnipresent (Danial-Saad & Chiari, 2018).

Being unable to make use of technology isolates users and makes it difficult to live their daily lives Quan-Haase et al. (2017), such as access to online banking and public services (Van Deursen & Helsper, 2015). In addition, mobile touch screen devices has features like buttons and texts be enlarged, making them clearly to see and accurate to selection (Caprani & Gurrin, 2012). As mobile devices have introduced new avenues to enhance the educational system, thus, mobile terminals have replaced traditional computers with the capability to have operating systems and storage capacity that allows many applications to run on them (Cruz-Cunha & Moreira, 2011).

The role of mobile phones has changed among users; it is not only for calling and texting, but also for other tasks (e.g. playing games, browse the web watching videos and using social media) (Boufaied et al., 2016). These devices need the users to touch on the screens using their fingers (Hoye & Kozak, 2010).

2.3 Musculoskeletal Disorders and Types of Risk Factors

Musculoskeletal disorders of the upper and lower extremities are that affect the back, neck, shoulders, arms, wrists, and fingers. They have symptoms such pain, tingling and numbness when the extremities are used (Hamilton et al., 2005). The general population is affected by symptoms/disorders of the musculoskeletal upper extremity. In 2008 Statistics Sweden, 32-34% of workers reported that every week they suffer from neck and upper extremity pain (Sweden, 2008). Carter and Banister (1994) indicated that the majority of musculoskeletal discomfort in short-term is resolved by rest, may only develop after a long period due to recurring injury. Therefore, musculoskeletal disorders is one factor vital that effect on public health.

The table below summarizes a selection of papers and publications which related the prevalence of musculoskeletal complaints and significant risk factors.

Table 1. Musculoskeletal complaints literature review

Topic	Author (s)	Journal Name	Study population	Study design and type of MTSD examined	Statistical analysis	Outcomes
Review of the factors associated with musculoskeletal problems in epidemiological studies.	Malchaire et al., 2001).	International archives of occupational and environmental health	n = 57 cross-sectional and 7 longitudinal studies were included Age: Unclear Gender: Unclear	Review paper.	Unclear	• The findings are systematically associated with musculoskeletal disorders in occupational risk factors such as repetitiveness, physical workload and static efforts for both neck-shoulder and hand-wrist. • The medical history refers to bad health was found significant for neck-shoulder and less systematically for hand-wrist. • There are several differences in muscle fibber type postulated (for neck disorders) and hormonal differences (especially for carpal tunnel syndrome) but, most of all, differences in occupational exposures and home activities. • Psycho-organizational factors referring to psycho-organizational

						and stress factors are more associated with musculoskeletal problems or disorders in the cervicobrachial region.
Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use: a preliminary study in a Canadian university population.	(Berolo et al., 2011)	Applied ergonmics	n = 140 students, staff, and faculty Age: Unclear Gender: 60 males, 80 females	A cross-sectional design. Mobile hand-held device	The chi-square probability. Multivariable logistic model.	• 84% of participants reported pain of any severity in at least one body part. • The results shows that the rising daily use of the majority of university students for the mobile devices, like instant SMS and reply to emails and internet browsing, severe pain in the neck and both shoulders. • The musculoskeletal symptoms occurring mostly at the middle of the right thumb associated to time spent on gaming. • Serious pain in the base of the right thumb connected with time spent on internet browsing.
The effect of carpal tunnel changes on smartphone users.	(Shim, 2012)	Journal of Physical Therapy Science	n = 20 young adults Age: 22.3 ± 0.8 Gender: 20 male and female	A laboratory study. Smartphone	Paired t-test	• Repetitive thumb pushing and repetitive movements have been reported as risk factors for developing thumb and thumb muscles in the forearm.

Effects of the use of smartphones on pain and muscle fatigue in the upper extremity.	(G. Y. Kim et al., 2012)	Annals of rehabilitation medicine	n = 43 healthy young adults Age: 20-27 Gender: 18 males, 25 females	A laboratory experiment. Smartphone and computer	The Kolmogorov Smirnov and Shapiro-Wilk tests one-way ANOVA Paired t-tests post hoc multiple comparison analysis	• There is relationship between touch screen devices and their long-term use. • There is an increases in risk of musculoskeletal symptoms in upper extremity and neck.
An empirical study on relationship between symptoms of musculoskeletal disorders and amount of smartphone usage.	(Eom et al., 2013)	Journal of the Korea safety management & science	n = 983 adults Age: Over age 20 Gender: 574 males, 409 females	An epidemiological study. Smartphone	Descriptive statistics Chi-squared test Logistic regression	• 19% of the participants had at least one body part with a musculoskeletal symptom (neck, shoulder, elbow, and hand). • The symptoms were also associated with the amount of text and the time to use the smartphone on a daily basis (hand/wrist/ fingers).
Musculoskeletal disorders of the upper extremities due to extensive usage of hand held devices.	(Sharan et al., 2014)	Annals of occupational and environmental medicine	n = 70 subjects Age: 34.18 Gender: 55 males, 15 females	A retrospective report analysis. Handheld device	Descriptive statistics Sample T test	• The usage of handheld devices that requires multi thumb movements, such as SMS texting, and video games on the smart electronic devices, was the main factor of increasing the disorders symptoms in the thumb and forearm.
Neck kinematics and muscle activity during mobile device operations.	(Ning et al., 2015)	International Journal of Industrial Ergonomics	n = 14 right-handed participants Age: Unclear Gender: 10 males, 4 females	A laboratory experiment. Smartphone and tablet	Turkey-Kramer post-hoc test Multivariate ANOVA (MANOVA)	• • When using mobile touchscreen devices while performing a typing task, users have low neck flexion.

						• Lower levels of neck muscle activity and holding mobile devices with hand were reported due to the reading task • When using a smartphone, versus a tablet, lower levels of neck muscle activity were reported.
The relationship between smartphone use and subjective musculoskeletal symptoms and university students.	(H.-J. Kim & Kim, 2015)	Journal of Physical Therapy Science	n = 292 university student Age: 21.42±1.5 Gender: Unclear	Self-administered questionnaire. Smartphone	Descriptive statistics Pearson's correlation Coefficient Logistic regression analysis	• Back pain had a positive correlation with the size of the LCD screen, while pain in the legs and feet had a negative correlation with the period of smartphone use. • Most of the musculoskeletal symptoms occurred mainly in the neck and shoulder region, and were reported to be prevalent among 55.3% of smartphone users
Exploration of the associations of touch-screen tablet computer usage and musculoskeletal discomfort.	(Chiang & Liu, 2016)	work	n = 80 college students Age: > 20 Gender: 26 males, 54 females	A laboratory experiment with questionnaire. Touch screen tablet	Descriptive statistics -Chi-squared test Independent t test	• After using tablets, more than half of the participants reported the most prevalent discomfort of their necks and shoulders. • The discomfort in those areas included various tasks (neck flexion when playing games.)

An extensive usage of hand held devices will lead to musculoskeletal disorder of upper extremity among student in AMU: A survey method.	(Balakrishnan et al., 2016)	International Journal of Physical Education, Sports and Health	n = 200 students Age: 18-30 Gender: Unclear	Cross sectional survey. Hand held devices	Frequency distribution	• 72.50% had mild to severe pain in the upper limb, 44% of participants had mild to extreme stiffness in the arm, shoulder and hand during performing any specific task.
Texting on mobile phones and musculoskeletal disorders in young adults: a five-year cohort study.	(Gustafsson et al., 2017)	Applied ergonomics	n = 7092 young adults Age: 20-24 Gender: 2759 males, 4333females at baseline	Cohort study. Mobile phone	Descriptive statistics -Logistic regression models Cross-tables Spearman correlation	• The cross-sectional associations between text messaging on mobile phone and reporting pain in the neck/upper back and shoulder/upper extremities, and numbness/tingling in the hand/fingers. • There are short-term effects and, long-term effects on musculoskeletal disorders in the neck region and upper extremities among users.
Prevalence and risk factors associated with musculoskeletal complaints among users of mobile handheld devices: A systematic review	(Y. Xie et al., 2017)	Applied ergonomics	n = 14 studies were included Age: Unclear Gender: Unclear	A systematic review. Tablets, handheld electronic game devices, smartphones and touchscreen phones	Unclear	• The results demonstrate that between 1% and 67.8% of users experience the propagation of musculoskeletal problems. • Of those results, the highest levels of a neck complaint ranged from 17.30% to 67.8%.

						• Neck flexion factors, telephone call frequencies, texting, and gaming contribute to mobile handheld device users' musculoskeletal complaints.
Texting with touchscreen and keypad phones-A comparison of thumb kinematics, upper limb muscle activity, exertion, discomfort, and performance.	(Gustafsson et al., 2018)	Applied ergonomics	n = 19 participants Age: 21-51 Gender: 7 males, 12 females	A laboratory study with a cross-over design. Touchscreen phone and had owned and used a keypad phone	Linear regression models Univariate regression analyses Wilcoxon signed rank test	• There are differences in thumb flexion. • The differences in muscle activity was found only in the group with longer hands. • There are differences in risks for developing musculoskeletal disorders during smartphone use with different key activation mechanisms and different hand sizes.
Factors associated with neck disorders among university student smartphone users.	(Namwongsa, Puntumetakul, Neubert, & Boucaut, 2018)	work	n = 779 undergraduate student Age: 17-26 Gender: 184 males, 459 females	Cross sectional design. Smartphone	Descriptive statistics Simple logistic regression analysis Multiple logistic regression	• Symptom prevalence of musculoskeletal disorders was less prevalent in the lower back among smartphone users (17.2%). • The most painful body region was found to be the neck (32.50%). • Two significant factors associated with neck disorders were a flexed neck posture and smoking.
Ergonomic risk assessment of	(Namwongsa, Puntumetakul,	PloS one	n = 30 students Age: 18-25	Cross sectional design.	Descriptive statistics	• There are significant correlations between the

smartphone users using the Rapid Upper Limb Assessment (RULA) tool.	Neubert, Chaiklieng, et al., 2018)		Gender: 4 males, 26 females	Smartphone	Chi-squared test Fisher's exact test	neck musculoskeletal disorder and RULA Grand Score. • The neck, trunk and leg postures had a combined effect on neck musculoskeletal disorders.
Mobile technology dominates school children's IT use in an advantaged school community and is associated with musculoskeletal and visual symptoms.	(Straker et al., 2018)	Ergonomics	n = 920 students Age: 10.4–19.3 Gender: 50% girls	A cross-sectional study. Information technology devices	Descriptive statistics Spearman correlations T-tests Mann–Whitney U tests Binary logistic regression	• Discomfort in both neck and shoulders and visual symptoms reported as a result of daily usage of mobile technology, tablets, and laptops.
Gender and posture are significant risk factors to musculoskeletal symptoms during touchscreen tablet computer use.	(S.-P. Lee et al., 2018)	Journal of Physical Therapy Science	n = 412 university population Age: 18-59 , >60 Gender: 135 males, 275 females	A cross-sectional Survey. Tablet computer	Descriptive statistics Chi-Square Logistic regression model	• Gender, roles, sitting on chair without back support sitting with device in lap, and lying on the side and on the back during use their devices are significant risk factors associated with musculoskeletal symptoms. • The odds for females to have symptoms were 2.059 times higher than for males.
Determination of musculoskeletal system pain, physical activity intensity, and prolonged sitting of university	(Can & Karaca, 2019)	Biomedical Human Kinetics	n = 387 university students Age: 21.79 ± 1.87 Gender: 181 males, 206 females	Self-designed questionnaire. Smartphones and laptops	Descriptive statistics Pearson chi-square test and t-test	• 52% males and 28.2% females had experienced musculoskeletal pain. • Complaints of pain or discomfort were in the

students using smartphone.						back (54.5%), the neck and shoulder (17.9%) and upper and lower back (27.6%). • The users with musculoskeletal pain or discomfort spend more time touch on screen phone and computer device than the users who do not have pain or discomfort. • Due to their devices usage, the users who are in the low-intensity physical activity category spend more time sitting down than user in the moderate/vigorous intensity physical activity category.
The relationship between smartphone usage duration (using smartphone's ability to monitor screen time) with hand-grip and pinch-grip strength among young people: an observational study.	(Osailan, 2021)	BMC Musculoskeletal Disorders	n = 100 participants Age: 18-30 Gender: Unclear	An observational study	Descriptive statistics. Kolmogorov-Smirnov test. Pearson. Two stepwise linear regressions.	• The usage of smartphones is related to weaker hand-grip and pinch-grip. • 18.8 % of the variance in hand-grip strength and 20.4 % of the variance in pinch-grip strength was explained by age, and period of usage.
Prevalence of mobile device-related lower extremity discomfort: a systematic review.	(Legan & Zupan, 2022)	International Journal of Occupational Safety and Ergonomics	n = 14 papers were included Age: Unclear Gender: Unclear	A systematic review. Mobile device, hand-held device,	Unclear	• The prevalence of pain in the lower back ranged between 32.9% and 39.4%.

				lap top, smartphone, tablet		• Lower body parts pain or discomfort are associated with mobile device use-related prolonged static body postures.
The relationship between smartphone addiction and musculoskeletal pain prevalence among young population: a cross-sectional study.	(Mustafaoglu et al., 2021)	The Korean journal of pain	n = 249 students Age: 18-25 Gender: 81males, 168 females	A cross-sectional study. Smartphone	Descriptive statistics The one-sample Kolmogorov–Smirnov test Pearson’s correlation tests An independent sample t-test Logistic regression models	• The prevalence of musculoskeletal pain in neck, shoulder, wrist/hand, and upper back was higher among females than among males. • The smartphone addiction scale was significantly associated with prevalence of musculoskeletal pain in the neck, wrists/hands and upper back.

Despite this high prevalence extent of technology among users with various tasks, little knowledge about risk factors to these users. Today's the devices come with different keyboards and finger-driven touch screen, all of which require the use of both hands such as fingers most frequently. Such over use of their devices may lead to risk for developing musculoskeletal discomfort because they spend much of their times in using these devices in wrong positions or/and repetitive movements, with different tasks.

Previous studies review showed sets of variety risk factors exist, which factors associated with complaints of musculoskeletal in the neck and upper limbs (Jacques Malchaire et al., 2001; Nunes & McCauley Bush, 2012). The following diagram of ishikawa cause and effect diagram highlighting the key factors leading to MSD as shown in Figure 2**.**

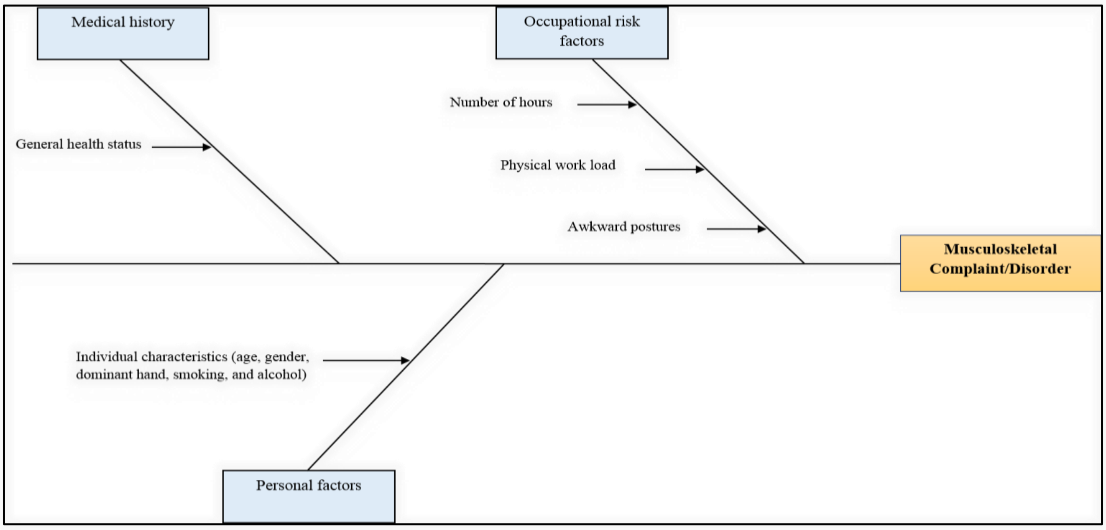

Figure 2. Ishikawa cause and effect diagram of risk factors contributing to appearance MSD

The above-mentioned diagram is referred to by Ishikawa as the 'fish-bone diagram of cause and effect'. It is designed to describe the factors affecting the musculoskeletal disorders. In detail, the diagram includes three major sets of potential risk factors that may play a role in causing the disorders. These factors are:

- The occupational (Bergqvist et al., 1995; Bernard et al., 1992; Dimberg et al., 1989; Ingelgård et al., 1996; Jensen et al., 1998),
- Medical history (Bernard et al., 1994; Brusco & Malchaire, 1993; Hughes et al., 1997; Lagerström et al., 1996; JB Malchaire et al., 1997).
- Individual risk factors (English et al., 1995; Fransson-Hall et al., 1995; Kilbom et al., 1986; JB Malchaire et al., 1997; Pope et al., 1997; Punnett et al., 1985; Roquelaure et al., 1997; Vasseljen et al., 1995).

Ishikawa clarifies that each of the given factors consists of several sub-factors that affect the musculoskeletal disorders. Experiencing one or more of the symptoms described under each factor represents a cause for musculoskeletal complaint among the participants.

The findings indicated factors systematically associated with musculoskeletal disorders in occupational risk factors such as repetitiveness, physical workload and static efforts for both neck-shoulder and hand-wrist. Additionally, the medical history refers to bad health was found significant for neck-shoulder and less systematically for hand-wrist. Moreover, related with personal factors there are several differences in muscle fiber type postulated (for neck disorders) and hormonal differences (especially for carpal tunnel syndrome) but, most of all, differences in occupational exposures and home activities.

Finally psycho-organizational factors refer to psycho-organizational and stress factors are more associated with musculoskeletal problems or disorders in the cervicobrachial region

2.4 Advantages and Disadvantages of Mobile Touch Screen Devices

There are some basic types of services that mobile devices provide (Boase & Ling, 2013; Cruz-Cunha & Moreira, 2011):

- Vocal services: It is one of the main services for mobile phones and is used for communication between individuals. While mobile devices are now used for several purposes, mainly for internet usage, these devices are primarily intended to make telephone calls between users with their families and friends and preventing from isolation .
- Short messaging service: Short messaging service is commonly referred to as SMS by mobile device users, it enables connection of users via sending short messages of not more than 160 characters across different mobile terminals. SMS is an effective way for people to communicate and control themselves without disturbing anybody around them as they can read the message when they are free to respond accordingly.
- Multimedia Messaging Service: This service is commonly known as MMS, it is available for transferring multimedia messages such as images and songs through mobile phones. MMS can be used for education purposes, for instance, sending audio recordings and images among students as well as instructors.
- Location-based services: These services identify the location of users of mobile phones with the aid of GPS and other applications.
- Mobile software applications: These applications are interactive and operate on different platforms; they are available and can be easily obtained and installed

on mobile devices via the internet. Furthermore, software applications can be developed for users' based on specifications.

- Data Services: This allows users to access the internet on their mobile devices, the internet is usually provided by the Global Service for Mobile (GSM) service providers at prescribed charge rate. The use of the internet offers access to unlimited information and allows users to gather and download information for educational purposes and otherwise.

A research study has revealed an increase in the number of university student's that use mobile phones. Therefore, many disadvantages such as exposure to musculoskeletal disorder, distractions and inattentiveness usually occur due to multi-tasking on mobile devices (Kahari, 2013). Equally, there are numerous advantages associated with mobile phones such as easy access to information in a fast and convenient way, ability to communicate anywhere anytime through texting or voice call and can be used effectively by instructors thus, aid faster teaching and learning methodologies (Kuznekoff & Titsworth, 2013). Moreover, mobile phones are not only used for texting and speaking but for browsing on the internet, online purchases, creating simple designs, music, games and videos.

According to Findlater et al. (2013), the advantage of touchscreen has been shown to reduce movement times and errors, thereby reducing age-related performance differences in comparison to conventional mouse input devices.

Kietrys et al. (2015) concluded study that, the students of university who are 18 years and above are right hand dominant, whose were tested for physical and touch keypad of phones when typing use. That aimed determine to the effect on the upper part of body region. Reported that the touch screen devices need motions less than physical keypad and that in thumb and finger. This movements also are effect on the muscle activity where was used design of devices similar dimensions.

2.5 Artificial Neural Networks

Due to the spread of Artificial Neural Networks (ANNs), there have been many different approaches for their application, such as the artificial neural network-based approach, robotics telecommunication and entertainment approach, and medical application. Huang et al. (2009) consider that ANNs are the newest technology for processing the data of toolboxes devoted to engineering applications. Somers (2001) suggests that ANNs are of great accuracy compared to conventional statistical analysis. Furthermore, ANNs have the ability to deal with non-linear relationships and checking data. Other studies also resulted in considering ANNs to be more insightful in providing thorough results that are more accurate than the normal statistical methods (Ladstätter et al., 2010; Walczak, 2007).

The Artificial Neural Networks (ANNs) are based on transfer functions and connections. Generally, the applications of ANNs consisting as following of four categories (Cha et al., 2011) :

1. Prediction: Uses input values as first layer in to predict some outputs in the last layer. In this study we use ANN model for the prediction of the risk levels that interfered with the ability to perform daily activities.
2. Classification: Uses input primary values to determine the classification patterns.
3. Data association: Used simulate the classification, while also detect input data that contains errors.

4. Data filtering: Analysis input data and makes it smooth for the output by preprocess such as check missing values.

2.6 Advantage of Artificial Neural Networks

According to Tu (1996) indicated that neural networks offer both advantages and disadvantages for predicting medical outcomes.

1. Neural network models require less formal statistical training to develop
2. Neural network models can implicitly detect complex nonlinear relationships between independent and dependent variables.
3. Neural network models have the ability to detect all possible interactions between predictor variables.
4. Neural networks can be developed using multiple different training algorithms.

2.7 Disadvantage of Artificial Neural Networks

1. Neural networks are a "black box" and have limited ability to explicitly identify possible causal relationships.
2. Neural networks models may be more difficult to use in the field.
3. Neural network modeling requires greater computational resources.
4. Neural network models are prone to over fitting.
5. Neural network model development is empirical, and many methodological issues remain to be resolved.

The literature provides conventional statistical analyses on their experiences of pain and discomfort about musculoskeletal disorders had collected through by questionnaires. In the literature, no methods of the Artificial Neural Networks techniques had been applied for predicting the risk of musculoskeletal disorders during mobile touch screen devices usage by the utilization of various machine learning algorithms. Moreover, the Association Rules Mining approaches to detect any relation between the different body regions experiencing pain or discomfort or the predictive information hidden in the behavioral patterns would be useful for analyzing and predicting customer behavior.

Chapter 3

METHODOLOGY

3.1 Preparatory Works

Prior to questionnaire distribution of participants at Eastern Mediterranean University, approval (Reference No: ETK00-2018-0260) of the EMU's Scientific Research and publication Ethics Committee has been secured which can be seen in Appendix A1, was obtained on 15/10/2018. The convenience sample technique is adopted for the survey; specific inclusion or exclusion criteria were not considered for any participants. However, all the participants are confirmed to be daily users of mobile touch screen devices by the researcher. A flowchart explaining the overall research methodology of the study as shown in Figure 3.

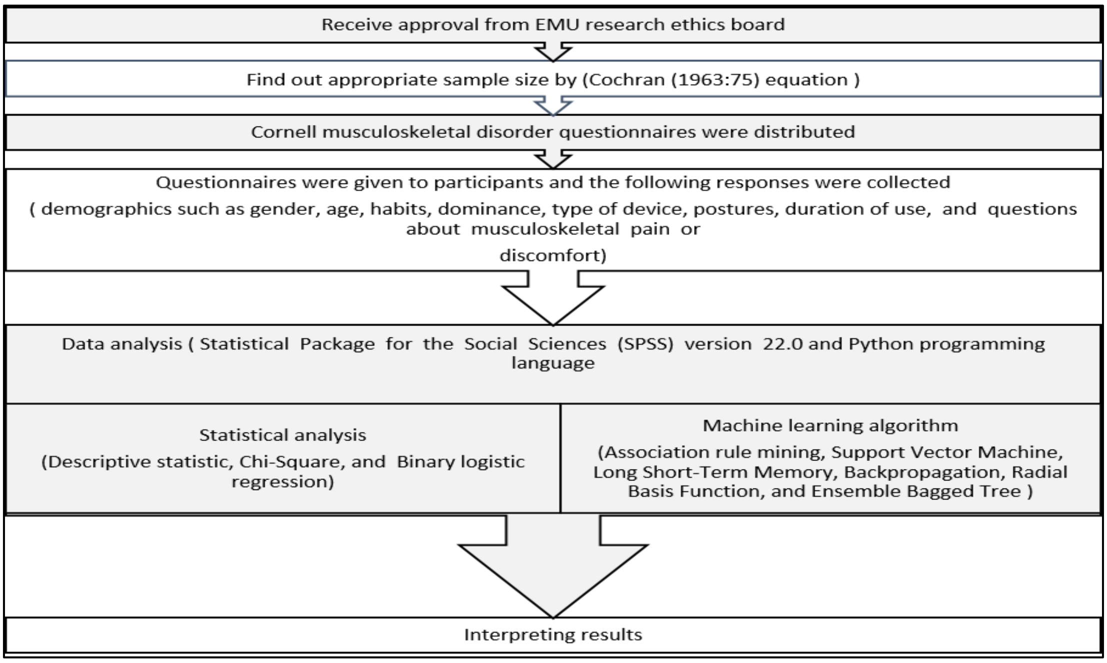

Figure 3. Flow diagram of the procedures of the study

3.2 Research Objectives

MSD pain/discomfort in different body regions in university students are common symptoms can be an outcome of causes like excessive usage, sports and exercise participation, residual effects of pre-existing injuries, poor posture while sitting, standing, and sleeping, and even high sedentariness and low levels of muscular fitness. So, it is reasonable to assume that they may be spending long hours in static postures owing to their academic requirements. Detailed exploration of these risks is critical for the prevention of further serious health effects. Due to the insufficient studies on risk assessment, modeling and verification, this current research is designed to collect data from the participants based on their experiences and behaviors during ache, pain and discomfort in the upper and lower limb extremities and body regions where the discomfort feelings occurred.

Precisely, this study aims to evaluate and confirm if and to what extent the use of touch-screen smartphones relates to the experience of musculoskeletal pains among the users of such devices. In additionally machine learning (ML) algorithms were implemented predict the impact pain or discomfort of mobile touch screen devices use on different body regions and defined the risk levels that interfered with the ability to perform daily activities.

In the following the summary of the study objectives are provided:

- To investigate and to analyze, students' attitudes and experiences on mobile touch screen devices, and musculoskeletal disorder developed by touch screen use.
- To detect any relationship between the different parts of the body experiencing discomfort by use Association Rules Mining (ARM).

- To determine a meaningful and statistically significant relationship between musculoskeletal system and mobile touch screen devices use, and develop a risk assessment model.

- To offer predictive accuracy using Artificial Neural Networks (ANN) model by several network architectures.

3.3 Questionnaire Description

The survey included two sections: demographics and musculoskeletal pain or discomfort. The collected demographic information included age, gender, smoking and drinking habits, and, right or left dominance, aimed to collect demographic data related to the population at (EMU) university. Such information provides details on the range of ages, gender, habits of smoking and drinking alcohol etc. Of our sample population. These questions can also be used to compare changes of reported musculoskeletal signs related to demographics. The next question in section one was about the form of touch screen mobile devices preferred (and used) by users (smartphones or tablets). The purpose of this question was to assess the possibility of a significant difference of the frequency as well as severity of musculoskeletal discomfort between students which are using one of these technologies and others who are using all or more of these devices. The question of part one is related with the daily mobile touch screen devices time usage. The rest of questions of first part are related with the daily usage mobile touch screen devices time usage and the body postures during using their devices, are designed to check whether using the such MTSDs for daily activities for extended periods of time and different postures increase the amount of discomfort or pain reported by the participants

The last question is to identify whether users experienced accidents or had injuries during the last year. Participants who experienced pain or discomfort in the past year should be excluded from reported pain investigations to avoid involving the consequences of an accident in the assessment of discomfort associated with smartphone or tablet use.

The convenience sample technique is adopted for the survey; specific inclusion or exclusion criteria were not considered for any participants except who had chronic injuries of MSDs. However, all the participants are confirmed to be users of MTSDs (which includes smartphones and/or tablets) by researchers. The hard copy of the questionnaire is directly administered to the participants; details about how to complete each section of the questionnaire were adequately explained.

The questionnaire second part was adapted from the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) CUergo (1999), which can be seen in Appendix A2.

The questionnaire was developed to detect subjects who are under extreme risk of MSD, which assesses the frequency of pain or discomfort during a week and looks for interruption of the subjects' daily activities by any discomfort.

The Cornell Musculoskeletal Discomfort Questionnaire included questions about aches, pains, and discomfort in the different body regions frequency or severity of the discomfort they experience within the last week during touch screen devices use. The CMDQ questionnaire is a 54-item questionnaire containing all body segments. In Appendix A2, there are three version sections of the questionnaire (English version).

The second part of CMDQ is designed to assess the severity as well as frequency of experienced discomfort, if any. In order to report any discomfort, the scale to determine degree of interference to daily activities. To detect any relationship between the different parts of the body experiencing discomfort between students' exposure to smartphones or tablet and related MSD experienced or been experiencing. In addition, the effect of experienced MSD to perform daily activities during past week. The Cornell Musculoskeletal Discomfort Questionnaire male and female the version consists included questions about aches, pains, and musculoskeletal discomfort that respondents experienced within the previous week during touch-screen device usage. The Cornell Musculoskeletal Discomfort Questionnaire consists covered questions about eleven different body regions of the upper and lower extremities (neck, shoulders, upper back, upper arms, lower back, forearms, hands and wrists, hips and buttocks, thighs, knees, and lower legs). The questions were grouped into three columns: (i) frequencies (Never, 1-2 times per week, 3-4 times per week, Once per day, and Several times per day), (ii) level of discomfort (slightly, moderately, and very uncomfortable), and (iii) interference with ability to work or do educational activities (not at all, slightly, and substantially interfered). In order to understanding of the questionnaire, in reporting musculoskeletal complaints the questionnaire involves a body map showing the different human body regions and a diagram **(**seen in Figure. 4) for demonstrating the parts of the human body and measurement scale of the discomfort.

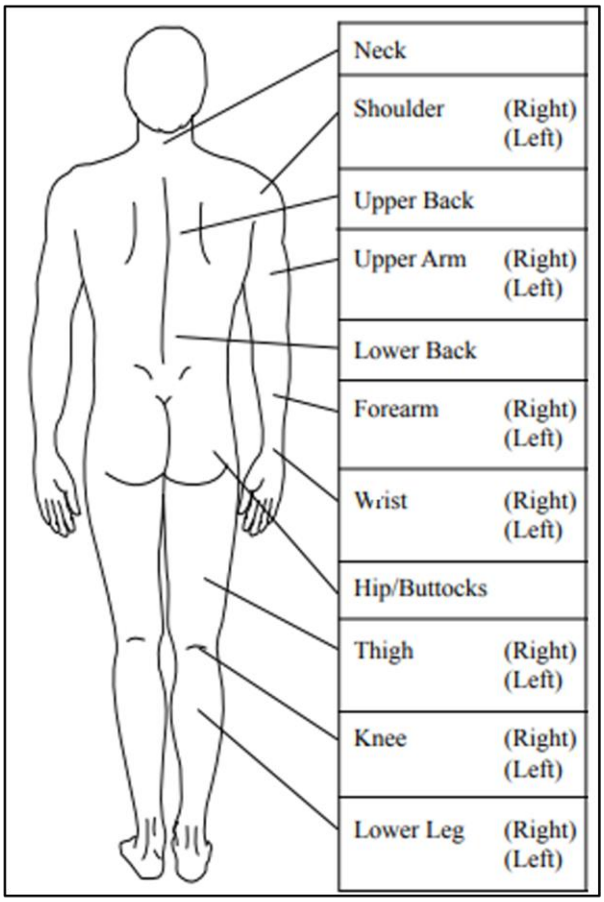

Figure 4. Body diagram to identifying the body parts of felt discomfort

3.4 Validity and Reliability

Reliability is the desired degree of consistency between multiple measurements of an experiment. For assurance of accuracy of evaluation, the reliability test would result a similar outcome if the same sample was to be tested at different time or by another researcher (Gay et al., 1996). The internal consistency of the CMDQ was examined by the authors in the current study, and the results have shown that all the questions are valid. The reliability and validity of the CMDQ was also examined by Dr. Oguzhan Erdinc in Turkey (CUergo, 1999).

To ensure feasibility and comprehensibility by participants in EMU, piloting was conducted using 10% of the sample size, in which responses of 60 university students were considered. After obtaining feedback of respondents, the formatting of the structure of the questionnaire were slightly amended to ensure the questions were understandable and clear.

3.5 Participants

According to the Eastern Mediterranean University web site, there were about twenty thousand students enrolled in the undergraduate and graduate programs. In order to find out the number of participants them. In order to find out the number of participants them. In this study, the sample size calculation was conducted using Cochran formula (1963:75). After doing the needed calculations depending on this formula, the required sample size was found to be 384 respondents. Consequently, the questionnaire was distributed among students at the Eastern Mediterranean University (EMU) in the Turkish Republic of Northern Cyprus. Data collection took place between 1 and 22 October 2020. The selection criteria of the participants was their medical conditions. In other words, those who reported having a severe pain or discomfort in the neck and the upper and lower extremities due to any incident in their medical history, and those that had been diagnosed with osteoarthritis, were excluded from the study. In total, 600 participants were reached to fill in the questionnaire. However, 56 participants did not complete it, and they were, therefore, excluded from the study.

In order to find out the number of participants the Cochran (1963:75) equation was used to yield a representative sample for proportions. Based on the Cochran (1963:75) following formula is used to determine the minimum required sample size for this research (Cochran, 1977; Snedecor & Cochran, 1989).

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where:

n is the sample size;

Z is the z-statistics for the desired level of confidence;

P is the estimated proportion of an attribute that is present in the population;

e is the desired level of precision;

q is (1-p).

The estimated proportion is calculated from the pilot search for prevalence of musculoskeletal disorder in various body regions. According to Z distribution table for $\alpha = 0.05$, Z is equal to 1.96 has been applied.

Questionnaires were directly and randomly administered to participants through face to face meetings. The volunteer participants were invited, in a random order to my office. After they were received the necessary instructions and explanations they were asked to fill the questionnaires of the survey.

3.6 Data Analysis

3.6.1 Statistical analysis

Descriptive statistics were obtained for MTSD users and musculoskeletal disorders. The collected data was entered into and analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0. Both percentage and frequencies were estimated of all demographics. The body areas of the subjects where physical discomforts are highly experienced were identified.

The percentages of the respondents were calculated, who have experienced musculoskeletal symptoms, to analyze the necessary data and elaborate on the result Microsoft Excel (2010) was used where high discomfort scores were identified.

To calculate the discomfort score, we multiplied the scores of interference, level of discomfort, and frequency with the weight (CUergo, 1999). The discomfort scores identified the cases under the risk (Table 2, 3, 4).

Total discomfort score was calculated by using the following formula:

$$Discomfort = ferquence \times discomfort \times interference$$

Table 2. The frequency score weights

Rate	Frequency score
Never	0
1-2 times	1.5
3-4 times	3.5
Every day	5
Several times a day	10

Table 3. The discomfort score weights

Rate	Discomfort score
Slightly uncomfortable	1
Moderately uncomfortable	2
Very uncomfortable	3

Table 4. The interference score weights

Rate	Interference score
Not at all	1
Slightly interfered	2
Substantially interfered	3

For the missing values of the discomfort and interference were considered as zero score (CUergo, 1999) . Hence, the score of the risk at minimum is equal to the score of the frequency.

In order to find a statistically significant correlation between participants-related MSDs and mobile touch screen use, logistic regression method is used, which shows the significant risk factors that contribute to the experience of physical discomfort among mobile touch screen devices-users.

Thus we identified all independent variables and the dependent variable. The dependent variable was selected to be the experiences of physical discomfort, which is a Boolean variable (yes/no). Independent variables were considered to be other variables from the questionnaire.

For calculated the odds ratio of the significant factors for each participant to determine the participants who are under a high risk of discomfort. The following equation is used to estimate the odds ratios:

$$log\left[\frac{prob(had\ pain\ for\ the\ last\ year)}{pro(Not\ had\ pain\ last\ year)}\right] = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \cdots$$

Where χ_i's (i=1, 2, 3…) are independent variables, β_0 is the intercept or constant, and β_1, β_2, β_3 are the independent regression coefficients.

$$Odds\ ratio = e^{(\beta_0+\beta_1\chi_1+\beta_2\chi_2+\beta_3\chi_3+\cdots)}$$

3.7 Input the Load Data in PYTHON-Programming Language

Association Rule Mining (ARM) has been used via the Apriori Algorithm in Python programming language to detect any relationship between the different parts of the body experiencing discomfort. For this purpose, two approaches (mining patterns and assigning weight) were applied as follows:

The researchers defined the item sets of the mining patterns to determine the interval support for the threshold, which is 0.20. Then, the Significant Least Pattern Tree (SLP-Tree) was created using the items of the study. After that, the researchers generated the Significant Least Pattern Growth (SLP-Growth), which leads to the significant factors of the study. The last stage of the analysis was to apply the correlation through association rules, which are derived from the equation (lift).

$$lift(A,B) = \frac{p(A/B)}{p(B)}$$

or

$$lift(A,B) = \frac{conf(A \Longrightarrow B)}{supp(B)}$$

The lift is defined as the simplest correlational measure, in which (≥ 1) means there is a positive correlation. Therefore, since A and B are dependent variables, the occurrence of one variable implies the occurrence of the other variable. This led to the discovery of the highly correlated least association rules This led to the discovery of the highly correlated least association rules (Abdullah et al., 2011).

Machine learning (ML) algorithms were implemented predict the impact pain or discomfort of mobile touch screen devices use on different body regions and defined the risk levels that interfered with the ability to perform daily activities.

The frequencies of ache pain and discomfort in body regions were sent to the ML algorithms as a total of 544 input samples after data preprocessing. The risk levels of MSD that interfere with the ability to perform educational activities were categorized into three levels, namely, low, medium and high.

The Cornell Musculoskeletal Discomfort Questionnaire consists of three parts; the first is about the frequency of aches, pains, and discomfort; the second is the type of severity of the discomfort, and the last one is the interference with the ability for daily activities within the last week. We used the first part as input data of frequency of pain and the third part of interference with ability for daily activities as output of data. Thus, the second part was ignored in the experiments in to provide the classification with the minimum number of the input data for neural networks to optimize the MSDs model solution. The motivation behind artificial neural networks use is of a biological nature and the model such as human brain, a highly interconnected system, called neurons.

The machine learning approach is a key part of artificial intelligence with increasing use in many industries due to technological advancements in the world that have increased data collection volume and improved processing capacity of data. The use of machine learning techniques in the field of musculoskeletal disorders due to their superior ability to capture non-linear relationships. This is important for the development of theories. In this research (supervised learning) applied to learn from existing data to make predictions on continuous or discrete output variable(s).To develop a model for predicting the risk of musculoskeletal disorders among MTSD usage.

Data normalization was not compulsory for the inputs which have similar input range, but minimum-maximum normalization was applied to all input and output data to reduce the computational time. The hold-out method, which is based on dividing all data randomly into two sets as training and testing, was used during the training of all machine learning models. The training set comprises 70% of total data and the rest was assigned to the test set.

For the present study, five different machine learning models were tested named as Support Vector Machine Neural Network (SVMNN), Long Short-Term Memory Neural Network (LSTMNN), Backpropagation Neural Network (BPNN), Radial Basis

Function Neural Network (RBFNN), and Ensemble Bagged Tree (EBT). Model evaluation was performed using the accuracies obtained for each model.

The parameter for each ML algorithm was determined after several experiments, separately. Radial-Basis Function Neural Network has a constant hidden layer and uses radial-basis functions as an activation function. Therefore, the tuning of hyper-parameters was minimized, and optimal convergence was obtained. Eighteen hidden nodes were selected, and the number of maximum epochs, the number of clusters, and the learning rate were set as 3000, 18, and 0.09, respectively.

On the other hand, the Radial-basis function kernel was used with gamma=0.001 in SVM, and the architecture of BP consisted of 4 hidden layers with 500 hidden nodes for each layer. The maximum iteration was set to 250. Finally, LSTM was used with 4 LSTM layers maximum epoch number was set to 100. 'Adam' optimizer was used for both BP and LSTM. The implementation of machine learning models was performed using the PYTHON-programming language (v. 3.8.1 (R14)). The steps of data analysis in respect of machine learning algorithms are illustrated in Figure 5.

Finally, EBT method is used based on the random forest method provided by (Breiman, 2001). Bag was used as the Ensemble method, and the learner type was set to Decision tree with 30 learners for the model. The program learning rate was set to 0.001-1.

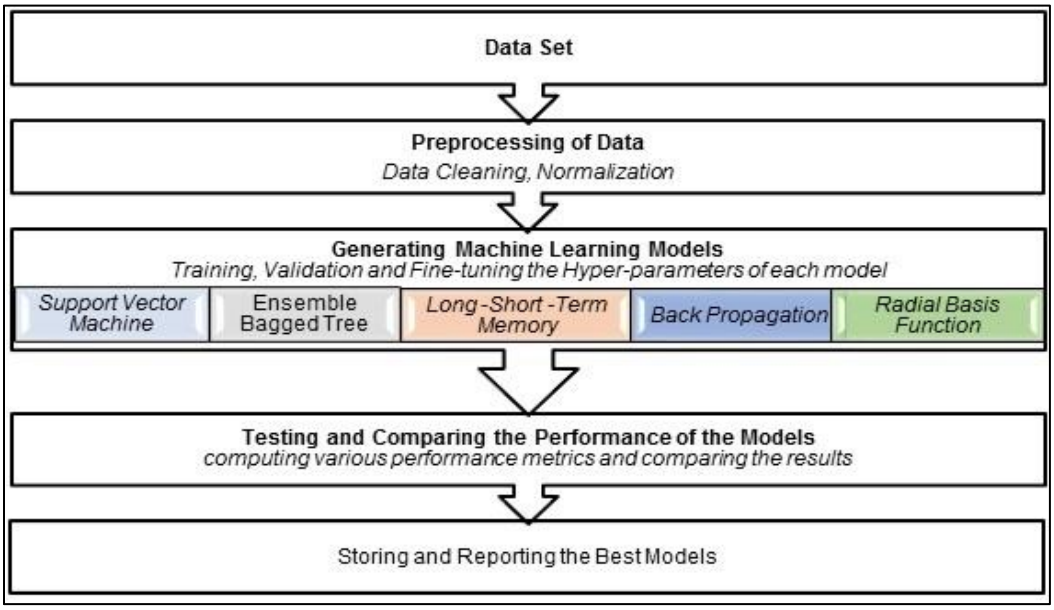

Figure 5. Steps of data analysis

Chapter 4

STATISTICAL RESULT AND INTERPRETATION

4.1 Respondents

The sample size was found to be 384 respondents; however, questionnaires were distributed to 400 participants who worked intensively with the mobile touch screen devices for daily purposes (education, calling, playing games, etc.) namely students and research assistants from the Eastern Mediterranean University. The rationale behind selecting the mentioned population is that they are expected to use mobile touch screen devices intensively especially for educational purposes and several other auxiliary purposes including personal and communication. To get appropriate results questionnaires were given to an additional 200 participants. Therefore, in this study the total number is 600 participants. 56 participants did not complete the questionnaire and were excluded from the study. A total of five hundred forty four (544) students of Eastern Mediterranean University, Famagusta, northern Cyprus drawn from all faculties irrespective of demographic in the survey. The convenience sample technique is adopted for the survey; specific inclusion or exclusion criteria are not considered for any participants. All the target groups of students are daily users of mobile touch screen devices.

In this research, the result of Cronbach's alpha is (n = 54), (0.975) as shown in Table 5. Therefore, all test items are reliable and consistent.

Table 5. Reliability statistics

Cronbach's alpha	No of item
0.975	54

Table 6 shows that the detailed of the outcomes of the pilot search for eighteen body parts of the study. The maximum value of the sample size is selected as the minimum required sample size for this study.

Table 6. Results of the sample size calculation

Regions	Z	p	q	Sample size
Neck	1.96	0.62	0.38	362
Right-shoulder	1.96	0.38	0.62	362
Left-shoulder	1.96	0.31	0.69	329
Upper back	**1.96**	**0.48**	**0.52**	**384**
Lower back	1.96	0.17	0.83	219
Right-upper arm	1.96	0.17	0.83	219
Left-upper arm	1.96	0.66	0.34	347
Right-forearm	1.96	0.17	0.83	219
Left-forearm	1.96	0.21	0.79	252
Right. Hand/wrist	1.96	0.41	0.59	373
Left. Hand/wrist	1.96	0.34	0.66	347
Buttocks/Hip	1.96	0.21	0.79	252
Right-thigh	1.96	0.14	0.86	183
Left-thigh	1.96	0.17	0.83	219
Right-knee	1.96	0.28	0.72	307
Left-knee	1.96	0.31	0.69	329
Right-lower leg	1.96	0.38	0.62	362
Left-lower leg	1.96	0.28	0.72	307

Z= confidence level; p= estimated proportion; q= 1-p

Note: The variation of the sample sizes for the different regions is because of the different region P- values. There are different P-values. For example, 18 out of 29 participants felt pain or discomfort in the neck region. Thus, the P-value for the neck region was calculated as 18/29. The sample size was found to be 384 respondents.

4.2 Demography of Participants

This questionnaire was given to MTSDs users for daily purposes. Most Of the participants were male (71%), and the rest self-identified as female (29%). Table 7 presents the results of the questionnaire regarding the general characteristics of the participants. The majority (89.7%) of participants were between 17 and 33 years of age. The mean age of participants was 24.6 years, eligible participants in this survey was (158 female and 356 male). A total of 195 (36%) and 153 (28%), participants also had the habit of smoking and drinking respectively. The majority of participants who owned MTSDs and were considered in the study were using smartphones (94.5%), while only a few participants used tablets (5.5%). Of those who used their MTSD daily for more than 6 hours, smartphone use accounted for 32.5%, while the use of tablets was 1.8%.

The manner of holding their devices varied in the responses of the participants. Right-hand holding of smartphones and tablets was 58.6%, while 33.5% used both hands. The percentage of left-hand use was only 8%. A total of 37% of participants also had the duration of owning more than 9 years. The majority of the participants who experienced pain or discomfort during the previous week used their MTSD either in sitting positions or while laying down on a sofa. Furthermore, 16% of them held one posture (sitting), and 80.9% had more than two postures (sitting and another posture).

Table 7. Frequency distribution of general characteristics of participants (n=544)

Variables	**Categories**	**Number of Participants**	**(%)**
Age	17 - 25	289	53.1
	25 - 33	199	36.6
	33 41	44	8.1
	+ 41	12	2.2
Gender	Male	386	71
	Female	158	29
Smoking	Yes	195	35.8
	No	349	64.2
Drinking alcohol	Yes	153	28.1
	No	391	71.9
	Yes	195	35.8
	No	349	64.2
Way of holding	Right hand	319	58.6
	Left hand	43	7.9
	Both	182	33.5

Daily usage (hr)			
Smartphone Tablet	1- 2	45 5	8.2 0.91
	3 - 4	151 9	27.7 1.6
	5 - 6	141 6	25.9 1.1
	> 6	177 10	32.5 1.83
Type of MTSD	Smartphone Tablet	514 30	94.5 5.5
Duration of owning (yr)			
Smartphone Tablet	1 - 3	37 4	6.8 0.73
	4 - 6	112 7	20.6 1.3
	7 - 9	164 11	30.1 2
	> 9	201 8	37 1.5
Posture	Sitting	472	34.4
	Standing	191	13.9
	Postures while performing a task	122	8.9
	Lap posture	78	5.5
	Walking	164	11.9
	Laying down on a sofa	342	24.9

The results show that 87% of the participants out of 544 experienced pain or discomfort in one or more body part, during the last week, with the prevalence being higher among males than among females as shown in Figure.6.

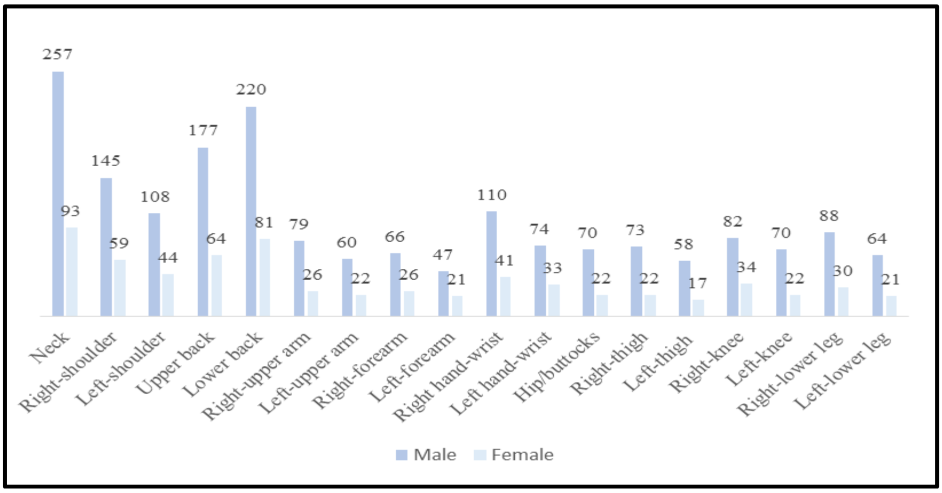

Figure 6. Gender distribution of discomforts

A total of 544 out of 600 questionnaires were retrieved at the end of the evaluation. Out these, 386 participants are male (representing 71%) and 158 are female (representing 29%). The results show that the participants (n = 544) experienced pain or discomfort in one or more body region during the last week with the high prevalence observed among males than the females.

Table 8 shows the parts of the body where pain or discomfort was experienced during the previous week due to the use of mobile touch screen devices and which body parts had the highest frequency of pain or discomfort.

The results revealed that 350 out of the total participants (representing 64%) reporting pain or discomfort in the neck part; 257 were males (73.4%) and were 93 females (26.6%). Furthermore, 301 (55.3%) in the lower back part; 220 males (73.4%) and 81 females (26.4%).

At the upper back, 241 (44.3%) of the participants experienced pain, with 177 males (73.4%) and 64 females (26.6%). Averagely, from Table 6, 73.3% male and 26.6% female of the participants experienced pain or discomfort in the neck, upper and lower extremities. The last remarkable result was in the right shoulder, which was reported by 37.5% of the whole population (145 males and 59 females). Pain or discomfort frequency in other body parts varied between 28% (left shoulder or right hand and wrist) and 12.50% (left forearm).

Table 8. Frequency distribution of experiences discomfort for male and female

Body Regions	Number of participants	Gender		% Participants	
		Male	Female	Male	Female
Neck	350	257	93	73.4	26.6
Right shoulder	204	145	59	71.1	28.9
Left shoulder	152	108	44	71.1	28.9
Upper back	241	177	64	73.4	26.6
Lower back	301	220	81	73.1	26.9
Right-upper arm	105	79	26	75.2	24.8

Left-upper arm	82	60	22	73.2	26.8
Right forearm	92	66	26	71.7	28.3
Left forearm	68	47	21	69.1	30.9
Right hand/wrist	151	110	41	72.8	27.2
Left hand/wrist	107	74	33	69.2	30.8
Hip/buttocks	92	70	22	76.1	23.9
Right thigh	95	73	22	76.8	23.2
Left thigh	75	58	17	77.3	22.7
Right knee	116	82	34	70.7	29.3
Left knee	92	70	22	76.1	23.9
Right-lower leg	118	88	30	74.6	25.4
Left-lower leg	85	64	21	75.3	24.7

4.3 Frequency of Discomforts

Table 9 shows that the most prevalent discomfort experienced in upper and lower extremities during last week was experiencing pain in the neck (64.3%), and the lower back (55.3%) the upper back (44.3%), and right-shoulder (37.5%), respectively. Pain or discomfort frequency in other body parts varied between 28% (left shoulder or right hand and wrist) and 12.50% (left forearm) of the respondents reported that discomforts were the lower felt last week as shown in Figure 7.

Table 9. Experienced physical discomfort during last week (n = 544)

Body regions	No of respondents	Pain, ache, and discomfort (%)
Neck	350	**64.3**
Right-shoulder	204	**37.5**
Left-shoulder	152	27.9
Upper back	241	**44.3**
Lower back	301	**55.3**
Right-upper arm	105	19.3
Left-upper arm	82	15.1
Right-forearm	92	16.9
Left-forearm	68	12.5
Right. Hand/wrist	151	27.8
Left. Hand/wrist	107	19.7
Hip/buttocks	92	16.9
Right-thigh	95	17.5
Left-thigh	75	13.8
Right-knee	116	21.3

Left-knee	92	16.9
Right-lower leg	118	21.7
Left-lower leg	85	15.6

The results of the musculoskeletal pain areas reported by the participants of this study is summarized using the Spider Web Chart in Figure 7. There, all the body regions included in the questionnaire where added and the line in the chart shows the most and least affected areas due to the use of smartphones and tablets by the participants. As it is observed from figure 7 above, the highest percentage of physical discomforts among participants, due to the use MTSDs, was observed in the neck, lower back, upper back and right shoulder regions, respectively. On the other hand, the regions that experienced the lowest level of discomfort among the participants of this study was in the left forearm and left thigh

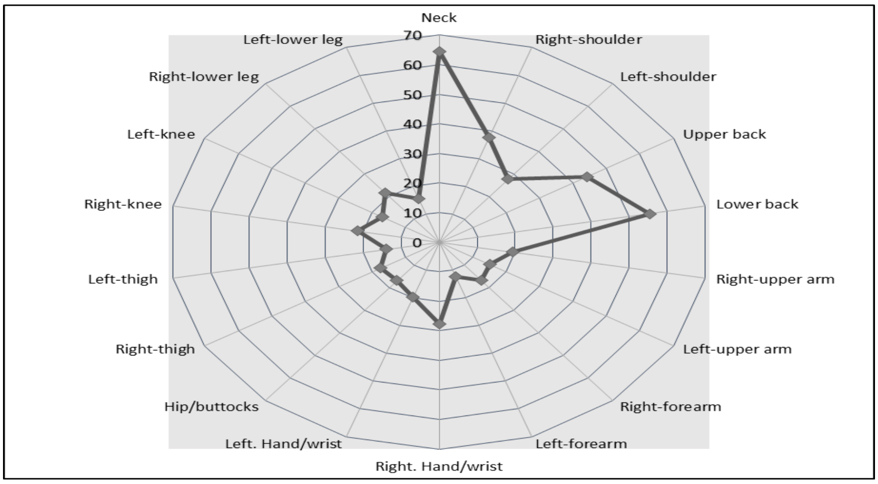

Figure 7. Musculoskeletal symptoms or discomfort in 18 body regions (in %)

In Table 10 shows the results indicated that, 176 out of 544 respondents that they were having the discomforts in their neck 1-2 times 32.35%, 3-4 times 16.17%, once every day 8.45%, and several times 7.35%. In the lower back, 151 out of 544 (27.75%) of the respondents reported that the discomforts were felt 1-2 times last week , 13.60 %, 3-4 times last week, 5.69% Once every day, 8.27% Several times every day.

Table 10. The frequency of feeling discomfort in body parts during last week

Regions	**Never**	**1-2 times**	**3-4 times**	**Once every day**	**Several times**
Neck	194	**176**	**88**	**46**	**40**
Right-shoulder	340	**101**	**52**	**24**	**27**
Left-shoulder	392	**77**	**45**	**12**	**18**
Upper back	303	**107**	**72**	**32**	**30**
Lower back	243	**151**	**74**	**31**	**45**
Right-upper arm	439	60	23	15	7
Left-upper arm	462	50	16	11	5
Right-forearm	452	61	18	7	6
Left-forearm	476	40	20	7	1
Right. Hand/wrist	393	**96**	**25**	**16**	**14**
Left. Hand/wrist	437	62	23	11	11
Buttocks/Hip	452	53	28	6	5
Right-thigh	449	64	19	9	3
Left-thigh	469	49	17	8	1
Right-knee	428	65	34	7	10
Left-knee	452	40	35	9	8
Right-lower leg	426	75	23	12	8
Left-lower leg	459	55	17	10	3

Additionally, in the upper back ,179 out of 544 (32.9%) of the respondents experience discomfort 1-4 times last week, 5.8% once into several times every day. In the right-shoulder 28.13% 153 of the respondents reported that the discomforts were felt 1-4 times last week, 4.41% once during a day, 5% several times every day. In the right-hand wrist, 22.4% 121 of the respondents reported that the discomforts were felt 1-4 times last week, 2.9% once every day, and 2.6% several times every day.

Furthermore, in the left-shoulder, (14.15%) 77 of the respondents experience discomfort during last week was 1-2 times, 8.3% 3-4 times, 2.2% once every day, and 3.3% several times every day. Similarly, in the right. Hand/wrist, 22.24% 121 of the respondents reported that the discomforts were felt 1-4 times last week, 3% once every day, and 2.57% several times every day. Thus, the high discomforts last week are most frequently experienced at the neck, lower and upper back, right-shoulder, right hand-wrist, and the left-shoulder regions respectively as shown in Table 10.

Table 11. The severity of feeling discomfort in body parts during last week

Regions	Low	Medium	High
Neck	158	158	34
Right-shoulder	87	95	22
Left-shoulder	70	64	18
Upper back	102	103	36
Lower back	117	125	59
Right-upper arm	56	41	8
Left-upper arm	49	28	5
Right-forearm	56	31	5
Left-forearm	41	23	4
Right. Hand/wrist	71	60	20
Left. Hand/wrist	48	47	12
Buttocks/Hip	41	40	10
Right-thigh	46	44	5
Left-thigh	37	35	3
Right-knee	48	53	15
Left-knee	33	47	12
Right-lower leg	57	47	14
Left-lower leg	43	32	10

Table 11 shows the results indicated that, 158 participants (45.14%) sensed slightly uncomfortable at neck per week and moderate severity level was (45.14%), and very uncomfortable (9.71%). Likewise in the lower back 117 of respondents was felt slightly uncomfortable, 125 moderately uncomfortable, and 59 very uncomfortable. In the upper back, right-shoulder, and right-wrist was (8.71%, 8.82%, 6.62%) very uncomfortable respectively. Furthermore, in the upper back, the level of discomfort was 102 slightly, 103 moderate, and 36 very uncomfortable. Thus the level of discomforts during last week were very uncomfortable of neck, upper back, lower back, and right. Hand/wrist.

Table 12. The effects of feeling discomfort on the working ability

Regions	Never	Low	High
Neck	157	169	24
Right-shoulder	97	89	18
Left-shoulder	80	59	13
Upper back	115	104	21
Lower back	129	130	42
Right-upper arm	54	43	8
Left-upper arm	53	24	5
Right-forearm	55	30	7
Left-forearm	38	25	5
Right. Hand/wrist	81	60	10
Left. Hand/wrist	50	48	9
Buttocks/Hip	42	41	9
Right-thigh	56	35	4
Left-thigh	41	32	2
Right-knee	55	51	10
Left-knee	40	44	8
Right-lower leg	53	59	6
Left-lower leg	43	38	4

In the Table 12 shows effects of discomfort on the ability to the work, the high interfere was 157, not at all, 169 slightly interfered, and 24 substantially interfered at the neck. While, the lower back 129 not at all, 130 slightly interfered, and 42 substantially interfered. Additionally, 115 of respondents experienced discomfort at upper back with not at all to ability to work, 104 slightly interfered, and 21 substantially interfered.

4.3.1 Total Discomfort

Table 13. Ranking body parts by total discomfort score

Body organs referred to in the questionnaire	% Discomfort
Neck	37.21
Lower back	28.96
Upper back	13.28
Right-shoulder	7.74
Left-shoulder	2.90
Right. Hand/wrist	2.48
Right-knee	1.24
Right-lower leg	1.15
Left. Hand/wrist	0.99
Right-upper arm	0.79
Left-knee	0.72
Buttocks/Hip	0.56
Right-thigh	0.46
Right-forearm	0.43
Left-lower leg	0.38
Left-upper arm	0.31
Left-thigh	0.22
Left-forearm	0.17

The results in Table 13 show the discomfort score according to CMDQ. The results show that there are three categories for these parts. The first is a high discomfort category, which includes the neck and the lower back with 37.21% and 28.96% respectively.

The second category is of medium discomfort level for the participants. This category includes the upper back (13.28%), right-shoulder (7.74%), the left-shoulder (2.90%) and right-wrist (2.48%). The last category, on the other hand, includes the other parts of the body, in which the discomfort percentage varied between (1.24%) right-knee and (0.17%) left forearm.

In this study, the cross tab analysis was used with the four major areas of the body that have the highest pain (Neck, right shoulder, upper back, and lower back). These areas were cross tabbed with the age, gender, smoking, and alcohol to examine any possible relations between them.

Table 14 is the cross tab of two independent variables gender and neck discomfort with the frequency, level of pain, and interference with the daily activities. Since there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 10.828; $P_{\text{frequency}} = 0.029$
- Chi-Square $_{level}$ = 4.208; $P_{level} = 0.379$
- Chi-Square $_{interference}$ = 4.739; $P_{interference} = 0.315$

Table 14. Cross tab for neck discomfort with gender

Gender	Neck pain or discomfort (last week)		
	Frequency	Level	Interference
	11.97[a,*]	4.53	5.18

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

As the p-value of the frequency is less than 0.05, there is an association between neck discomfort and type of gender. In words, gender significantly influenced discomfort frequency in the neck.

Table 15 is the cross tab of two independent variables age group and neck discomfort with the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 15.156; $P_{\text{frequency}}$ = 0.233;
- Chi-Square $_{level}$ = 10.621; P_{level} = 0.562
- Chi-Square $_{interference}$ = 8.08; $P_{interference}$ = 0.779

Table 15. Cross tab for neck discomfort with age group

Age	Neck pain or discomfort (last week)		
	Frequency	Level	Interference
	16.34[a]	9.88	8.08

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

The results indicate that there is no significant association between neck discomfort and age categories.

Table 16 is the cross tab of two independent variables smoking and neck discomfort with the frequency, level of pain, and interference with the daily activities. Since there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 4.069; $P_{\text{frequency}}$ = 0.397
- Chi-Square $_{level}$ = 4.281; P_{level} = 0.396
- Chi-Square $_{interference}$ = 5.357; $P_{interference}$ = 0.253

Table 16. Cross tab for neck discomfort with smoking

Smoking	Neck pain or discomfort (last week)		
	Frequency	Level	Interference
	3.97[a]	4.60	5.82

[a]The max likelihood ratio chi-square; $^*p < 0.05$

The results indicate that there is no significant between independent variables of MSDs in neck factors and smoking status (Table 16)

Table 17 is the cross tab of two independent variables alcohol drinking and neck discomfort with the frequency, level of pain, and interference with the daily activities. Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 0.622; $P_{\text{frequency}}$ = 0.961
- Chi-Square $_{level}$ = 7.435; P_{level} = 0.115
- Chi-Square $_{interference}$ = 2.971; $P_{interference}$ = 0.563

Table 17. Cross tab for neck discomfort with drinking

Alcohol	Neck pain or discomfort (last week)		
	Frequency	Level	Interference
	6.30[a]	7.79	2.94

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

As the p-value is greater than 0.05, there is no association between neck discomfort and drinking alcohol.

Table 18 is the cross tab of two independent variables gender and upper back discomfort with the frequency, level of pain, and interference with the daily activities. Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 2.452; $P_{\text{frequency}}$ = 0.653
- Chi-Square $_{level}$ = 1.879; P_{level} = 0.598
- Chi-Square $_{interference}$ = 2.054; $P_{interference}$ = 0.561

Table 18. Cross tab for upper back discomfort with gender

Gender	Upper back pain or discomfort (last week)		
	Frequency	Level	Interference
	2.50[a]	1.91	2.09

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

The results of Chi-square test shows there is no a significant association between gender and upper back region (p-value < 0.05).

Table 19 is the cross tab of two independent variables age group and upper back discomfort with the frequency, level of pain, and interference with the daily activities.

Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 13.653; $P_{\text{frequency}}$ = 0.325
- Chi-Square $_{level}$ = 8.720; P_{level} = 0.464
- Chi-Square $_{interference}$ = 12.889; $P_{interference}$ = 0.168

As the p-value is greater than 0.05, there is no association between upper back discomfort and age categories.

Table 19. Cross tab for upper back discomfort with age group

Age	**Upper back pain or discomfort (last week)**		
	Frequency	Level	Interference
	14.79[a]	10.35	15.07

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

Table 20 is the cross tab of two independent variables smoking status and upper back discomfort with the frequency, level of pain, and interference with the daily activities. Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 1.226; $P_{\text{frequency}}$ = 0.874
- Chi-Square $_{level}$ = 1.337; P_{level} = 0.720
- Chi-Square $_{interference}$ = 1.348; $P_{interference}$ = 0.718

Table 20. Cross tab for upper back discomfort with smoking

Smoking	**Upper back pain or discomfort (last week)**

	Frequency	Level	Interference
	1.27[a]	1.35	1.35

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

The results indicate that there is no association between independent variables for upper back and smoking (p-vale >0.05).

Table 21 is the cross tab of two independent variables alcohol drinking and upper back discomfort with the frequency, level of pain, and interference with the daily activities. Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 1.226; $P_{\text{frequency}}$ = 0.874
- Chi-Square $_{level}$ = 1.086; P_{level} = 0.781
- Chi-Square $_{interference}$ = 0.243; $P_{interference}$ = 0.970

Table 21. Cross tab for upper back discomfort with drinking

Alcohol	**Upper back pain or discomfort (last week)**		
	Frequency	Level	Interference
	2.29[a]	1.11	0.25

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

None of the factors in Table 19 are found to be significant.

Table 22 is the cross tab of two independent variables gender and lower back discomfort with the frequency, level of pain, and interference with the daily activities. Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 2.747; P $_{\text{frequency}}$ = 0.601
- Chi-Square $_{level}$ = 6.516; P $_{level}$ = 0.089
- Chi-Square $_{interference}$ = 1.843; P $_{interference}$ = 0.606

Table 22. Cross tab for lower back discomfort with gender

Gender	Lower back pain or discomfort (last week)		
	Frequency	Level	Interference
	2.80[a]	6.86	1.85

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

As the p-value is greater than 0.05, there is no association between lower back discomfort and type of gender.

Table 23 is the cross tab of two independent variables age group and lower back discomfort with the frequency, level of pain, and interference with the daily activities. Since there is no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 19.050; P $_{\text{frequency}}$ = 0.799
- Chi-Square $_{level}$ = 5.390; P $_{level}$ = 0.089
- Chi-Square $_{interference}$ = 4.508; P $_{interference}$ = 0.875

Table 23. Cross tab for lower back discomfort with age group

Age	Lower back pain or discomfort (last week)		
	Frequency	Level	Interference
	21.61[a]	6.88	4.52

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

As the p-value is greater than 0.05, there is no association between lower back discomfort and age categories.

Table 24 is the cross tab of two independent variables smoking and lower back discomfort with the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 0.987; $P_{\text{frequency}}$ = 0.912
- Chi-Square $_{level}$ = 0.531; P_{level} = 0.912
- Chi-Square $_{interference}$ = 4.646; $P_{interference}$ = 0.216

Table 24. Cross tab for lower back discomfort with smoking

Smoking	Lower back pain or discomfort (last week)		
	Frequency	Level	Interference
	0.98[a]	0.52	4.42

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

In table 24 shows that there is no association between lower back discomfort and smoking status.

Table 25 below is the cross tab of two independent variables alcohol drinking and lower back discomfort the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 0.857; $P_{\text{frequency}}$ = 0.931
- Chi-Square $_{level}$ = 0.392; P_{level} = 0.942
- Chi-Square $_{interference}$ = 0.317; $P_{interference}$ = 0.957

Table 25. Cross tab for lower back discomfort with drinking

Alcohol	**Lower back pain or discomfort (last week)**		
	Frequency	Level	Interference
	0.85[a]	0.39	0.31

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

None of the factors in Table 25 are found to be significant.

Table 26 is the cross tab of two independent variables gender and right shoulder discomfort with the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 3.656; $P_{\text{frequency}}$ = 0.455
- Chi-Square $_{level}$ = 1.554; P_{level} = 0.672
- Chi-Square $_{interference}$ = 0.994; $P_{interference}$ = 0.803

Table 26. Cross tab for right shoulder discomfort with gender

Gender	**Right shoulder pain or discomfort (last week)**		
	Frequency	Level	Interference
	3.99[a]	1.55	1.01

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

As the p-value is greater than 0.05, there is no association between right shoulder discomfort and type of gender.

Table 27 is the cross tab of two independent variables age group and lower back discomfort with the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 11.149; $P_{\text{frequency}} = 0.516$
- Chi-Square $_{level}$ = 5.796; $P_{level} = 0.760$
- Chi-Square $_{interference}$ = 6.214; $P_{interference} = 0.718$

Table 27. Cross tab for right shoulder discomfort with age group

Age	**Right shoulder pain or discomfort (last week)**		
	Frequency	Level	Interference
	10.79[a]	4.82	4.77

[a]The max likelihood ratio chi-square; $^{*}p < 0.05$

None of the factors in Table 27 are found to be significant.

Table 28 is the cross tab of two independent variables smoking status and right shoulder discomfort the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 1.865; $P_{\text{frequency}}$ = 0.760
- Chi-Square $_{level}$ = 2.142; P_{level} = 0.544
- Chi-Square $_{interference}$ = 0.157; $P_{interference}$ = 0.984

Table 28. Cross tab for right shoulder discomfort with smoking

Smoking	**Right shoulder pain or discomfort (last week)**		
	Frequency	Level	Interference
	1.87[a]	2.15	0.15

[a]The max likelihood ratio chi-square; $^{*}p_{<0.05}$

As the p-value is greater than 0.05, there is no association between right shoulder discomfort and smoking status.

Table 29 is the cross tab of two independent variables drinking and right shoulder discomfort the frequency, level of pain, and interference with the daily activities. As there was no expected value less than or equal 5, chi-square test of independence variable(s) is applied to determine whether there is a significant association.

The results are as follows:

- Chi-Square $_{frequency}$ = 1.070; $P_{\text{frequency}}$ = 0.899
- Chi-Square $_{level}$ = 1.818; P_{level} = 0.611
- Chi-Square $_{interference}$ = 1.431; $P_{interference}$ = 0.698

Table 29. Cross tab for right shoulder discomfort with drinking

Alcohol	**Right shoulder pain or discomfort (last week)**		
	Frequency	Level	Interference
	1.06[a]	1.89	1.42

[a]The max likelihood ratio chi-square; $^{*}p_{<0.05}$

As the p-value is greater than 0.05, there is no association between right shoulder discomfort and drinking alcohol.

4.4 Association Rules

Table 30 presents the association rule mining results among the different parts that experience discomfort based on the support of the item sets only, which are higher than the threshold value of 20%.The table presents the correlation between different parts of the body to figure out any positive relation of the pain or discomfort in these areas. Support of the antecedent represents the first body part while the ‘support of consequence’ represents the second body part. Consequently, the ‘support of item set’ represents the percentage of the positive relation between the antecedent and consequence.

The confidence, on the other hand, states the percentage of the pain in the consequence when the item set is available.

The ‘lift’ column shows the areas that have a positive relation. When the field is **1** or more, there is a positive relation between the different body parts. For instance, the results reveal that 55% of the participants have pain in their lower back and 64% have pain in their neck.

Table 30. Positive association rules of independent variables

Association Rules	**Support of Antecedent**	**Support of Consequence**	**Support of Item Set**	**Confidence**	**Lift**
Lower Back → Neck	0.55	0.64	0.43	0.77	1.20
Neck → Lower Back	0.64	0.55	0.43	0.66	1.20
Upper Back → Neck	0.44	0.64	0.35	0.80	1.24
Neck → Upper Back	0.64	0.44	0.35	0.55	1.24
Upper Back → Lower Back	0.44	0.55	0.33	0.76	1.36
Lower Back → Upper Back	0.55	0.44	0.33	0.60	1.36
Right Shoulder → Neck	0.38	0.64	0.32	0.84	1.31
Neck → Right Shoulder	0.64	0.38	0.32	0.49	1.31
Right Shoulder → Lower Back	0.38	0.55	0.28	0.74	1.34
Lower Back → Right Shoulder	0.55	0.38	0.28	0.50	1.34
Upper Back, Lower Back → Neck	0 .33	0.64	0.27	0.82	1.27
Neck, Upper Back → Lower Back	0.35	0.55	0.27	0.77	1.40
Neck, Lower Back → Upper Back	0.43	0.44	0.27	0.64	1.45
Upper Back → Neck, Lower Back	0.44	0.43	0.27	0.62	1.45
Lower Back → Neck, Upper Back	0.55	0.35	0.27	0.50	1.40
Neck → Upper Back, Lower Back	0.64	0.33	0.27	0.43	1.27
Lower Back, Right Shoulder → Neck	0.28	0.64	0.25	0.90	1.40
Neck, Right Shoulder → Lower Back	0.32	0.55	0.25	0.79	1.43
Right Shoulder → Neck, Lower Back	0.38	0.43	0.25	0.67	1.56
Neck, Lower Back → Right Shoulder	0.43	0.38	0.25	0.59	1.56
Lower Back → Neck, Right Shoulder	0.55	0.32	0.25	0.45	1.43
Neck → Lower Back, Right Shoulder	0.64	0.28	0.25	0.39	1.40
Right Shoulder → Upper Back	0.38	0.44	0.24	0.65	1.47
Upper Back → Right Shoulder	0.44	0.38	0.24	0.55	1.47
Right Hand/Wrist → Neck	0.28	0.64	0.24	0.85	1.32
Neck → Right Hand/Wrist	0.64	0.28	0.24	0.37	1.32
Left Shoulder → Neck	0.28	0.64	0.24	0.84	1.31
Neck → Left Shoulder	0.64	0.28	0.24	0.37	1.31
Left Shoulder → Right Shoulder	0.28	0.38	0.22	0.80	2.12
Right Shoulder → Left Shoulder	0.38	0.28	0.22	0.59	2.12
Upper Back, Right Shoulder → Neck	0.24	0.64	0.21	0.86	1.33
Right Hand/Wrist → Lower Back	0.28	0.55	0.21	0.75	1.36
Neck, Right Shoulder → Upper Back	0.32	0.44	0.21	0.66	1.50
Neck, Upper Back → Right Shoulder	0.35	0.38	0.21	0.59	1.58
Right Shoulder → Neck, Upper Back	0.38	0.35	0.21	0.56	1.58
Upper Back → Neck, Right Shoulder	0.44	0.32	0.21	0.47	1.50
Lower Back → Right Hand/Wrist	0.55	0.28	0.21	0.38	1.36
Neck → Upper Back, Right Shoulder	0.64	0.24	0.21	0.33	1.33
Left Shoulder → Lower Back	0.28	0.55	0.21	0.74	1.33
Lower Back → Left Shoulder	0.55	0.28	0.21	0.37	1.33

Among the whole sample, there is 43% of them who have pain in both the lower back and the neck. Furthermore, 77% of those who have pain in the lower back experience discomfort in their necks. It was observed that there were 49 positive correlations of ARs based on the 20% minimum support. The highest percentage of the positive correlation rule between item sets was the lower back → neck which has support (43%) and confidence (77%) while the 'upper back → neck' has 35% support and 80% confidence respectively. The 'lower back → left shoulder', on the other hand, had 21

% support of the item set while its confidence was 37%.There are 15 extracted association rules that have confidence more than 70%, which means that there is a significant relation between the pains experienced in many different parts of the body. From these rules, we find that the participants had high frequency of pain or discomfort in the neck with 77 to 90% confidence as shown in Figure 8. The participants who felt pain or discomfort in the neck region most likely also had pain or discomfort in the upper back, lower back, or right shoulder with support from 32 to 43%. The participants had pain or discomfort in the neck along with right shoulder and right hand and wrist pain or discomfort with a confidence between 84 and 85%, which indicates dominance of the right hand while using their devices. Moreover, 25% of pain or discomfort in the right shoulder and lower back were associated with 64% of pain or discomfort in the neck with 90% confidence, representing the probability that the pain or discomfort occurs simultaneously in these parts.

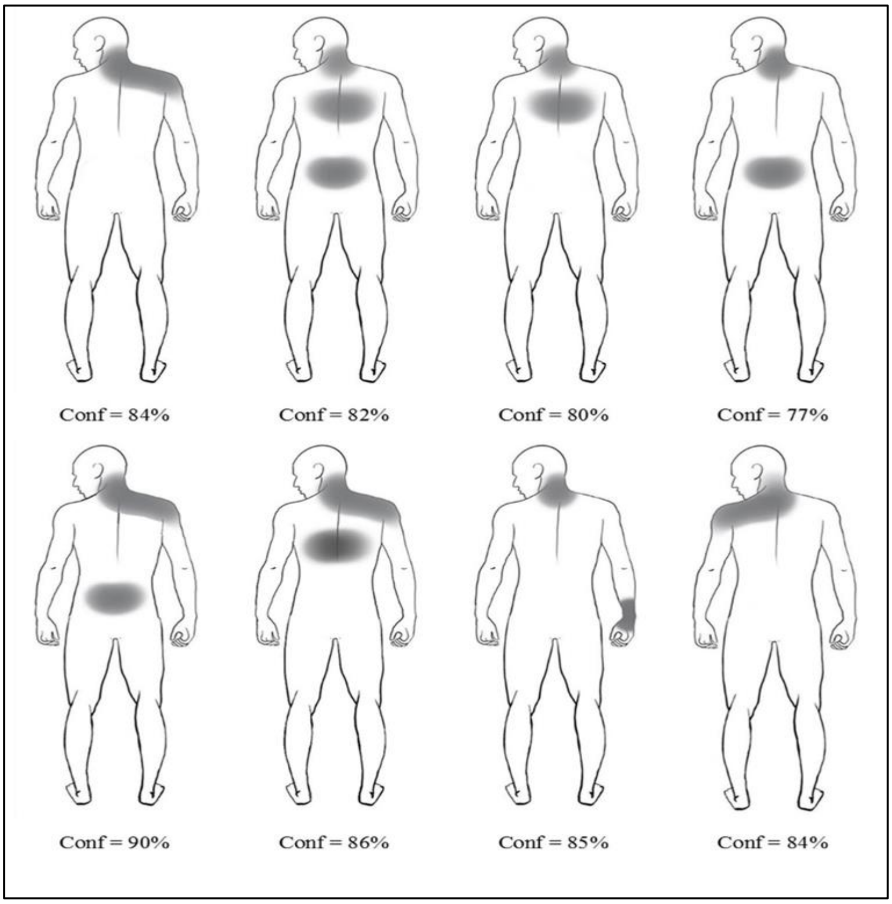

Figure 8. Discovery correlations between body parts according to ARM approch

4.5 Logistic Regression Analysis

Logistic regression analysis is utilized to determine the touch screen device usage risk factors and significantly correlated with MSDs. Logistic regression technique was applied because the dependent variable was nominal and the explanatory variables were continuous quantity and the normality assumption is not necessary.

For an avoiding the Multicolinearity between independent variables in this study that were used, a correlation analysis was applied to identify relationships among independent variables.

In Table 31 the variables that were highly correlated (with a correlation coefficient greater than r = 0.5) were found, and only one variable was used in the regression analysis (Hair et al., 1995). The result show 11 positive correlation among independents variables (r > 0.50). The dependent variable is experiences of physical discomfort last year (dichotomous dependent variable), and the independent variables are the rest other variables. In each module, the relationship between different variables was investigated and then correlation analysis was conducted using Excel in order to determine any relationship between the variables.

Table 31. Correlation analysis of independent variables

Variable 1	**Variable 2**	**Correlation Coefficient**
Ache, pain, discomfort in shoulder (Left)	Ache, pain, discomfort in shoulder (Right)	0.604
Ache, pain, discomfort in upper arm (Left)	Ache, pain, discomfort in upper arm (Right)	0.541
Ache, pain, discomfort in forearm (Left)	Ache, pain, discomfort in forearm (Right)	0.663
Ache, pain, discomfort in hand-wrist (Left)	Ache, pain, discomfort in hand-wrist (Right)	0.646
Ache, pain, discomfort in thigh (Left)	Ache, pain, discomfort in thigh (Right)	0.705
Ache, pain, discomfort in lower leg (Left)	Ache, pain, discomfort in thigh (Right)	0.586
Ache, pain, discomfort in lower leg (Right)	Ache, pain, discomfort in thigh (Right)	0.563
Ache, pain, discomfort in lower leg (Left)	Ache, pain, discomfort in thigh (Left)	0.514
Ache, pain, discomfort in lower leg (Right)	Ache, pain, discomfort in thigh (Left)	0.568
Ache, pain, discomfort in knee (Left)	Ache, pain, discomfort in knee (Right)	0.844
Ache, pain, discomfort in lower leg (Left)	Ache, pain, discomfort in lower leg (Right)	0.778

In order to satisfy the requirements of logistic regression, the sample size should be enough to have at least 5 instants of data points for each combination of the independent variables (Hair et al., 1995) . Therefore, 544 observations were used for the proportion of independent variables to observations to meet the proposed guideline. Selecting this sample size would help reducing the effect of over fitting and would provide a more generalized outcome. In order to run the logistic regression analysis SPSS (version 21) was used.

Table 32. Demographics model of logistic regression technique

Predictor	**B**	**SE**	**Z**	**P**	**Odds Ratio**	**95% CI**	
						Lower	**Upper**

Constant	1.219	0.814	2.241	0.134	3.383		
Gender	-0.256	0.193	1.750	0.186	0.774	0.530	1.131
Age	0.038	0.133	0.082	0.775	1.039	0.800	1.350
Smoking	-0.220	0.187	1.391	0.238	0.802	0.557	1.157
Drinking	-0.053	0.199	0.070	0.791	0.49	0.643	1.400
Owning (yr)	-0.020	0.102	0.040	0.841	0.980	0.802	1.197
Type of device	-0.388	0.391	0.981	0.322	0.679	0.315	1.461
Daily duration (hr)	-0.091	0.100	0.824	0.364	0.913	0.751	1.111
Sitting	0.515	0.264	3.801	***0.05***	1.673	0.997	2.808
Standing	-0.1978	0.203	0.949	0.330	0.821	0.551	1.222
Lap-posture	0.309	0.276	1.253	0.263	1.362	0.793	2.338
Behind a desk performing a task	-0.438	0.220	3.972	***0.046***	0.645	0.419	0.993
Laying down on a sofa	0.043	0.187	0,051	0.821	1.043	0.723	1.507
Walking	0.032	0.199	0.026	0.871	1.033	0.699	1.526

Table 32 shows that sitting posture and behind a disk performing a task have significant effect on musculoskeletal disorder.

Table 33. Neck model using logistic regression technique

Predictor	**B**	**SE**	**Z**	**P**	**Odds Ratio**	**95% CI**	
						Lower	**Upper**
Constant	-0.724	0.188	14.825	**0.000**	0.485		
Neck (Experience)	0.358	0.115	9.664	***0.002***	1.431	1.141	1.793
Neck (Severity)	-0.131	0.19	0.479	0.489	0.877	0.604	1.272
Neck (Interference)	0.198	0.179	1.223	0.269	1.219	0.858	1.732

According to Table 33, the only significant factor as the predictor of MSD was the experience of neck discomfort (p = 0.002).

Table 34. Right-shoulder model using logistic regression technique

Predictor	**B**	**SE**	**Z**	**P**	**Odds Ratio**	**95% CI**	
						Lower	**Upper**
Constant	-0.598	0.209	8.183	**0.004**	0.55		
Shoulder (Experience)	0.441	0.177	6.238	***0.013***	1.554	1.1	2.196
Shoulder (Severity)	-0.138	0.269	0.263	0.608	0.871	0.514	1.476
Shoulder (Interference)	0.113	0.246	0.211	0.646	1.119	0.692	1.812

The results show that there is significant predictor variable of MSDs in right-shoulder factor at experience (Table 34).

Table 35 Left-shoulder model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI Lower	95% CI Upper
Constant	0.668	0.251	7.066	**0.008**	0.513		
Shoulder (Experience)	0.59	0.227	6.773	**0.009**	1.805	1.157	2.815
Shoulder (Severity)	0.286	0.33	0.749	0.387	0.752	0.394	1.435
Shoulder (Interference)	0.115	0.319	0.131	0.718	1.122	0.6	2.099

The results show that there is significant predictor variable of MSDs in left-shoulder factors at experience with p = 0.009 (Table 35).

Table 36. Upper back model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI Lower	95% CI Upper
Constant	0.710	0.203	12.160	0.000	0.492		
Upper back (Experience)	0.344	0.162	4.498	**0.034**	1.41	1.026	1.937
Upper back (Severity)	0.168	0.235	0.511	0.475	1.183	0.746	1.876
Upper back (Interference)	0.128	0.223	0.33	0.566	1.137	0.734	1.76

Table 36 shows that of experience at the upper back model (p = 0.034 < 0.05) is significantly affects in MSDs.

Table 37. Right-upper arm model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI Lower	95% CI Upper
Constant	0.115	0.259	0.197	0.657	0.891		
Upper arm ((Experience)	0.153	0.237	0.413	0.52	1.165	0.731	1.855
Upper arm (Severity)	0.237	0.367	0.416	0.519	1.267	0.617	2.603
Upper arm (Interference)	0.126	0.325	0.15	0.699	0.882	0.466	1.667

The results show that there is no significant predictor variable of MSDs in right-upper arm factors (Table 37).

Table 38. Left upper arm model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI Lower	95% CI Upper
Constant	0.213	0.311	0.471	0.493	0.808		
Upper arm (Experience)	0.261	0.295	0.782	0.377	1.298	0.728	2.313
Upper arm (Severity)	0.531	0.449	1.394	0.238	0.588	0.244	1.419
Upper arm (Interference)	0.6	0.406	2.178	0.14	1.821	0.821	4.038

The results indicate that there is no significant dependent variable of MSDs in left-upper arm factors (Table 38). Also, table 39 shows that the lower back factors at experience are found to be significant predictors of MSDs.

Table 39. Lower back model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	-0.814	0.193	17.78	**0.000**	0.443		
Lower back (Experience)	0.343	0.14	6.005	**0.014**	1.409	1.071	1.853
Lower back (Severity)	0.146	0.211	0.479	0.489	1.157	0.765	1.749
Lower back (Interference)	0.116	0.198	0.341	0.56	1.123	0.761	1.655

Table 40. Right-forearm model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.079	0.276	0.082	0.775	1.082		
Forearm (Experience)	-0.026	0.257	0.01	0.921	0.975	0.589	1.612
Forearm (Severity)	0.272	0.393	0.477	0.49	1.312	0.607	2.837
Forearm (Interference)	0.025	0.396	0.004	0.95	1.025	0.472	2.228

Table 40 indicates there is no significant predictor of MSDs in the right-forearm model.

Table 41. Left-forearm model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.163	0.344	0.224	0.636	1.177		
Forearm (Experience)	-0.087	0.328	0.07	0.792	0.917	0.482	1.743
Forearm (Severity)	-0.062	0.429	0.021	0.886	0.94	0.405	2.181
Forearm (Interference)	0.373	0.416	0.802	0.371	1.452	0.642	3.284

None of the factors in Table 41 are found to be significant predictors of MSDs in the left-forearm model.

Table 42. Right-wrist model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.261	0.212	1.505	0.22	1.298		

Wrist (Experience)	-0.278	0.184	2.279	0.131	0.757	0.528	1.086
Wrist (Severity)	0.204	0.296	0.474	0.491	1.226	0.687	2.189
Wrist (Interference)	0.413	0.302	1.872	0.171	1.512	0.836	2.733

None of the factors in Table 42 are found to be significant predictors of MSDs in the right wrist model.

Table 43. Left wrist model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.334	0.263	1.613	0.204	1.397		
Wrist (Experience)	0.314	0.244	1.653	0.199	0.731	0.453	1.179
Wrist (Severity)	0.455	0.42	1.174	0.279	0.635	0.279	1.445
Wrist (Interference)	1.149	0.419	7.509	**0.006**	3.154	1.387	7.172

There is predictor variable has been found, among left wrist at interference, to be significant predictor of MSDs (Table 43).

Table 44. Hip/buttocks model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.297	0.307	0.934	0.334	1.346		
Hip (Experience)	0.243	0.29	0.701	0.403	0.785	0.445	1.385
Hip (Severity)	0.251	0.387	0.418	0.518	0.778	0.364	1.663
Hip (Interference)	0.737	0.379	3.783	**0.052**	2.091	0.994	4.396

None of the factors in Table 44 are found to be significant predictors of MSDs in the hip/buttocks model.

Table 45. Right thigh model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.147	0.316	0.216	0.642	1.158		
Thigh (Experience)	0.155	0.3	0.269	0.604	0.856	0.476	1.54
Thigh (Severity)	0.652	0.413	2.496	0.114	1.919	0.855	4.308
Thigh (Interference)	0.009	0.395	0.000	0.982	0.991	0.457	2.148

The results indicate that there is no significant dependent variable of MSDs in right-thigh factors (Table 45).

Table 46. Left-thigh model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.432	0.359	1.452	0.228	1.541		
Thigh (Experience)	-0.408	0.344	1.407	0.236	0.665	0.339	1.305
Thigh (Severity)	0.887	0.48	3.416	0.065	2.427	0.948	6.216
Thigh (Interference)	-0.008	0.445	0.000	0.986	0.992	0.415	2.372

The results indicate that there is no significant dependent variable of MSDs in left-thigh factors (Table 46).

Table 47. Right-knee model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.339	0.27	1.584	0.208	1.404		
Knee (Experience)	-0.352	0.251	1.969	0.161	0.703	0.43	1.15
Knee (Severity)	0.243	0.34	0.511	0.475	1.276	0.655	2.486
Knee (Interference)	0.511	0.338	2.284	0.131	1.667	0.859	3.233

The results show that there is no significant predictor variable of MSDs in right-knee factors (Table 47).

Table 48 Left-knee model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.36	0.319	1.272	0.259	1.433		
Knee (Experience)	-0.326	0.305	1.144	0.285	0.722	0.397	1.312
Knee (Severity)	0.186	0.357	0.273	0.601	1.205	0.599	2.423
Knee (Interference)	0.479	0.347	1.908	0.167	1.614	0.818	3.183

The results show that there is no significant predictor variable of MSDs in left-knee factors (Table 48).

Table 49. Right lower leg model using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.023	0.285	0.007	0.935	1.023		
Lower leg (Experience)	0.056	0.268	0.044	0.833	0.945	0.559	1.597
Lower leg (Severity)	0.882	0.384	5.276	**0.022**	2.415	1.138	5.124
Lower leg (Interference)	0.366	0.382	0.919	0.338	0.694	0.328	1.465

Table 49 indicate that of the right lower leg factors are found to be significant predictors of MSDs. Additionally the table 50 indicate that of the left lower leg factors are found to be significant predictors of MSDs.

Table 50. Left lower leg using logistic regression technique

Predictor	B	SE	Z	P	Odds Ratio	95% CI	
						Lower	Upper
Constant	0.42	0.376	1.249	0.264	1.522		
Lower leg (Experience)	0.416	0.363	1.308	0.253	0.66	0.324	1345
Lower leg (Severity)	1.071	0.501	4.562	**0.033**	2.918	1.092	7.795
Lower leg (Interference)	0.169	0.503	0.113	0.737	0.845	0.316	2.262

Table 51. Significant risk factors using discomfort experience

Predictor	P	OR	95% CI	
			Lower	Upper
Sitting posture	**0.05***	1.673	0.997	2.808
Behind a desk performing a task	**0.046***	0.645	0.419	0.993
Experience in the neck	**0.002***	3.258	1.049	10.120
Experience in the right shoulder	**0.013***	1.554	1.1	2.196
Experience in the upper back	**0.034***	1.41	1.026	1.937
Experience in the lower back	**0.014***	1.409	1.071	1.853

Note: *CI* = confidence interval; *Experience* = frequency of discomfort; *OR* = odds ratio

A list of significant risk factors is provided in Table 51. These include the symptoms of musculoskeletal discomfort, the frequency, severity, and interference ability to work on these symptoms to the formation of MSD.

The following mathematical models are used to calculate the *OR* of the significant factors for the participants to figure out those who have high levels of discomfort.

Where; Y is the dependent variable about physical discomfort.

- The neck model is as shown below:

$$Y = -0.724 + 0.358x_1 - 0.131x_2 + 0.198\chi_3$$

Where

- χ_1 = experience at the neck; χ_2 = severity at the neck; χ_3 = interference at the neck
- χ_1 = 1, 2, 3, 4, 5 χ_2, χ_3 = 1, 2, 3

- The right shoulder model is as shown below:

$$Y = -0.598 + 0.441\chi_4 - 0.138\chi_5 + 0.113\chi_6$$

Where

- χ_4 = experience at the right shoulder; χ_5 = severity at the right shoulder; χ_6 = interference at the right shoulder
- χ_4 = 1, 2, 3, 4, 5 $\chi_{5,6}$ = 1, 2, 3

- The upper back model is as shown below:

$$Y = -0.71 + 0.344\chi_7 + 0.168\chi_8 + 0.128\chi_9$$

Where

- χ_7= experience at the upper back; χ_8= severity at upper back; χ_9= interference at the upper back
- χ_7= 1, 2, 3, 4, 5 $\chi_{8,9}$= 1, 2, 3

- The lower back model is as shown below:

$$Y = -0.814 + 0.343\chi_{10} - 0.146\chi_{11} + 1.116\chi_{12}$$

Where

- χ_{10} = experience at the lower back; χ_{11} = severity at lower back; χ_{12} = interference at the lower back
- χ_{10} = 1, 2, 3, 4, 5 $\quad$ $\chi_{11,12}$ = 1, 2, 3

The risk assessment model was developed and it needed to be verified. Therefore, we clarify the ‘under the risk’ variable and the respondents included in it to enable further appraisal.

The risk assessment model was developed and it needed to be verified. Therefore, we clarify the ‘under the risk’ variable and the respondents included in it to enable further appraisal.

Table 52 reveals the number of respondents under high risk of having physical discomfort, which reflects the maximum levels of OR for each significant factor. OR for more than 50% for each respondent were calculated based on the risk assessment model. Thus, 25 respondents were identified to be in the neck group according to the neck model to suffer ache or discomfort, 17 respondents were assessed to have discomforts according to right shoulder model and 9 respondents were assessed to have discomforts according to upper back model. Moreover, 106 (19.48%) respondents were estimated to experience discomforts at all body regions as evaluated by the questionnaire.

Table 52. Respondents under risk of having MSDs by OR and CMDQ

Model	**N**
Neck	25
Right shoulder	17
Upper back	9
Lower back	2
Neck & Right shoulder	6
Neck & Upper back	7
Neck & Lower back	1

Right shoulder & Upper back	3
Upper back & lower back	8
Neck & Right shoulder & Upper back	3
Neck & Right shoulder & Lower back	1
Neck & Right shoulder &Upper back & Lower back	2
CMDQ	106

4.6 Summary Model

Table 53 illustrate the summary model presents the likelihood percentage, which reflects that the intercept model needs to be improved using the entire model (greater improvement found when ratio values are low). The conditional probability (L (M)) result in the occurrences of the dependent variable based on the values of the predictors. L (M) is the multiplication of N observation probabilities. Hence, In order to calculate the likelihood of each dependent variable, the nth root of the values should be computed. Cox & Snell's value shows the alternative value to R^2 as a transformation of the -2ln [L ($M_{Intercept}$)/L (M_{Full})] statistic and is provided to find the ability of the convergence of the presented logistic regression model.

$$.Cox\ and\ Snell\ R^2 = 1 - \left\{\frac{L\left(M_{Intercept}\right)}{L\left(M_{Full}\right)}\right\}^{2/N}$$

$$Nagelkerke\ R^2 = \frac{1 - \left\{\frac{L\left(M_{Intercept}\right)}{L\left(M_{Full}\right)}\right\}^{2/N}}{1 - L\left(M_{Intercept}\right)^{2/N}}$$

Nevertheless, the full [0, 1] range (seen in OLS R- squareds) may be uncovered if the intercept model Nagelkerke/ R-squared >0 doesn't improve the full model. (http://www.ats.ucla.edu/stat/mult_pkg/faq/general/Psuedo_RSquareds.htm). Thus, if the log likelihood (-2LL) value is almost zero, the model will be considered to be good. Furthermore, the good model should have high Cox and Snell R^2 and the Nagelkerke R^2, which values should be close to 1.

Table 53. Model summaries

Model	-2LL	Cox&Snell R^2	Nagelkerke R^2
1. Demographic Structure	737.350	0.027	**0.036**
2. Pain or discomfort of Neck	723.692	0.051	**0.068**
3. Discomfort of Right-shoulder	726.540	0.046	0.062
4. Pain or Discomfort of Upper back	702.431	0.088	0.117
5. Pain or Discomfort of Right-upper arm	747.362	0.009	0.012
6. Pain or Discomfort of Lower back	700.908	0.090	0.120
7. Pain or Discomfort of Right-forearm	748.889	0.006	0.008
8. Pain or Discomfort of Right hand-wrist	741.275	0.020	0.027
9. Pain or Discomfort of Hip/Buttocks	745.867	0.012	0.016
10. Pain or Discomfort of Right-thigh	739.335	0.023	0.031
11. Pain or Discomfort of Right-knee	739.642	0.023	0.031

The predictor variables among all models are ranges between one two, thus not all our models have significant variables as shown in Table 53. There is difference among strength of the model based on the model parameters. Since, the log likelihood values were positive and Nagelkerke R2 were greater than 1, all models were weak models. Thus, all the associations are weak, and the predictors of MSDs have a weak explaining the variance.

4.7 Goodness-of-Fit Measure

In Table 54 of Hosmer-Leme show Goodness-of-Fit tests results show that the p-values of all of the models were more than 0.05. Greater p-values show that the logistic model is fitted well. Therefore, according to the result, the hypothesis related to factors in each model and their contributions to the prevalence of MSDS was rejected in some models. Consequently models 1, 2, 3, 7, and 11 were relatively resulted in a good fit with their respective p-values of 0.700, 0.783, 0.521, 0.660, and 0.638.

Table 54. Goodness-of-fit result by Hosmer-Lame

Model	Chi-Square	df	Sig.
1. Demographic Structure	5.524	8	0.700
2. Pain or discomfort of Neck	3.201	6	0.783
3. Discomfort of Right-shoulder	1.771	3	0.621
4. Pain or Discomfort of Upper back	5.211	4	0.266
5. Pain or Discomfort of Right-upper arm	2.199	1	0.138
6. Pain or Discomfort of Lower back	4.327	5	0.503
7. Pain or Discomfort of Right-forearm	0.193	1	0.660
8. Pain or Discomfort of Right hand-wrist	7.231	3	0.065
9. Pain or Discomfort of Hip/Buttocks	0.481	1	0.488
10. Pain or Discomfort of Right-thigh	1.630	1	0.202
11. Pain or Discomfort of Right-knee	0.898	2	0.638

4.8 The Neural Networks

The neural networks are defined as simplified models with many layers of neurons interrelating by identical weight sets. The input data is processed in these layers as neurons, which transfer the functions to have outputs. The neural networks model work adjusted the interconnected weights in the process of learning in the input values. Four algorithms of different machine learning models were applied to all input and out data to predict the impact of mobile touch screen devices between users until that the achieves the best of high accuracy.

We implemented five different function networks to determine the best machine-learning classification in terms of prediction accuracy when studying risk levels that interfere with the ability to perform daily activities. According on the interference ability index, the risk level class of each participant was identified, and the frequency distribution for classes is shown in Figure 9.

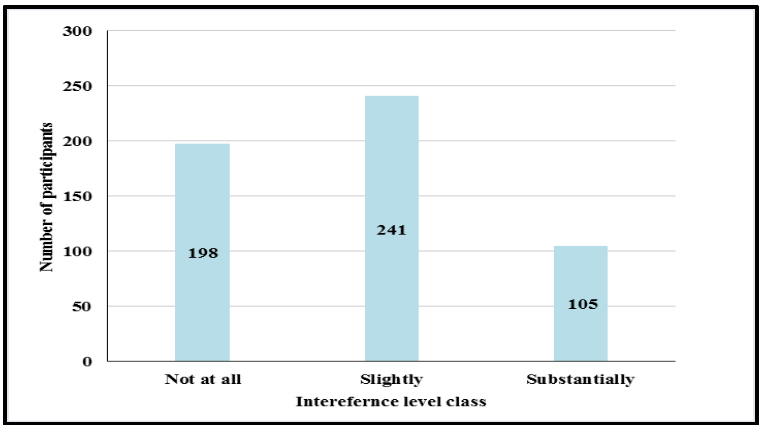

Figure 9. Interfere level class frequency distribution

In this study, researchers use pilot study of 400 participants to four different algorithms of machine learning each of them has different name and is prediction model. The machine leering algorithms namely; support vector machine neural network, long short-term memory neural network, back-propagation neural network, radial basis function neural network, and ensemble bagged tree. The frequency of aches, pains, and discomfort in various body regions were inputted to the machine learning algorithms as 544 samples after data preprocessing as shown in Table 55.

Table 55. Classification of risk levels

Risk class	**interfere ability index**
Low	0.00-33.33
Medium	33.33-66.67
High	66.67-100

Table 56. Pilot of different algorithms of machine learning (n = 400)

Function network	**Accuracy**	**Mean Square Error**
Support vector machine (SVM)	70%	0.30
long short term memory (LSTM)	75%	0.25
Back propagation (BP)	67.5%	0.325
Radial basis function (RBF).	80%	0.20
Ensemble bagged tree (EBT)	83.2%	0.168

Table 56 shows the pilot of different algorithms, the highest one is 83.2% of ensemble bagged tree, which is one of the best representative models in comparison to other networks in terms of accuracy. This was revealed after applying the training data to the networks. Comparing the accuracy level of each network, the ensemble bagged tree was the most accurate, with 83.2% the error of the network was 0.168.The second accurate network was radial basis function (80%), the third long short-term memory (75%), the fourth support vector machines algorithm (70%), and last one back propagation algorithm (67.5%) (Refer to Appendix B).

Table 57. Comparison of different algorithms of machine learning (n = 544)

Function network	**Accuracy**	**Mean Square Error**
Support vector machine (SVM)	63%	0.37
long short-term memory (LSTM)	79.8%	0.202
Back propagation (BP)	73.7%	0.263
Radial basis function (RBF).	84%	0.16
Ensemble bagged tree (EBT)	91%	0.09

Table 57 shows the algorithm of ensemble bagged tree, which is one of the best representative models in comparison to other networks in terms of accuracy.

This was revealed after applying the training data to the networks. Comparing the accuracy level of each network, the ensemble bagged tree was the most accurate, with 91% the error of the network was 9%.

The second accurate network was radial basis function (79.8%), back-propagation algorithm (73.7%), and support vector machines algorithm (63%) (Refer to Appendix C).

The performance measures used to assess the performance of four different algorithms were accuracy, macro-precision, macro-recall, and macro-averaged F1-score due to the multinomial classification task. Since here the problem was a multiclass classification, performance measures such as precision, recall and F1 score were calculated for each class and the average was taken to compare the models. We implemented five different algorithms to determine the superior machine learning classifier in terms of prediction ability when studying risk levels that interfere with the ability to perform daily activities. A comparison of the considered metrics of each algorithm is shown in Figures (10, 11, 12 and 13).In the Figure 10 is illustrate the comparison of accuracy of each the machine learning algorithms.

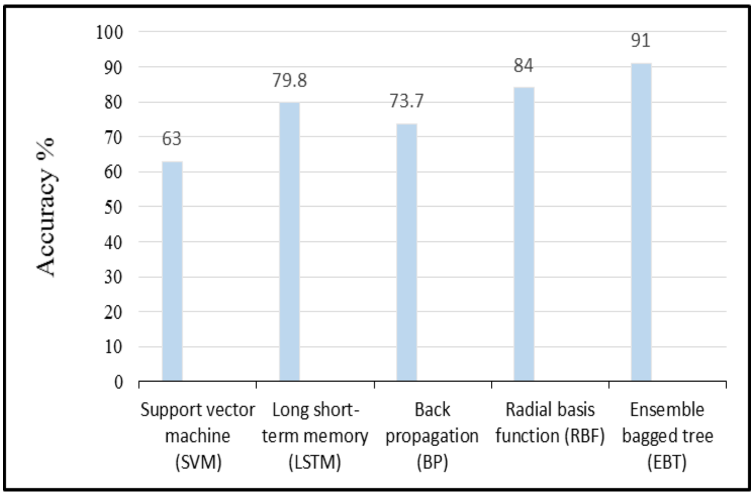

Figure 10. Comparison of accuracy among the machine learning algorithms

The ensemble bagged tree algorithm had the highest accuracy value (91%) among the algorithms and the radial basis function had the second highest accuracy value (84%). Long short-term memory networks also had a good accuracy value (79.8%) also back propagation had good accuracy value (73.7).Support vector machines algorithm had the lowest accuracy (63%). The comparison of Macro-precision in the machine learning algorithms is shown in Figure 11.

The macro-precision performance was near to accuracy, where the ensemble bagged tree algorithm had the highest macro-precision value (94.3%), the radial basis function algorithm had the second highest macro-precision value (85.2%) and long short time memory classifier had the third highest macro-precision value (82) while back propagation networks had a higher macro-precision (73.5%) than support vector machines algorithm (63.5%).

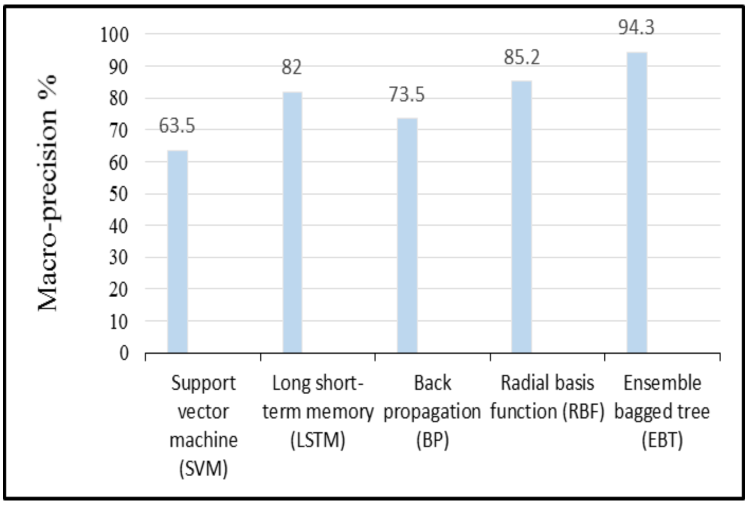

Figure 11. Comparison of macro-precision among the ML algorithms

The results of machine learning algorithms revealed that both the Ensemble Bagged Tree algorithm and Basis Radial Function had the highest predictive accuracy for the predictive modelling. The comparison of macro-recall in the machine learning algorithms is shown Figure 12. Both the ensemble bagged tree and the radial basis function algorithm classifier had the highest recall (96.1% and 77.9%) respectively compared to the other algorithms. Support vector machines had the lowest macro-recall (59.5%).

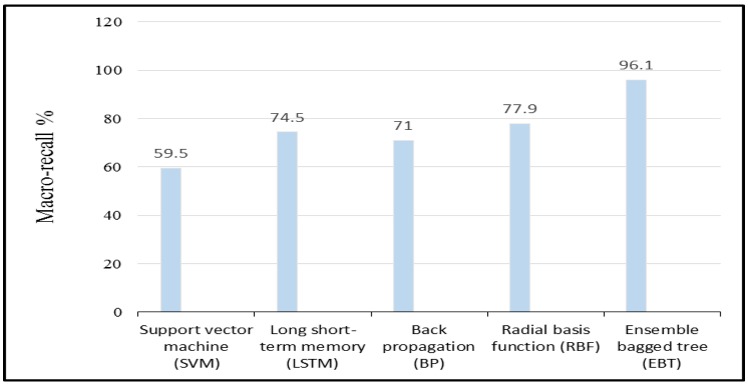

Figure 12. Comparison of macro-recall among the ML algorithms

The comparison of the macro -averaged F1 score in the machine learning algorithms is shown in Figure 13., where the ensemble bagged tree algorithm had the highest F1 score (95.2%), radial basis function classifier had the second highest F1 score (81.3%), the third one was long-short-term memory (78.1%) and back propagation (72.2%). While the support vector machines had the lowest F1 score (61.4%).

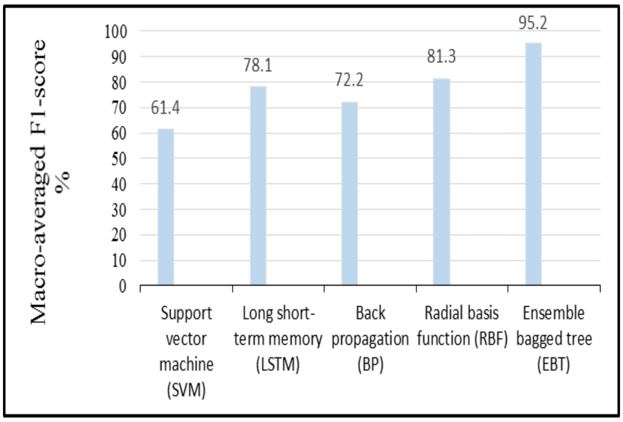

Figure 13. Comparison of macro–averaged F1 score among the ML algorithms

Chapter 5

CONCLUSION AND DISCUSSION

5.1 Discussion

This study focuses on to develop a model for classifying the pain or discomfort interference with the daily activities performance among university students. Additionally, logistic regression was used for modelling and to identify the significant risk factors, which elaborates on the physical discomforts resulting from the mobile touch screen devices usage. This study contributes to the literature in its results that mobile touch screen devices have a significant impact on university students. The research findings have provided that the physical discomfort related problems experienced in parts of the body have related together.

The study contributed insights about symptom prevalence of musculoskeletal disorders in users of mobile touch screen devices who are prone to suffer pain or discomfort in various body regions. Mobile touch screen devices use can logically be expected to overload the neck and the dominant upper extremities, and the neck region. Unexpectedly, the authors found that participants also had pain or discomfort in the lower extremities through with high prevalence at the upper extremities. These are 64.3% pains in the neck region, 37.5% in the right shoulder, 27.9% in the left shoulder, 44.3% in the upper back, 55.3% in the lower back, 19.3% in the right-upper arm, 15.1% the left-upper arm, 16.9% in the right forearm, 12.5% the left forearm, 27.8% in the right hand/wrist and 19.7% in the left hand/wrist. Interestingly, male correspondents showed higher pains in the neck region and the upper extremities compared to females. For the male, the pains experienced ranged between 73.4-69.1%, while the females experienced pains ranging between 30.9-24.8%.

Similarly, for the lower extremities, 16.9% pains in the hip/buttocks, 17.4% in the right thigh, 13.7% in the left thigh, 21.3% in the right knee, 16.9% in the left knee, 21.6% in the right- lower leg and 15.6% the left- lower leg. Male correspondents showed higher pains in the lower extremities (ranged between 77.3 - 74.6%) compared to the female (ranged between 29.3- 22.7%). Hence, this finding is consistent with the neck, upper back, and shoulder discomfort reported in the literature.

Can and Karaca (2019), found that about half of their participants reported discomfort in the neck region and some parts of the upper extremities. The results of this study also corroborated the findings of Berolo et al. (2011) who showed that daily usage affects the upper extremities. Likewise, Chiang and Liu (2016) confirmed that participants using tablets had symptoms related to the neck and intensity of discomfort in the back.

The authors found that the lower back was more often a prominent site of musculoskeletal disorders symptoms in participants might be due to taking a sitting posture during use of mobile touch screen devices. Todd et al. (2007) revealed that the sitting posture, over the long term, leads to higher levels of pain in the upper and lower back areas.

Conversely, Namwongsa et al. (2018) reported that symptom prevalence of musculoskeletal disorders was less prevalent in the lower back among smartphone users (17.2%). Legan and Zupan (2022) reported that the prevalence of pain in the lower back ranged between 32.9% and 39.4%. Our results align with the findings of these previous studies, but the percentages were higher in our study. In detail, the lower back was found to be the second-highest area of pain after the neck (55.3%). Additionally, the logistic regression analysis showed that spending a long portion of the day in the postures of sitting or postures while performing a task using a mobile touch screen devices were significantly ($P<0.05$) associated with a high prevalence of musculoskeletal pain in the neck, upper back, and lower back regions.

In a recent study, Mustafaoglu et al. (2021), used logistic regression models that shows spending over six hours a day on a smartphone and sitting without supporting the arms causes increased frequency of pain in the neck and upper back. Similarly, in our study, we observed that the posture of sitting was associated with the presence of neck, upper back, and lower back pain or discomfort. Hakala et al. (2006) , found an increase in the risk of pain or discomfort in the following areas when using smartphones for long periods: neck, shoulder, and lower back.

In general, the prevalence of musculoskeletal disorders among users of mobile touch screen device is due to the application of sustained muscle load on the body. It is reasonable to assume that participants in this study (students) may be spending long hours in static postures owing to their academic requirements. However, the Covid-19 Pandemic also increased the time they spend with those for educational purposes. Therefore, mobile touch screen devices use or overuse appears to lead to musculoskeletal overload, stress, and subsequent symptoms.

In this research, the mean age of the participants is 24.6 years. Therefore, they can be considered to be in the prime of health and physical function. The pain or discomfort experienced by these respondents might be due to the static postures the participants adopt for their studies, their associated daily activities, and their reduced physical activity caused by their academic burden. The neck flexion is the most common posture among smartphone users and may cause musculoskeletal disorders (Kang et al., 2012).

Since the pain was found in four main areas of the participants, namely: neck, right shoulder, upper back, and lower back, there was a need for correlating these findings with any independent factors to find any possible relation. The findings of this study revealed that there is no positive relation between the pains of the aforementioned areas and gender, age, smoking, and alcohol drinking.

This result had one exception only, which was the pain in the neck area with the gender. It was found that males experienced more pain in the neck area compared to the females (p- value = 0.029). This is in line with (Blatter & Bongers, 2002; Moom et al., 2015) who found a positive relation between gender and body discomfort. According to (Sasikumar & Binoosh, 2020), however, there is a relationship between gender and lower back pain rather than the neck. Furthermore, the findings of this study are also in line with the ones of (Guan et al., 2016) that examined the MSDs with university students and found male participants had a significantly larger neck flexion angle than females.

Furthermore, this study found no positive relation between smoking and MSDs, which is opposite to the findings of (Namwongsa et al., 2018) who examined the effects of smoking on university students in Thailand. The study found a positive correlation between smoking and the neck discomfort, which is unlike the current study. However, the findings of (Park et al., 2010) study were in line with the ones of this study in terms of alcohol since both found that there is no positive relation between drinking alcohol and neck disorder.

The researchers of this study used the AMR model to verify the results. From the extracted association rules, participants that have pain or discomfort in the lower back and neck have the highest positive correlation of support and confidence in the lower back and neck. In this way, pain in the lower back was associated with pain in the neck. L. L. Y. Chan et al. (2020) , conducted a cross-sectional study to compare the prevalence of neck pain among undergraduate students of the University Hong Kong (HKU). The results reveal that students with low back pain or discomfort had three times the odds of reporting neck pain or discomfort. Similarly, discomfort in the upper back and right shoulder were associated with discomfort in the neck region.

The current study also revealed that 58.6% of participants were dominant with their right hand. Concurrently, the results revealed the association between pain or discomfort in the neck with pain or discomfort in the right shoulder and right hand and wrist with confidence between 84% and 85%. The prevalence of discomfort on the right side might be indicative of the dominance of usage and holding their devices with the right hand. This suggests that those who continuously use MTSDs with one hand are more uncomfortable, and continued use will lead to increased pain or discomfort of musculoskeletal disorder in that side. Moreover, 25% of pain or discomfort in the right shoulder and lower back were associated with 64% of pain or discomfort in the neck with 90% confidence, representing the probability that the pain or discomfort occurs simultaneously in these parts. Syamala et al. (2018) found that muscle activities like flexion angle and gravitational moments are all significant predictors of pain in the neck and upper extremities when mobile devices are in use. They also asserted that the use of an adequately supportive chair could serve as a remedy for these pains.

In this study, the prevalence of MSD in the neck and lower back may be related to a flexed neck posture while staring into the devices. It is clear that excessive use of their devices can lead to habitual repetitive and continuous movements of the head and neck regions (AlAbdulwahab et al., 2017; Veiersted & Westgaard, 1993) . Our findings reinforce the results of the study by Ning et al. (2015) pointed there are lower levels of neck muscle activities while working on a duty, such as a reading task, and holding the device in one hand. This result was also verified by Kingston et al. (2016) pointed out that using tablets affects the wrist, elbow, and shoulder during reading tasks. Hence, the varied patterns of using the MTSDs, regardless of time, may represent a risk for MSD (Toh et al., 2020). In this regard, Lee (2002) stated that the use of smaller display terminal screens causes a significant bending of the angles around the neck and backbones. Therefore, the use of large LCD screens is more comfortable and convenient for users and leads to a reduction in the discomfort of musculoskeletal symptoms (H.-J. Kim & Kim, 2015). Moreover, it is likely the discomfort at the right hand arises might to is holding position and increased touches while using the on-screen keyboard. The prevalence of MSDs on right hand were also reported from the mobile hand-held device users in a study carried out in in a population of university students, staff, and faculty (Berolo et al., 2011).

The finding in this study is consistent with those found in the literature. Our results highlight a direct relationship between mobile device use and the prevalence of experiencing symptoms of pain or discomfort. The literature suggests that these problems can be alleviated through increased participation in physical activities, reduced sitting time during usage, use of appropriate chairs, and adoption of correct postures (Can & Karaca, 2019; Syamala et al., 2018; Yan Fei Xie et al., 2018).

The results of machine learning algorithms revealed that both the Ensemble Bagged Tree algorithm and Basis Radial Function had the highest predictive accuracy for the predictive modelling. (Saeed et al., 2019) used ensemble bagged tree to discover the losses of the Non-technical losses. The results of this study show that the accuracy of the ensemble bagged tree is found to be 93.1%, which is considerably higher compared to the other algorithms such as support vector machine.(Al-Barazanchi et al., 2017) used publicly available EMG data to diagnose neuromuscular disorders. The results revealed that the classification accuracy rate was 92.8%. (Umer et al., 2020) conducted a study applying several algorithms - such as support vector machine, bagged trees, k-Nearest Neighbors, and others - to monitor cardiorespiratory and thermoregulatory measures. The results revealed that bagged trees led the best performance (accuracy =95.3%). Furthermore, (Widasari et al., 2020) studied the sleep disorders diagnosis process based on the ensemble of bagged tree classifier, which was able to discriminate the sleep disorders and healthy Insomnia by a good accuracy (86.27%). The aforementioned results are in line with the findings of the current study, which also found that the Bagged Tree Algorithm (BTA) had the highest result compared to the other four algorithms.

Zhao et al. (2010) have confirmed that the RBF network is superior to other theories not only in theory but also in prediction. Likewise, Ladstätter et al. (2010) has pointed out that the result produced by has RBF network is 15% better than traditional statistical methods. Accordingly, by comparing different kinds of the predictive modelling networks to detect the accuracy, this study discovered that simulating the (RBF) and (BTA) networks with validation data produced better results (with 95.3% and 84.0% accuracy).

The predictive performance of the Radial Basis Function algorithm tended to be the second superior algorithm compared to the other models. This could be due to the superiority of its method in defining the importance of the variables and its ability in showing the interactions among the predictor variables. The results show that the Support Vector Machine is the lowest algorithm in predicting the accuracy with (63.0%). Moreover, the results of this study showed that the Support Vector Machine is the weakest algorithm in predicting accuracy (63.0%). This matches with the results of Sasikumar and Binoosh (2020) who found that Support Vector Machine is the lowest in the accuracy with (56.25%).

According to the literature review for this study, no previous research used machine learning to assess the impacts of MTSD usage on daily activities. This study fills gaps in scholarship by identifying MSK-symptom prevalence, body region distribution, the relation between body parts, and predictors. It also applied the ARM approach to detect any relationship between body parts where respondents experienced discomfort. Thus, the current research is unique in the topical literature and provides results that are more accurate. Regardless, there remains a need for further studies in this direction.

This study concentrated on both the traditional approach and the analytical approach, which included machine learning in the field of musculoskeletal disorders. According to work-related musculoskeletal disorders steps the authors identified the step of the development of intervention (s) to reducing a possible risk factor. This study revealed that machine-learning algorithms have an accurate prediction of musculoskeletal disorders risk among respondents who use MTSDs. It incorporated RBF to accurately predict the relation of pain or discomfort with risk levels that interfere with the ability to perform ADL. Regarding the algorithms used in the study, the RBF and LSTM were superior in terms of F1-score and accuracy compared to the other algorithms. Even though BPNN is the most common and superior neural network for MSDs research V. C. Chan et al. (2022), the obtained results demonstrated that the implementation of different ANN types such as RBF and LSTM could outperform BP and would provide more accurate results.

In this study, the prevalence of musculoskeletal disorder in the neck and lower back may be related to taking a flexed neck posture while staring down into devices that are held lower than head level. It is clear that excessive use of devices can lead to habitual, repetitive, and continuous movement of the head and neck regions.

5.2 Strengths and Limitations

This research adopted the Association Rule Mining approaches and machine learning algorithm, thereby it is improving and increasing the chances of a more accurate prediction of pain/ discomfort and their interference in daily activities among the university students who use MTSD. Regarding the algorithms used in the study, the Radial Basis Function algorithm and Long Time Short Memory were the highest in terms of accuracy prediction compared to the other algorithms. Furthermore, there is only a handful of scholarly studies in the recent literature examining the impact or contribution of mobile devices on musculoskeletal disorders. Our model can be used in an organization to predict if there will be an interference with the employees' work performance. This research is unique in terms of applying the AR mining approach to detect any relationship of the body parts experiencing discomfort. It also incorporates RBF to accurately predict pain and discomfort with the risk levels that interferes with the ability to work. However, prediction methods in machine learning algorithms and data mining approaches are still lacking in MTSDs field.

The major drawback associated with the current study is that significant issues have not been considered, which include the effect of mobile touch screen device use such as physical exercise. Furthermore, the study did not include device dimensions, data entry method and purpose of use. Another drawback is that the data used to gauge the relationships between touch screen device use and musculoskeletal disorders was solicited from the student population and convenience sampling was used. Also, the sample size was small and may not provide a sufficiently accurate prediction to detect differences in risk levels that interfere with ability to work.

The influence or effects of other variables such as age brackets which could constitute noise in the total outcome, is also being considered a ground for further research. Furthermore, the age group ’17-33’ raises more concern because of the increase in variability among the ages grouped. Also, there are behavioural changes that can affect the use of mobile devices within the age group. In addition, the sample size was small and may not provide a sufficiently accurate prediction to detect differences in risk levels that interfere with the ability to perform ADL.

This study can also aid researchers with reliable references for any future studies related to this field. For this purpose, the researchers recommend having intervention and follow up studies to examine the effects of mobile touch screen devices in the long term and compare the self-reported and observed data in using various touch screen devices. Future studies are also advised to be conducted using more demographic characteristics on the prevalence of musculoskeletal disorders. In addition, more participants contribute to the prediction accuracy in detecting MSDs when using mobile touch screen devices.

The study was male gender-biased since the majority of the participants were males (71%) while the females were minor participants. In fact, this has a direct effect on the generalizability of the data, which further warrant research involving a female investigator and other age categories. Therefore, there is a need for a wider study that takes into consideration the balance in the number of participants in terms of gender.

Furthermore, the participants were only university students, while there are other significant stakeholders that may be investigated, such as school students, workers, and even retired people. Therefore, future studies, based on different age groups, and recording these data for long-term smartphone use, could highlight further effects on the musculoskeletal system.

Moreover, since there is a growing orientation of the institutional organizations, such as schools, universities, and learning centers, to increase the e-learning experience and adopt the blended learning policy, especially after Covid-19, it is suggested to enlarge the study scope and involve more e-learning machines usage in the future studies. This may include the use of laptops, desktops, tablets, and other gadgets.

In addition, future research should also investigate other activities which involve the use of thumb and fingers' of the hand during screening. The findings of the study were restricted to the body parts excluding the hands while there is a need for a study that includes both the body parts and hands.

Last but not the least, the study was restricted to the survey conducted by the participants. Nevertheless, those who were under the risk were not examined clinically using the electromyography equipment to define the level of stress in the muscles. Therefore should be validation of the result by using electromyography system.

5.3 Conclusion

This study is designed to examine the pain or discomfort of MSDs experienced by users of MTSD. It provided an analysis and comparison of the vital body regions where discomfort occurs while using touch screen device usage with the view of investigating the risk factors of MSDs. The result obtained showed that the impacts of MTSDs on the physical discomfort of participants are similar to the majority of the findings in the literature. Specifically, the developed risk assessment model has shown that the neck, right shoulder, and upper back are significant risk factors for physical discomfort experienced by MTSD users.

The study has also shown that machine learning algorithms could accurately predict the interference of pain level with work performance ability for touch screen users. The BTA has the highest predictive accuracy, which denotes the importance of the machine learning algorithm to predict the impact of pain or discomfort of MTSDs use and define the risk levels that interfere. However, it is noteworthy to mention at this point that a machine learning algorithm is like a black box. After training and testing the dataset, it was not likely to find the weights of the prediction model that were created to exploit which body parts as an independent variable had the most or least importance with the interference of pain level with work performance ability. Yet, the model which was created by machine learning algorithms were able to successfully predict the interference of pain from various body parts to the work performance ability as a whole.

The BTA model developed in our study for mobile touch screen users can be used to alert users of MTSDs when exhibiting interference with high risk levels. Thereby, helping them to reduce the risk of interference of ability for daily activities. Bosman et al. (2019) found MSD is one of the strongest predictors of sick leave. Our model can be used in an organization to predict if there will be an interference to the employees' work performance that can lead to absenteeism because of pain in their various body parts and take preliminary measures to safeguard organizational performance. In addition, continuous assessment of employees' wellbeing can also increase the experimenter effect on them where the feeling of being cared for may lead to increased productivity.

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APPENDICES

Appendix A: Questionnaire Related Correspondences

Ethic Committee

Doğu Akdeniz Üniversitesi
"Uluslararası Kariyer İçin"

Eastern Mediterranean University
"For Your International Career"

P.K.: 99628 Gazimağusa, KUZEY KIBRIS /
Famagusta, North Cyprus,
via Mersin-10 TURKEY
Tel: (+90) 392 630 1995
Faks/Fax: (+90) 392 630 2919
bayek@emu.edu.tr

Etik Kurulu / *Ethics Committee*

Reference No: ETK00-2018-0260 15.10.2018
Subject: Application for Ethics.

RE: Ali Elghomati
Faculty of Engineering

To Whom It May Concern:

On the date of **15.10.2018**, (Meeting number ***2018/60-09),*** EMU's Scientific Research and Publication Ethics Committee (BAYEK) has granted**,** Ali Elghomati , from the to Faculty of Engineering pursue with her Phd. thesis work **"The impact of mobile touch screen devise use on musculoskeletal disorders:Risk assessment modeling and verification"** under the supervision of Assoc. Prof. Dr. Adham Mackieh.This decision has been taken by the majority of votes.

Regards,

Assoc. Prof. Dr. Şükrü Tüzmen
Director of Ethics Commitee

ŞT/ba.

www.emu.edu.tr

Questionnaire

MOBILE TOUCH SCREEN DECIVE USER QUESTIONNAIRE

Dear students,

Kindly, please answer the survey below about Portable Touch-screen Devices Use. There are no dangers or punishments for your participation in this investigate think about. Your information you give will offer us an assistance about users experience in mobile touch screen device (s) and related musculoskeletal disorders. All records information that is personally identifiable will stay confidential.

Please for further explanation about this study feel free to contact us by call or email. PhD. Candidate. Ali Elghomati (+905338482556, ali_algomati@yahoo.com) and Prof. Dr. Orhan Korhan (1052, orhan.korhan@emu.edu.tr).

Thank you

THE HABITS OF USING MOBILE TOUCH SCREEN DEVICES

Dear respondents,

Please answer all questions in this survey below and don't skip any questions. You do not need to worry about your responses for this questionnaire which will be anonymous.

Thank You

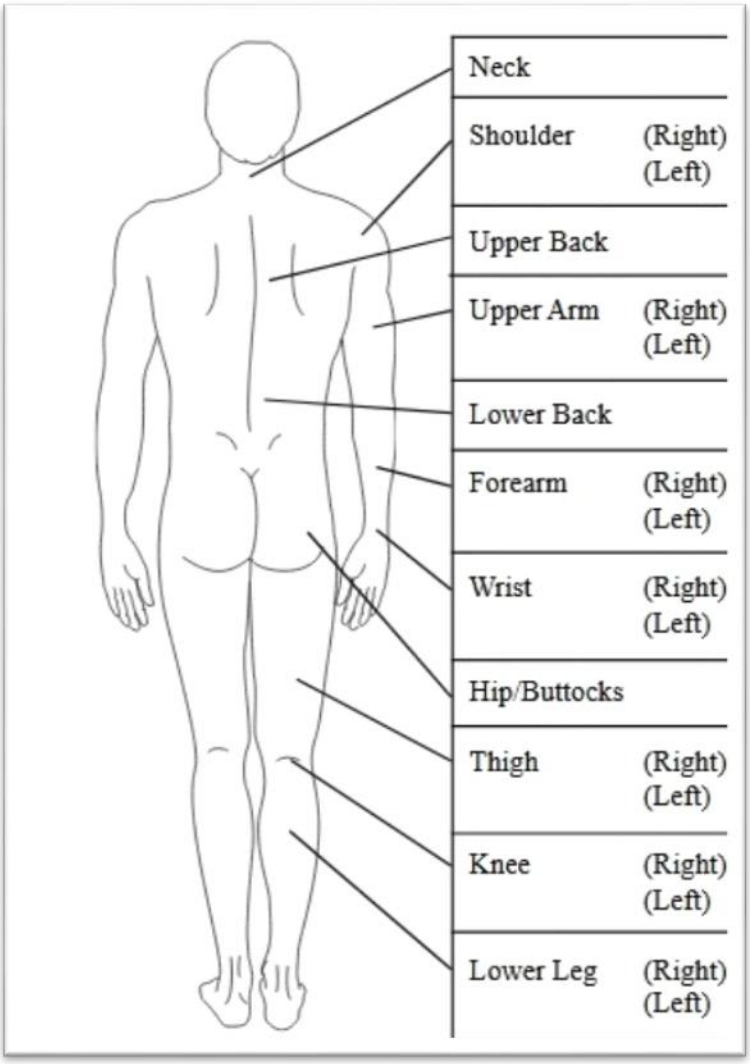
Date / Time …………… Student No…………………………….

1. Gender
   - ☐ Male
   - ☐ Female

2. Age
   - ☐17-25
   - ☐ 25-33
   - ☐ 33- 41
   - ☐ +41
3. Are you a smoker?
   - ☐ Yes
   - ☐ No
4. Do you drink alcohol?
   - ☐ Yes
   - ☐ No
5. What gadget do you use?
   - ☐ Smartphone
   - ☐ Tablet
   - ☐ Smartphone & Tablet
6. Way of holding your device
   - ☐ Right hand
   - ☐ Left hand
   - ☐ Both of hands
7. How long have been using your
   a. Smartphone?
      - ☐ I don't use a smartphone
      - ☐ 1 – 3 years
      - ☐ 4 – 6 years
      - ☐ 7 – 9 years
      - ☐ More than 9 years

   b. Tablet?
      - ☐ I don't use a tablet
      - ☐ 1 – 3 years
      - ☐ 4 – 6 years
      - ☐ 7 – 9 years
      - ☐ More than 9 years

8. Duration of usage as daily (hours)
   a. Smartphone?
      - ☐ 1 – 2
      - ☐ 3 – 4
      - ☐ 5 – 6 years
      - ☐ More than 6
   b. Tablet?
      - ☐ 1 – 2
      - ☐ 3 – 4
      - ☐ 5 – 6 years
      - ☐ More than 6
9. Posture in use
   - ☐ Sitting
   - ☐ Standing
   - ☐ Lap posture
   - ☐ Behind a desk
   - ☐ Laying down on a sofa
   - ☐ Walking
10. Have you had any pain or discomfort during the last year?
    - ☐ Yes
    - ☐ No
11. The diagram below of the body regions. Please answer by choosing the appropriate circle.



1. During the last week, how often did you experience ache, pain, discomfort in. (Please answer for all body regions.)

Body region	**Never**	**1-2 times Last week**	**3-4 times last week**	**Once Every day**	**Several times per day**
Neck	○	○	○	○	○
Shoulder. Right	○	○	○	○	○
Shoulder. Left	○	○	○	○	○
Upper back	○	○	○	○	○
Lower back	○	○	○	○	○

Upper arm. Right	○	○	○	○	○
Upper arm. Left	○	○	○	○	○
Forearm. Right	○	○	○	○	○
Forearm. Left	○	○	○	○	○
Wrist. Right	○	○	○	○	○
Wrist. Left	○	○	○	○	○
Buttocks	○	○	○	○	○
Thigh. Right	○	○	○	○	○
Thigh. Left	○	○	○	○	○
Knee. Right	○	○	○	○	○
Knee. Left	○	○	○	○	○
Lower leg. Right	○	○	○	○	○
Lower leg. Left	○	○	○	○	○

2. If you experienced ache, pain, discomfort, how uncomfortable was this?

Body region	**Slightly uncomfortable**	**Moderately uncomfortable**	**Very uncomfortable**
Neck	○	○	○
Shoulder. Right	○	○	○
Shoulder. Left	○	○	○
Upper back	○	○	○
Lower back	○	○	○
Upper arm. Right	○	○	○
Upper arm. Left	○	○	○
Forearm. Right	○	○	○

Forearm. Left	○	○	○
Wrist. Right	○	○	○
Wrist. Left	○	○	○
Buttocks	○	○	○
Thigh. Right	○	○	○
Thigh. Left	○	○	○
Knee. Right	○	○	○
Knee. Left	○	○	○
Lower leg. Right	○	○	○
Lower leg. Left	○	○	○

3. If you experienced ache, pain, discomfort, did this interfere with your ability to daily activities?

Body region	**Not at all**	**Slightly interfered**	**Substantially interfered**
Neck	○	○	○
Shoulder. Right	○	○	○
Shoulder. Left	○	○	○
Upper back	○	○	○
Lower back	○	○	○
Upper arm. Right	○	○	○
Upper arm. Left	○	○	○
Forearm. Right	○	○	○
Forearm. Left	○	○	○
Wrist. Right	○	○	○

Wrist. Left	○	○	○
Buttocks	○	○	○
Thigh. Right	○	○	○
Thigh. Left	○	○	○
Knee. Right	○	○	○
Knee. Left	○	○	○
Lower leg. Right	○	○	○
Lower leg. Left	○	○	○

Appendix B: List of Variables

1	Age
1	Gender
2	Smoking
3	Drinking alcohol
4	Way of holding
5	Daily usage (hr)
6	Type of device
7	Postures
8	Pain or discomfort
9	Experienced ache, pain, discomfort in neck
10	Experienced ache, pain, discomfort in shoulders
11	Experienced ache, pain, discomfort in upper back
12	Experienced ache, pain, discomfort in upper arms
13	Experienced ache, pain, discomfort in lower back
14	Experienced ache, pain, discomfort in forearms
15	Experienced ache, pain, discomfort in wrists
16	Experienced ache, pain, discomfort in hip/buttocks
17	Experienced ache, pain, discomfort in thighs
18	Experienced ache, pain, discomfort in knees
19	Experienced ache, pain, discomfort in lower legs
20	Ache, pain, discomfort, uncomfortable in neck
21	Ache, pain, discomfort, uncomfortable in shoulders
22	Ache, pain, discomfort, uncomfortable in upper back
23	Ache, pain, discomfort, uncomfortable in upper arms
24	Ache, pain, discomfort, uncomfortable in lower back
25	Ache, pain, discomfort, uncomfortable in forearms
26	Ache, pain, discomfort, uncomfortable in wrists
27	Ache, pain, discomfort, uncomfortable in hip/buttocks
28	Ache, pain, discomfort, uncomfortable in thighs
29	Ache, pain, discomfort, uncomfortable in knees
30	Ache, pain, discomfort, uncomfortable in lower legs
31	Ache, pain, discomfort, Interference in neck
32	Ache, pain, discomfort, Interference shoulders
33	Ache, pain, discomfort, Interference in upper back
34	Ache, pain, discomfort, Interference in upper arms
35	Ache, pain, discomfort, Interference in lower back
36	Ache, pain, discomfort, Interference in forearms
37	Ache, pain, discomfort, Interference in wrists
38	Ache, pain, discomfort, Interference in hip/buttocks
39	Ache, pain, discomfort, Interference in thighs
40	Ache, pain, discomfort, Interference in knees
41	Ache, pain, discomfort, Interference in lower legs

Appendix C: Results of Questionnaire

Table C1-1.Total discomfort of body regions (n=544)

Body parts referred to in the questionnaire	Frequency	Discomfort	Interference	Discomfort score	%
Neck	1202	576	567	392563584	37.2108
Right-shoulder	723.5	343	329	81644804.5	7.73905
Left-shoulder	513	252	237	30638412	2.90419
Upper back	872.5	416	386	140102560	13.2802
Lower back	1090.5	544	515	305514480	28.9595
Right-upper arm	315.5	162	164	8382204	0.79454
Left-upper arm	236	120	116	3285120	0.31139
Right-forearm	249.5	133	136	4512956	0.42778
Left-forearm	175	99	103	1784475	0.16915
Right. Hand/wrist	451.5	251	231	26178421.5	2.48143
Left. Hand/wrist	338.5	178	173	10423769	0.98806
Buttocks/Hip	257.5	151	151	5871257.5	0.55653
Right-thigh	237.5	149	138	4883475	0.4629
Left-thigh	183	116	111	2356308	0.22335
Right-knee	351.5	199	187	13080369.5	1.23988
Left-knee	307.5	163	152	7618620	0.72216
Right-lower leg	333	193	189	12146841	1.15139
Left-lower leg	222	137	131	3984234	0.37766

Table C2-1. SS-CMDQ scores for all respondent students for determining the ones under higher risk than the other students involved in the study

Neck	Shoulder (right)	Shoulder (left)	Upper back	Upper arm (right)	Upper arm (left)	Lower back	Forearm (right)	Forearm (left)	Wrist (right)	Wrist (left)	Hip / Buttocks	Thigh (right)	Thigh (left)	Knee (right)	Knee (left)	Lower leg (right)	Lower leg (left)	*SS CMDQ score*
0	0	0	7	14	14	0	90	0	0	0	0	0	0	0	0	0	0	**125**
40	60	3	14	30	0	90	20	20	3.5	3.5	45	20	20	3.5	3.5	30	30	**436**
40	40	0	90	90	0	90	90	0	0	0	0	0	0	0	0	0	0	**440**
3	0	0	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	12
14	3	0	3	0	0	31.5	0	0	1.5	3	0	0	0	0	0	1.5	1.5	59
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	7	0	0	0	3.5	0	3	1.5	10	0	7	10	1.5	0	7	0	52
1.5	0	0	0	0	0	0	0	0	40	40	0	0	0	0	0	0	0	81.5
0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.5
5	10	10	15	0	0	15	4.5	4.5	5	0	3	4.5	4.5	4.5	4.5	15	15	**120**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	7
5	5	0	5	3.5	3.5	3.5	3.5	3.5	0	0	0	1.5	1.5	1.5	1.5	1.5	1.5	41.5
6	3	6	3	6	6	3	6	6	6	6	6	6	6	6	6	6	6	**99**
3	0	0	3	0	3	1.5	1.5	5	14	20	6	3.5	3.5	3.5	7	10	10	**94.5**
3.5	7	7	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	19
15	10	0	6	20	0	30	0	0	15	0	3	10	0	4.5	0	15	0	**128.5**
3	0	3	15	0	30	10	0	0	0	0	7	0	0	0	0	10.5	0	78.5
6	7	3	14	0	3	6	7	7	6	6	6	7	7	14	7	6	6	118
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	3	0	3	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	16.5
60	20	20	90	1.5	1.5	60	0	0	40	40	0	0	0	0	0	6	6	345
20	13.5	90	3.5	1.5	3	90	0	3	0	0	0	20	20	90	90	90	90	**624.5**
6	90	90	20	20	20	90	1.5	1.5	6	6	0	6	6	6	6	7	7	**389**
6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	12
20	0	0	20	0	0	10	0	0	0	0	0	0	0	0	0	0	0	50
0	0	0	1.5	0	0	1.5	0	0	0	0	1.5	0	0	0	0	0	0	4.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	7	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	28
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
21	7	7	3	0	0	14	0	0	1.5	1.5	1.5	0	0	21	3	0	0	80.5
13.5	0	0	6	0	0	1.5	0	0	0	0	21	0	0	1.5	1.5	0	0	45
20	20	0	1.5	0	0	3	0	0	0	0	1.5	0	0	0	0	0	0	46
0	7	0	1.5	7	0	0	1.5	0	21	0	0	0	0	0	0	6	0	44
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	6	0	0	9	0	0	0	0	0	0	0	0	0	0	0	16.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	10	10	40	0	0	6	20	20	10	1.5	0	0	0	20	15	0	0	**212.5**
14	0	0	3	0	0	9	0	0	0	0	0	0	0	0	0	0	0	26
3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	28.5
0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	6
20	0	0	20	0	0	6	0	0	0	0	0	0	0	0	0	0	0	46
3	1.5	3	6	3	7	3	3.5	3.5	1.5	1.5	3	1.5	0	0	0	3	7	51
7	3	3	1.5	21	3	7	20	13.5	9	4.5	6	7	20	6	7	90	30	**258.5**
9	3	3.5	3.5	3	3.5	1.5	0	0	6	0	6	0	1.5	6	14	14	1.5	76
3	0	0	10	7	3.5	3	7	7	0	0	0	3	3	0	0	7	7	60.5
3	1.5	0	3	0	1.5	6	0	0	0	0	0	1.5	1.5	0	0	1.5	1.5	21
3	6	7	3.5	0	0	0	0	3	3	0	0	0	0	0	0	0	0	25.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1.5	1.5	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	7.5
7	3	3	7	6	3	7	6	14	6	6	1.5	3	0	14	14	21	21	**142.5**
10	3	0	3	3	0	6	3	0	3	0	3	3	0	3	0	3	0	43
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	40
3	6	3	3.5	6	3	3.5	1.5	1.5	6	6	6	6	6	14	14	3	3	**95**
0	1.5	1.5	3	0	0	0	0	0	7	7	0	0	0	0	0	0	0	20
3	9	9	9	0	3	31.5	0	0	0	0	0	3	3	0	0	3	0	73.5

0	1.5	0	0	1.5	1.5	1.5	0	0	0	0	0	14	14	0	0	14	14	62
14	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	20
1.5	0	0	3.5	0	0	7	0	0	0	0	0	0	0	0	0	0	0	12
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	3	0	0	3	0	0	0	0	0	0	0	90	90	0	0	**189**
3	0	0	0	1.5	0	90	0	0	0	0	0	0	0	0	0	0	0	**94.5**
0	0	0	3	3	3	7	0	0	0	3	0	3	0	3	0	0	0	25
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	1.5	5	0	5	5	0	10	0	0	0	0	0	0	0	0	28
6	3	0	0	0	0	0	0	3	0	0	6	0	0	0	0	6	0	24
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	60	0	0	60	0	0	0	0	0	0	0	1.5	1.5	0	0	**123**
0	0	3.5	7	0	40	0	0	0	0	14	0	0	0	0	7	0	0	71.5
6	1.5	1.5	0	0	0	1.5	1.5	0	3	0	3	0	3	3	3	0	0	27
10	0	10	10	10	0	1.5	0	0	0	0	1.5	0	0	1.5	1.5	1.5	1.5	49
0	3	0	7	0	0	3	0	0	0	0	0	0	0	0	0	0	0	13
0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	40
0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	0	0	**120**
10	3	0	1.5	3	0	0	0	0	20	0	0	0	0	0	0	0	0	37.5
1.5	1.5	0	0	0	0	6	0	0	1.5	0	0	0	0	0	0	0	0	10.5
6	31.5	31.5	0	10	10	3	7	7	1.5	1.5	0	0	0	0	0	0	0	**109**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	46
0	0	0	20	0	0	0	0	0	0	0	0	10	0	10	0	0	0	40
0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5
20	30	3	60	1.5	1.5	40	1.5	1.5	1.5	1.5	0	0	0	90	90	0	0	**342**
3	0	0	0	0	0	3	0	0	0	0	0	6	6	0	0	3	3	24
1.5	21	13.5	0	0	0	3	0	31.5	3	10.5	0	0	0	0	0	45	31.5	**160.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	10.5	0	6	0	9	6	0	0	5	5	0	0	0	0	0	1.5	1.5	44.5
0	0	0	20	0	0	10	9	0	9	0	0	1.5	1.5	0	0	0	0	51
14	7	7	3.5	0	0	6	0	0	0	0	1.5	0	0	0	0	0	0	39

1.5	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	9
0	7	0	30	0	0	0	0	0	0	20	0	0	0	0	0	0	0	57
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	6	0	0	0	7.5
20	3.5	3.5	20	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	50.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.5	0	0	7	0	0	0	30	0	0	0	0	0	0	0	38.5
1.5	0	0	0	0	0	14	0	0	0	0	0	0	0	1.5	1.5	0	0	18.5
1.5	0	1.5	9	3	0	4.5	9	3	0	3	0	3	3	0	0	3	3	46.5
21	0	0	60	3	3	0	0	0	1.5	1.5	1.5	6	6	0	0	0	0	**103.5**
3	6	0	0	0	0	3	1.5	0	0	0	0	0	0	0	0	0	0	13.5
14	1.5	1.5	1.5	1.5	1.5	0	1.5	1.5	0	0	0	1.5	1.5	0	0	1.5	1.5	30.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.5	3	0	3	7	0	10	0	0	1.5	6	7	3	3	0	0	6	0	60
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	20	0	1.5	0	0	0	0	0	6	0	0	0	0	6	0	6	0	45.5
7	1.5	0	1.5	0	0	3	3	0	6	0	3	3	0	0	0	3	0	31
5	1.5	1.5	1.5	0	0	3	1.5	0	0	0	1.5	0	0	1.5	1.5	1.5	1.5	21.5
0	0	0	0	0	0	31.5	0	0	0	0	0	0	0	0	0	0	0	31.5
0	0	0	3	0	0	4.5	0	0	0	0	0	0	0	0	0	0	0	7.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	40	40	3.5	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	95
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1.5	0	0	0	6	0	0	0	0	0	0	0	3	0	0	0	10.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	20	0	0	0	0	13.5	0	0	3	0	0	0	0	4.5	0	0	0	44
20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
21	14	14	6	0	0	14	0	0	30	30	0	6	6	0	0	0	0	**141**
1.5	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	6	0	10.5
7	1.5	0	3	9	6	6	3.5	0	9	0	3	31.5	0	6	0	60	0	145.5
0	0	0	1.5	0	0	0	1.5	1.5	0	0	0	0	0	3	3	14	3	27.5

0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	20
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42
6	0	0	6	0	0	7	0	3	0	0	0	0	0	13.5	0	6	0	41.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	1.5
0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	1.5
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5
7	5	7	10	1.5	0	6	3	0	0	0	3	60	0	21	10.5	40	40	**214**
0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	3	0	0	0	6.5
0	3	3	7	0	0	1.5	0	0	0	0	0	1.5	1.5	1.5	1.5	0	0	20.5
3	0	0	3	0	0	3	0	0	3	3	0	0	0	0	0	0	0	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	3.5	3	14	0	0	20	1.5	3.5	40	40	0	0	0	7	14	0	0	**156.5**
3	1.5	0	0	7	0	6	3	4.5	14	6	3	3	7	3	6	1.5	3	71.5
0	0	0	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0	9
0	0	1.5	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3
14	14	14	14	14	14	6	0	0	6	6	14	14	14	14	14	14	14	**200**
14	14	14	1.5	3	3	6	6	6	14	14	14	14	14	14	14	14	14	**193.5**
6	6	6	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	**228**
14	14	0	14	14	14	9	6	6	6	6	14	6	6	9	6	6	6	**156**
20	0	0	14	0	0	14	0	0	0	0	6	0	0	0	0	1.5	1.5	57
20	6	6	6	20	20	6	1.5	1.5	3	3	0	7	7	20	20	1.5	1.5	**150**
0	0	3	14	0	0	40	0	0	0	0	0	0	0	0	0	0	0	57
0	3	1.5	21	0	0	30	1.5	1.5	0	0	0	3	3	3	3	6	6	82.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	6	0	6	0	0	0	0	0	0	0	0	0	0	0	24
1.5	0	0	0	0	0	7	0	0	14	14	0	0	0	0	0	0	0	36.5
5	0	7	3	0	0	7	0	0	1.5	1.5	0	0	0	3.5	3.5	0	0	32
3	7	0	1.5	0	0	6	0	0	6	6	0	0	0	1.5	1.5	0	0	32.5
1.5	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	4.5
0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5

14	1.5	1.5	45	1.5	1.5	3	7	7	20	20	0	0	0	0	0	0	0	**122**
6	0	0	0	0	0	0	0	0	3.5	3.5	0	0	4.5	0	0	0	0	17.5
0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	9	0	18
14	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56
7	0	0	6	0	0	45	0	0	0	0	0	0	0	0	0	0	0	58
1.5	1.5	0	20	0	0	0	3	0	7	0	0	0	0	1.5	0	0	0	34.5
3	0	0	1.5	0	1.5	3	0	0	0	3	0	1.5	1.5	0	0	0	0	15
6	7	0	7	0	0	14	9	0	1.5	0	6	0	6	6	6	9	9	86.5
60	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	61.5
3	6	6	6	1.5	1.5	14	0	0	0	0	0	0	0	0	0	0	0	38
0	6	6	7	13.5	0	7	0	0	1.5	1.5	0	6	6	14	14	1.5	1.5	85.5
1.5	0	0	0	1.5	1.5	0	0	0	14	14	0	0	0	0	0	0	0	32.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	1.5	0	1.5	0	0	30	0	0	1.5	0	0	0	0	0	0	1.5	1.5	39
3	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	4.5
0	14	0	0	0	0	0	1.5	0	4.5	0	0	0	0	1.5	0	0	0	21.5
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1.5	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	15.5
0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	3
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
1.5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	7.5
0	0	0	9	0	0	21	0	0	0	0	0	0	0	14	14	0	0	58
3	0	3	1.5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	10.5
7	3	3	6	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	20.5
3	1.5	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	11.5
20	3.5	3.5	90	3.5	3.5	20	0	0	1.5	1.5	0	3	1.5	0	0	1.5	1.5	**154.5**
3	3	0	31.5	0	90	90	0	0	0	0	0	1.5	3.5	20	20	0	0	**262.5**
7	0	0	3	0	0	1.5	0	0	3	1.5	0	0	0	0	0	0	0	16
0	3	3	0	0	0	0	0	0	20	20	0	20	20	1.5	1.5	20	20	**129**
3	90	90	0	0	0	0	0	0	0	0	0	0	0	20	20	0	0	**223**
1.5	0	0	0	0	0	1.5	0	0	0	3	0	0	0	0	0	0	0	6
3	0	0	0	0	0	3	0	0	0	0	7	0	0	0	0	0	0	13
3	0	1.5	3	0	1.5	0	0	0	0	0	0	6	6	0	0	3	3	27

14	0	0	0	1.5	0	9	0	0	3	0	0	0	0	0	0	0	0	27.5
10	21	0	90	0	0	20	0	0	0	0	90	0	0	0	0	0	0	**231**
0	0	0	20	0	0	40	20	20	0	0	0	0	0	0	0	0	0	**100**
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
14	0	0	3	0	0	30	0	0	0	0	0	0	0	0	0	0	0	47
20	0	0	0	0	0	0	0	3.5	0	0	0	0	0	20	20	0	0	63.5
3	0	0	14	0	0	90	0	0	0	0	0	0	0	0	0	0	0	**107**
14	0	0	0	6	6	0	0	0	0	0	20	14	0	0	0	6	6	72
6	20	14	14	3	0	7	3	3	0	0	1.5	0	0	0	0	0	0	71.5
3	4.5	0	0	0	0	21	0	0	0	0	14	0	0	0	0	3	3	48.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	3	0	0	0	1.5	1.5	1.5	3	3	0	0	0	0	0	0	0	19.5
14	3	3	0	0	0	1.5	0	0	7	7	1.5	0	0	0	0	0	0	37
3	0	0	90	14	0	90	3	3	20	20	14	0	0	0	0	0	0	**257**
1.5	3	3	0	0	0	1.5	0	0	1.5	1.5	0	0	0	0	0	0	0	12
20	21	7	0	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	51
90	20	90	20	0	0	14	0	0	90	90	20	0	0	0	0	0	0	**434**
20	40	0	20	90	0	10.5	1.5	0	30	0	1.5	0	0	3	0	0	0	**216.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	40	0	0	90	0	40	0	0	0	0	0	0	**190**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	14	0	1.5	1.5	0	1.5	0	1.5	0	0	0	0	0	0	0	23
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	7	3	0	0	0	0	0	1.5	1.5	0	0	0	0	0	1.5	1.5	17.5
14	14	3.5	0	14	7	90	0	0	0	0	0	0	0	0	0	6	0	**148.5**
0	0	0	0	0	0	21	0	0	0	0	0	6	6	3.5	1.5	6	6	50
0	1.5	1.5	0	3.5	1.5	0	0	0	0	3	3	3	7	3.5	3.5	3	3	37
1.5	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.5
1.5	0	0	0	0	0	6	0	0	6	6	0	0	0	0	0	0	0	19.5
0	0	0	0	0	0	0	0	0	0	0	0	3.5	3.5	0	0	3.5	3.5	14

3	6	0	0	0	0	21	1.5	0	0	0	0	0	0	0	0	0	0	31.5
0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6
14	0	30	0	0	0	0	0	0	0	0	0	1.5	0	1.5	0	1.5	0	48.5
0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6
6	0	0	0	1.5	1.5	1.5	6	6	0	0	0	0	0	0	0	3	3	28.5
31.5	20	20	90	0	0	90	1.5	1.5	90	90	0	0	0	0	0	20	20	**474.5**
1.5	0	20	0	0	0	3	0	0	0	0	0	1.5	1.5	14	14	3	0	58.5
3.5	0	0	7	0	0	3.5	0	0	1.5	0	0	0	0	0	0	0	0	15.5
0	1.5	1.5	0	0	1.5	0	0	0	0	0	0	0	0	1.5	1.5	0	0	7.5
1.5	1.5	0	0	1.5	0	3	0	0	0	1.5	0	0	0	1.5	0	0	0	10.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	7	7	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	26
0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	1.5	0	1.5	0	4.5
3	0	0	1.5	40	0	0	40	0	60	0	0	0	0	0	0	0	0	**144.5**
31.5	31.5	31.5	3.5	0	0	3.5	0	0	0	0	0	0	0	0	0	1.5	1.5	**104.5**
9	3	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	90	90	0	0	0	0	0	0	0	0	0	0	0	0	**270**
3.5	0	0	7	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	14
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	10	10	0	0	0	0	0	0	0	0	0	1.5	1.5	1.5	1.5	1.5	1.5	39
90	20	20	0	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	**133**
40	7	7	60	20	20	90	7	7	3	3	0	0	0	0	0	1.5	1.5	**267**
1.5	6	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
1.5	0	0	14	0	0	14	0	0	0	0	0	0	0	14	14	0	0	57.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	90
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	1.5	0	3
20	14	6	7	3	3	20	1.5	1.5	3.5	3.5	3.5	1.5	1.5	14	14	1.5	1.5	**120.5**
60	0	0	6	0	0	60	0	0	0	0	0	14	14	14	14	14	14	**210**

6	6	6	31.5	0	0	6	0	0	0	0	31.5	6	6	0	0	0	0	**99**
13.5	0	0	31.5	0	0	0	0	0	9	9	3	3	3	3	3	3	3	84
3	6	6	0	0	0	6	0	0	0	6	0	0	0	0	0	0	9	36
60	7	3	1.5	0	0	21	0	0	0	0	0	1.5	1.5	0	0	0	0	**95.5**
0	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	20
3.5	0	0	10	0	0	3.5	0	0	1.5	0	0	0	0	0	0	0	0	18.5
1.5	0	0	0	0	0	30	0	0	0	0	0	0	0	6	0	0	0	37.5
0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
3	3	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.5
3	0	0	7	0	0	0	0	0	1.5	1.5	0	1.5	1.5	20	20	0	0	56
1.5	14	14	1.5	0	0	90	0	0	14	14	1.5	0	0	14	14	0	0	**178.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	60	60	3.5	0	0	10	3	0	0	0	0	0	0	0	0	0	0	**139.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	1.5	9	0	0	31.5	0	0	0	0	0	0	0	0	0	0	0	49
0	0	0	7	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	8.5
1.5	7	0	0	0	0	10.5	0	0	0	0	0	0	0	0	0	3	3	25
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	1.5
3	0	0	7	3	0	0	0	0	0	0	3	0	0	0	0	0	0	16
21	3	3	6	0	0	0	0	0	0	0	0	0	0	14	14	14	14	89
6	1.5	0	0	0	0	21	0	0	0	0	7	0	0	0	0	0	0	35.5
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	3	0	0	0	4.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	7	0	0	7	0	0	0	0	7	0	0	0	0	0	0	26
6	0	0	3	0	0	3	0	0	0	0	10	0	0	0	0	0	0	22
14	0	0	3.5	0	0	1.5	0	0	0	0	14	0	7	3	3	0	0	46
3.5	0	0	1.5	1.5	1.5	7	0	0	0	0	0	1.5	1.5	7	7	3.5	3.5	39
13.5	0	0	3.5	6	0	0	6	0	0	0	0	0	0	14	0	60	0	**103**
7	1.5	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	15.5
14	0	0	0	10	10	0	0	0	0	90	0	0	0	0	0	0	0	**124**
20	1.5	1.5	60	3	3	21	0	0	0	0	0	0	0	7	15	0	0	**132**
0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5

3.5	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.5
1.5	1.5	1.5	1.5	0	0	31.5	0	0	7	7	0	0	0	0	0	0	0	51.5
6	14	14	45	0	0	13.5	0	0	0	0	0	0	0	6	6	0	0	**104.5**
30	0	0	20	0	0	30	0	0	30	30	0	7	7	1.5	3	0	0	**158.5**
0	90	90	14	0	0	45	0	0	6	6	0	0	0	0	0	0	0	**251**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	1.5	0	0	3	0	0	1.5	1.5	0	1.5	1.5	0	0	0	0	12
3	0	0	3	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	7.5
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
14	6	0	3	3	14	21	14	14	6	14	20	20	20	0	0	0	0	**169**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	5
10	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	31
15	1.5	0	4.5	0	0	0	1.5	0	1.5	0	0	0	0	0	0	0	0	24
20	40	0	7	7	0	0	10	10	0	0	0	0	0	0	0	0	0	**94**
5	60	0	1.5	1.5	1.5	1.5	1.5	1.5	0	0	0	0	0	0	0	20	0	**94**
40	30	0	1.5	60	0	0	0	0	1.5	0	0	0	0	0	0	0	0	**133**
6	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	27
60	0	1.5	14	0	0	60	0	0	0	0	0	0	0	0	0	0	0	**135.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	0	0	3
10	0	0	20	0	0	10	0	0	1.5	0	10	1.5	0	0	0	0	0	53
9	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6	0	0	21
7	7	0	0	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	17
0	0	0	0	0	0	30	0	0	0	0	0	31.5	31.5	0	0	1.5	0	**94.5**
3	0	0	7	0	7	60	0	3	20	0	3	0	0	0	0	1.5	0	**104.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	40	40	7	0	0	13.5	0	0	0	0	0	1.5	0	0	0	0	0	**102**
0	0	1.5	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3
90	90	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**201**
10	3.5	3.5	0	7	0	15	10	0	10	0	0	0	0	0	0	0	0	59
0	7	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	21
20	0	0	60	0	0	60	0	0	3	0	0	0	0	0	0	0	0	**143**

0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	14
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
3	0	0	3	0	0	14	0	0	1.5	0	0	0	0	0	0	0	0	21.5
60	60	60	10	10	10	1.5	0	0	1.5	0	0	1.5	0	0	0	0	0	**214.5**
0	0	0	1.5	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3
1.5	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	3.5	0	60	0	68
0	90	0	6	20	0	0	14	0	6	0	0	0	0	0	0	0	0	**136**
14	31.5	31.5	30	9	9	10.5	1.5	1.5	21	21	14	1.5	1.5	21	21	1.5	1.5	**242.5**
45	0	31.5	40	0	0	7	0	21	0	21	7	0	7	0	3.5	20	0	**203**
0	1.5	0	21	0	3	90	0	0	0	0	0	1.5	1.5	0	0	1.5	1.5	**121.5**
10	20	10	10	7	7	21	0	0	40	40	90	7	0	60	60	0	0	**382**
0	3	0	6	0	0	6	0	0	14	0	3	0	0	0	0	3	0	35
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	1.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	6
3	0	0	0	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	6
14	1.5	0	0	0	0	30	0	0	30	0	3	0	0	30	30	7	0	**145.5**
0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	1.5
0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	3	3	0	0	0	40	0	0	90	90	0	0	0	1.5	1.5	0	0	**236**
90	30	6	15	0	0	1.5	0	0	1.5	0	0	0	0	0	0	0	0	**144**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	1.5	1.5	1.5	1.5	1.5	3	0	0	0	0	0	0	0	0	0	0	0	12
1.5	0	0	0	0	0	14	1.5	0	1.5	0	0	7	0	3	0	3.5	0	32
30	1.5	1.5	40	0	0	6	0	0	1.5	1.5	0	0	0	0	0	0	0	82
21	0	90	21	21	21	31.5	21	21	31.5	31.5	9	6	6	6	6	0	6	**349.5**
6	1.5	0	0	0	0	40	0	0	0	0	0	0	0	14	14	0	0	75.5
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
3.5	1.5	5	3.5	1.5	5	1.5	1.5	1.5	1.5	1.5	1.5	0	0	0	0	0	0	29
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	1.5	3
3	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	9
0	1.5	0	0	0	0	14	0	0	0	14	0	3	3	0	0	0	0	35.5

0	0	1.5	1.5	0	1.5	1.5	0	0	0	0	1.5	0	0	0	0	0	0	7.5
3.5	0	0	0	0	0	0	0	0	5	0	0	1.5	0	0	0	0	0	10
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
1.5	0	0	1.5	0	0	1.5	1.5	0	0	0	0	0	0	0	0	1.5	1.5	9
3	0	21	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	38
3	7	1.5	14	3	0	14	0	0	0	0	0	0	0	0	0	0	0	42.5
3	7	0	0	0	0	14	0	0	7	0	0	0	0	0	0	0	0	31
10	20	20	60	5	5	45	0	0	0	0	45	0	0	0	0	0	0	**210**
1.5	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	7	7	7	3	3	3	3	3	3	3	3	3	3	3	3	3	0	63
0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	9
0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	3	0	0	17
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	60	60	30	1.5	1.5	1.5	7	1.5	0	0	1.5	10	10	0	0	1.5	1.5	**201.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
5	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
0	0	0	9	0	0	9	0	0	1.5	0	0	3	0	0	0	0	0	22.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	1.5	1.5	0	0	0	0	0	0	3.5	1.5	1.5	0	0	0	0	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	1.5	0	0	1.5	0	0	0	0	1.5	0	0	0	8
0	40	40	5	0	0	40	0	0	1.5	0	0	1.5	1.5	1.5	1.5	1.5	1.5	**135.5**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5
3	7	7	0	0	0	7	0	0	3	3	0	3	3	7	7	3	3	56
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9

6	1.5	1.5	3	3	0	3	0	0	3	3	0	0	0	0	0	0	0	24
3.5	1.5	1.5	1.5	0	0	3.5	0	0	0	0	0	1.5	1.5	1.5	3.5	3.5	3.5	26.5
1.5	0	0	1.5	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	4.5
0	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	6	0	7.5
3.5	1.5	1.5	9	0	45	9	9	20	0	0	31.5	3	20	0	30	30	30	**243**
3	21	21	6	0	0	6	0	0	0	0	21	10.5	10.5	21	21	21	21	**183**
7	3.5	3.5	3.5	0	0	10	0	0	0	0	0	3.5	0	7	0	3.5	0	41.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	1.5	0	3
60	60	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	**125**
20	10	10	30	5	5	30	3	3	10	10	0	0	0	3	3	0	0	**142**
3	0	0	0	0	0	1.5	0	0	6	6	0	0	0	0	0	0	0	16.5
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90
4.5	14	14	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	39.5
3.5	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	6.5
0	0	0	1.5	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	20	0	0	20	0	0	0	0	0	0	0	0	0	0	0	40
3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	6
90	90	90	90	0	0	1.5	0	0	0	0	3	0	0	0	0	0	0	**364.5**
0	0	7	7	0	0	3	0	0	0	0	0	0	0	6	0	6	0	29
0	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	20
0	40	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	46
1.5	0	0	1.5	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	4.5
31.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33
10	1.5	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	51.5
5	5	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	11.5
14	0	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	43.5
1.5	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3
1.5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5
0	10	7	3.5	0	0	0	0	0	0	0	3.5	10	10	10	10	20	20	**104**
1.5	0	0	3	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	6
10	0	0	10	0	0	20	3.5	3.5	3.5	3.5	3.5	1.5	1.5	7	7	3.5	3.5	81.5

13.5	31.5	0	6	9	0	60	1.5	0	7	0	1.5	40	0	31.5	0	6	0	**207.5**
6	0	0	30	0	0	30	0	0	7	7	0	0	0	30	30	0	0	**140**
14	3.5	3.5	20	1.5	1.5	30	0	0	7	0	0	0	0	0	14	0	0	**95**
1.5	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.5
1.5	0	0	0	0	0	1.5	0	0	1.5	1.5	0	0	0	0	0	0	0	6
1.5	1.5	0	3	1.5	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	10.5
10	10	10	14	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	47
1.5	1.5	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	4.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
1.5	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	0	1.5	0	6
0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	6
10	10	3.5	7	1.5	0	5	1.5	0	1.5	1.5	0	0	0	1.5	1.5	0	0	44.5
10	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	4.5	0	0	19
20	40	40	20	3	3	1.5	1.5	1.5	0	0	0	1.5	1.5	0	0	1.5	1.5	**136.5**
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
0	1.5	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	4.5
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
1.5	0	0	0	0	0	0	0	0	0	0	1.5	0	0	1.5	1.5	0	0	6
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
7	0	0	3	0	0	30	0	0	0	0	0	0	0	0	0	0	0	40
0	1.5	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
14	0	0	1.5	0	0	3	0	0	0	0	0	1.5	0	1.5	0	0	0	21.5
3.5	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	6.5
0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	1.5
0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	1.5

0	0	0	0	0	0	14	0	0	0	1.5	3.5	0	0	0	7	0	1.5	27.5
0	0	0	0	0	0	6	0	0	0	0	0	0	0	40	0	0	0	46
3	0	0	3	0	0	90	0	0	0	0	0	0	0	0	0	0	0	**96**
6	0	0	0	0	0	3	0	0	0	0	6	0	0	0	0	6	6	27
3.5	0	1.5	0	0	3.5	0	0	0	0	14	0	0	0	0	0	0	0	22.5
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
7	9	0	6	3	0	14	30	0	9	0	3	10	0	3	0	3	0	**97**
3.5	1.5	0	1.5	3.5	0	20	1.5	0	1.5	0	0	1.5	0	0	0	1.5	0	36
14	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	15.5
3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
7	0	0	7	0	0	14	0	0	7	0	0	0	0	0	0	0	0	35
3	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	17
3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	6
7	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	**97**
20	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
0	6	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	9
1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0	0	0	0	0	0	0	16.5
6	0	1.5	14	0	0	0	14	14	0	0	0	0	0	0	0	0	0	49.5
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	1.5
3.5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.5
6	14	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	21.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	20	0	40	7	0	5	1.5	0	1.5	0	0	0	0	0	0	0	0	89
14	0	0	0	0	0	0	0	0	13.5	0	0	0	0	0	0	0	0	27.5
1.5	1.5	1.5	21	0	0	6	3.5	3.5	0	0	0	0	0	0	0	3.5	3.5	45.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	10	10	20	10	10	10	30	30	30	30	0	0	0	0	0	0	0	**204**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	3	0	0	0	0	0	0	30	30	42	45	0	90	90	90	90	**516**
6	6	6	45	0	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	66

14	14	14	7	3.5	3.5	1.5	0	0	1.5	1.5	0	0	0	0	0	0	0	60.5
14	14	14	0	0	0	0	20	20	0	0	0	0	0	0	0	0	0	82
0	0	0	0	0	0	14	14	14	14	14	0	0	0	0	0	0	0	70
0	0	0	0	1.5	1.5	1.5	1.5	1.5	0	0	0	0	0	0	0	0	0	7.5
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
21	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	22.5
0	0	0	21	7	0	9	0	0	9	9	0	0	0	0	0	0	0	55
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	1.5	1.5	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	6
0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6
10	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	13
0	20	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
20	1.5	1.5	20	1.5	1.5	90	0	0	1.5	1.5	0	0	0	14	14	0	0	**167**
90	0	0	0	0	0	0	3.5	3.5	0	0	0	0	0	0	0	0	0	**97**
14	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
14	3	3	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	40
6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	20	20	0	20	20	0	0	0	0	0	0	0	0	0	0	0	0	90
1.5	1.5	1.5	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	44.5
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
1.5	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3
20	1.5	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.5
0	0	0	3.5	0	0	7	0	0	0	0	0	0	0	0	0	0	0	10.5
40	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	80
1.5	0	0	0	6	0	6	0	0	0	0	0	0	0	0	0	0	0	13.5
40	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	80
20	0	0	0	0	0	0	0	0	20	20	0	0	0	0	0	0	0	60
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5

3	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	4.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.5
14	21	14	90	0	0	6	0	0	0	0	60	0	0	0	0	7	3	**215**
0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	1.5
3	3	0	1.5	3	0	1.5	0	0	1.5	0	0	0	0	0	0	6	6	25.5
0	0	0	7	0	0	7	0	0	0	0	7	0	0	0	0	0	0	21
4010.5	2700.5	1937.5	3224	1054	697.5	4739	734.5	462	1563	1281	981.5	678	474.5	1346.5	1219.5	1248	797.5	**Scores of all body regions**

Appendix D: Simulation Source Codes and Results of ML (n= 400)

Support Vector Machine Algorithm

```
Python 3.7.3 (default, Oct  7 2019, 12:56:13)
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IPython 7.9.0 -- An enhanced Interactive Python.

In [1]:         '/home/kan/Documents/ORHAN/ORHAN/SVM.py'      ='/home/kan/
Documents/ORHAN/ORHAN'
Using TensorFlow backend.
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:516: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:517: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:518: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:519: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:520: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:525: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:541: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:542: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:543: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:544: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:545: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
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'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:550: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
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(280, 18)
(280, 1)
(120, 18)
(120, 1)
accuracy
0.7
/home/kan/.local/lib/python3.7/site-packages/sklearn/utils/validation.py:724:
DataConversionWarning: A column-vector y was passed when a 1d array was expected.
Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

```
Figures now render in the Plots pane by default. To make them also appear inline
in the Console, uncheck "Mute Inline Plotting" under the Plots pane options menu.
```

```
 MSE: 0.30000000 MSE
Train:(280, 18)
Test: (120, 1)

In [2]:
```

```
Python 3.7.3 (default, Oct  7 2019, 12:56:13)
Type "copyright", "credits" or "license" for more information.

IPython 7.9.0 -- An enhanced Interactive Python.

In [1]:          '/home/kan/Documents/ORHAN/ORHAN/LSTM.py'       ='/home/kan/
Documents/ORHAN/ORHAN'
Using TensorFlow backend.
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:516: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:517: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:518: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:519: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:520: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:525: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:541: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:542: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:543: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:544: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:545: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
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1

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'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:550: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
WARNING: Logging before flag parsing goes to stderr.
W0115 09:45:54.623292 140444126672704 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:74: The
name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph
instead.

W0115 09:45:54.638146 140444126672704 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:517:
The name tf.placeholder is deprecated. Please use tf.compat.v1.placeholder
instead.

W0115 09:45:54.641765 140444126672704 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:4138:
The name tf.random_uniform is deprecated. Please use tf.random.uniform instead.

(320, 18)
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W0115 09:45:55.313799 140444126672704 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:133:
The name tf.placeholder_with_default is deprecated. Please use
tf.compat.v1.placeholder_with_default instead.

W0115 09:45:55.323006 140444126672704 deprecation.py:506] From /home/kan/.local/
lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:3445: calling
dropout (from tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will
be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 -
keep_prob`.
W0115 09:45:57.324971 140444126672704 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/optimizers.py:790: The name
tf.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer instead.

W0115 09:45:57.585485 140444126672704 deprecation.py:323] From /home/kan/.local/
lib/python3.7/site-packages/tensorflow/python/ops/math_grad.py:1250:
add_dispatch_support.<locals>.wrapper (from tensorflow.python.ops.array_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
W0115 09:45:59.635461 140444126672704 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:986:
The name tf.assign_add is deprecated. Please use tf.compat.v1.assign_add instead.

Epoch 1/100
2020-01-15 09:46:00.042501: I tensorflow/core/platform/cpu_feature_guard.cc:142]
Your CPU supports instructions that this TensorFlow binary was not compiled to
use: AVX2 FMA
2020-01-15 09:46:00.076621: I tensorflow/core/platform/profile_utils/cpu_utils.cc:
94] CPU Frequency: 1396710000 Hz
2020-01-15 09:46:00.077083: I tensorflow/compiler/xla/service/service.cc:168] XLA
service 0x4f18c30 executing computations on platform Host. Devices:
2020-01-15 09:46:00.077137: I tensorflow/compiler/xla/service/service.cc:175]
```

```
StreamExecutor device (0): <undefined>, <undefined>
2020-01-15 09:46:00.905583: W tensorflow/compiler/jit/
mark_for_compilation_pass.cc:1412] (One-time warning): Not using XLA:CPU for
cluster because envvar TF_XLA_FLAGS=--tf_xla_cpu_global_jit was not set.  If you
want XLA:CPU, either set that envvar, or use experimental_jit_scope to enable
XLA:CPU.  To confirm that XLA is active, pass --vmodule=xla_compilation_cache=1
(as a proper command-line flag, not via TF_XLA_FLAGS) or set the envvar
XLA_FLAGS=--xla_hlo_profile.
320/320 [==============================] - 19s 58ms/step - loss: 0.1421
Epoch 2/100
320/320 [==============================] - 15s 46ms/step - loss: 0.1376
Epoch 3/100
320/320 [==============================] - 16s 50ms/step - loss: 0.1378
Epoch 4/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1373
Epoch 5/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1386
Epoch 6/100
320/320 [==============================] - 17s 53ms/step - loss: 0.1385
Epoch 7/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1386
Epoch 8/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1388
Epoch 9/100
320/320 [==============================] - 17s 53ms/step - loss: 0.1386
Epoch 10/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1398
Epoch 11/100
320/320 [==============================] - 18s 57ms/step - loss: 0.1380
Epoch 12/100
320/320 [==============================] - 17s 55ms/step - loss: 0.1374
Epoch 13/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1363
Epoch 14/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1368
Epoch 15/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1382
Epoch 16/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1376
Epoch 17/100
320/320 [==============================] - 21s 64ms/step - loss: 0.1372
Epoch 18/100
320/320 [==============================] - 21s 65ms/step - loss: 0.1372
Epoch 19/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1371
Epoch 20/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1369
Epoch 21/100
320/320 [==============================] - 17s 55ms/step - loss: 0.1371
Epoch 22/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1382
Epoch 23/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1367
Epoch 24/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1388
Epoch 25/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1379
Epoch 26/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1357
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3

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Epoch 27/100
320/320 [==============================] - 18s 57ms/step - loss: 0.1382
Epoch 28/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1375
Epoch 29/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1379
Epoch 30/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1369
Epoch 31/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1372
Epoch 32/100
320/320 [==============================] - 20s 63ms/step - loss: 0.1383
Epoch 33/100
320/320 [==============================] - 19s 61ms/step - loss: 0.1368
Epoch 34/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1378
Epoch 35/100
320/320 [==============================] - 16s 51ms/step - loss: 0.1378
Epoch 36/100
320/320 [==============================] - 16s 51ms/step - loss: 0.1366
Epoch 37/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1361
Epoch 38/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1374
Epoch 39/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1375
Epoch 40/100
320/320 [==============================] - 17s 52ms/step - loss: 0.1366
Epoch 41/100
320/320 [==============================] - 17s 53ms/step - loss: 0.1345
Epoch 42/100
320/320 [==============================] - 21s 66ms/step - loss: 0.1404
Epoch 43/100
320/320 [==============================] - 21s 65ms/step - loss: 0.1350
Epoch 44/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1380
Epoch 45/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1372
Epoch 46/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1365
Epoch 47/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1376
Epoch 48/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1365
Epoch 49/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1358
Epoch 50/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1345
Epoch 51/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1362
Epoch 52/100
320/320 [==============================] - 17s 54ms/step - loss: 0.1331
Epoch 53/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1368
Epoch 54/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1375
Epoch 55/100
320/320 [==============================] - 20s 62ms/step - loss: 0.1412
Epoch 56/100
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4

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320/320 [==============================] - 18s 57ms/step - loss: 0.1436
Epoch 57/100
320/320 [==============================] - 19s 60ms/step - loss: 0.1398
Epoch 58/100
320/320 [==============================] - 18s 58ms/step - loss: 0.1375
Epoch 59/100
320/320 [==============================] - 19s 59ms/step - loss: 0.1353
Epoch 60/100
320/320 [==============================] - 19s 61ms/step - loss: 0.1372
Epoch 61/100
320/320 [==============================] - 20s 61ms/step - loss: 0.1374
Epoch 62/100
320/320 [==============================] - 20s 62ms/step - loss: 0.1361
Epoch 63/100
320/320 [==============================] - 20s 63ms/step - loss: 0.1349
Epoch 64/100
320/320 [==============================] - 20s 63ms/step - loss: 0.1357
Epoch 65/100
320/320 [==============================] - 20s 62ms/step - loss: 0.1433
Epoch 66/100
320/320 [==============================] - 20s 63ms/step - loss: 0.1387
Epoch 67/100
320/320 [==============================] - 20s 63ms/step - loss: 0.1353
Epoch 68/100
320/320 [==============================] - 22s 69ms/step - loss: 0.1338
Epoch 69/100
320/320 [==============================] - 25s 78ms/step - loss: 0.1372
Epoch 70/100
320/320 [==============================] - 28s 88ms/step - loss: 0.1356
Epoch 71/100
320/320 [==============================] - 22s 68ms/step - loss: 0.1351
Epoch 72/100
320/320 [==============================] - 15s 46ms/step - loss: 0.1321
Epoch 73/100
320/320 [==============================] - 25s 78ms/step - loss: 0.1326
Epoch 74/100
320/320 [==============================] - 14s 44ms/step - loss: 0.1287
Epoch 75/100
320/320 [==============================] - 23s 70ms/step - loss: 0.1391
Epoch 76/100
320/320 [==============================] - 19s 58ms/step - loss: 0.1361
Epoch 77/100
320/320 [==============================] - 18s 55ms/step - loss: 0.1382
Epoch 78/100
320/320 [==============================] - 20s 64ms/step - loss: 0.1374
Epoch 79/100
320/320 [==============================] - 16s 50ms/step - loss: 0.1375
Epoch 80/100
320/320 [==============================] - 22s 70ms/step - loss: 0.1358
Epoch 81/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1353
Epoch 82/100
320/320 [==============================] - 18s 56ms/step - loss: 0.1344
Epoch 83/100
320/320 [==============================] - 21s 65ms/step - loss: 0.1396
Epoch 84/100
320/320 [==============================] - 27s 84ms/step - loss: 0.1406
Epoch 85/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1360
```

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Epoch 86/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1308
Epoch 87/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1402
Epoch 88/100
320/320 [==============================] - 26s 80ms/step - loss: 0.1397
Epoch 89/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1392
Epoch 90/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1388
Epoch 91/100
320/320 [==============================] - 26s 80ms/step - loss: 0.1372
Epoch 92/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1376
Epoch 93/100
320/320 [==============================] - 25s 77ms/step - loss: 0.1374
Epoch 94/100
320/320 [==============================] - 14s 44ms/step - loss: 0.1370
Epoch 95/100
320/320 [==============================] - 30s 93ms/step - loss: 0.1359
Epoch 96/100
320/320 [==============================] - 28s 87ms/step - loss: 0.1364
Epoch 97/100
320/320 [==============================] - 20s 62ms/step - loss: 0.1373
Epoch 98/100
320/320 [==============================] - 19s 61ms/step - loss: 0.1341
Epoch 99/100
320/320 [==============================] - 26s 81ms/step - loss: 0.1353
Epoch 100/100
320/320 [==============================] - 14s 43ms/step - loss: 0.1327
MSE: 0.13689160 MSE
0.13689160132040326
R Score: -0.005862512572423428
EV Score: 0.022 (initial)
0.75
```

```
Figures now render in the Plots pane by default. To make them also appear inline
in the Console, uncheck "Mute Inline Plotting" under the Plots pane options menu.
```

In [2]:

6

```
Type "copyright", "credits" or "license" for more information.

IPython 7.9.0 -- An enhanced Interactive Python.

In [1]:          '/home/kan/Documents/ORHAN/ORHAN/bpcl.py'      ='/home/kan/
Documents/ORHAN/ORHAN'
Using TensorFlow backend.
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:516: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:517: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:518: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:519: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:520: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:525: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:541: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:542: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:543: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:544: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:545: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
```

1

```
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:550: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
WARNING: Logging before flag parsing goes to stderr.
W0115 09:28:44.972692 140504231475008 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:74: The
name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph
instead.

W0115 09:28:44.984616 140504231475008 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:517:
The name tf.placeholder is deprecated. Please use tf.compat.v1.placeholder
instead.

W0115 09:28:44.987317 140504231475008 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:4138:
The name tf.random_uniform is deprecated. Please use tf.random.uniform instead.

W0115 09:28:45.002051 140504231475008 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:133:
The name tf.placeholder_with_default is deprecated. Please use
tf.compat.v1.placeholder_with_default instead.

W0115 09:28:45.009913 140504231475008 deprecation.py:506] From /home/kan/.local/
lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:3445: calling
dropout (from tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will
be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 -
keep_prob`.
W0115 09:28:45.055266 140504231475008 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/optimizers.py:790: The name
tf.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer instead.

[1.  1.  1.  1.  1.  1.  1.  1.  1.  0.5 0.5 0.5 1.  1.  1.  0.5 0.5 0.5
 0.5 1.  0.5 1.  0.5 0.5 0.5 0.5 0.5 1.  1.  1.  1.  0.5 1.  1.  0.5 0.5
 0.5 0.5 0.5 1.  0.5 0.5 1.  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 1.  1.  1.
 0.5 1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  0.5 1.  0.5
 1.  0.5 0.5 0.5 1.  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 1.  0.5 0.5 1.  0.5
 1.  0.5 0.5 0.5 0.5 0.5 0.5 1.  1.  0.5 0.5 1.  0.5 1.  0.5 1.  0.5 0.5
 0.5 0.5 0.5 1.  1.  0.5 0.5 1.  0.5 0.5 1.  0.5 0.5 1.  0.5 0.5 1.  1.
 0.5 1.  0.5 0.5 0.5 0.5 0.5 0.5 0.5 1.  0.5 1.  0.5 1.  0.5 0.5 1.  1.
 0.5 0.5 0.5 1.  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 1.
 0.  0.  0.  0.  0.5 0.  0.  0.  1.  0.  0.  0.5 0.5 0.5 0.  0.  0.  0.5
 0.  0.5 0.  0.  0.5 0.  0.  0.5 0.  1.  0.5 0.  0.  1.  0.  0.  0.  0.
 0.  0.  0.5 0.5 0.  0.5 0.5 0.5 0.5 0.5 0.  0.5 1.  0.  0.5 0.5 0.  0.5
 0.  0.5 0.5 1.  0.  0.5 0.  0.  0.5 1.  1.  0.  0.  0.5 0.  0.  0.5 0.
 0.5 0.5 0.  0.  0.  0.  0.  0.5 0.5 0.  0.  0.  0.  0.  0.  0.5 0.5 0.
 0.  0.5 0.  0.5 0.5 1.  0.  0.5 0.  0.5 0.  0.  0.5 1.  0.5 1.  0.  0.5
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.5 0.5 0.5 0.5 0.  0.5 0.5 0.5 0.
 0.5 0.  0.  0.  0.  0.  0.  0.  0.5 0.5 0.  0.  1.  0.  0.  0.5 0.  0.5
 0.  0.  0.5 0.  0.5 0.  0.  1.  0.  0.  0.  0.5 0.  0.5 0.  0.5 0.5 0.
 0.  1.  0.  0.5 0.  0.  0.  0.5 0.  0.5 0.  0.  0.  1.  1.  0.  1.  0.
 0.  0.5 0.5 0.  0.  0.5 1.  0.  0.  0.  0.  0.  0.  0.  0.5 0.5 0.5 0.
 0.  0.  0.5 0.  0.  0.  0.  0.5 0.5 0.5 1.  0.  0.  1.  0.5 0.  0.  0.
 0.  0.  1.  0.  0.  0.  0.  0.  0.5 0.  0.  0.  0.5 0.  0.  0.  0.  0.5
 1.  0.5 0.  0. ]
```

2

```
(280, 18)
(280,)
(120, 18)
(120,)
W0115 09:28:45.221786 140504231475008 deprecation_wrapper.py:119] From /home/
kan/.local/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:986:
The name tf.assign_add is deprecated. Please use tf.compat.v1.assign_add instead.

Epoch 1/205
2020-01-15 09:28:45.428274: I tensorflow/core/platform/cpu_feature_guard.cc:142]
Your CPU supports instructions that this TensorFlow binary was not compiled to
use: AVX2 FMA
2020-01-15 09:28:45.451732: I tensorflow/core/platform/profile_utils/cpu_utils.cc:
94] CPU Frequency: 1396695000 Hz
2020-01-15 09:28:45.452198: I tensorflow/compiler/xla/service/service.cc:168] XLA
service 0x153fb60 executing computations on platform Host. Devices:
2020-01-15 09:28:45.452243: I tensorflow/compiler/xla/service/service.cc:175]
StreamExecutor device (0): <undefined>, <undefined>
2020-01-15 09:28:45.552991: W tensorflow/compiler/jit/
mark_for_compilation_pass.cc:1412] (One-time warning): Not using XLA:CPU for
cluster because envvar TF_XLA_FLAGS=--tf_xla_cpu_global_jit was not set.  If you
want XLA:CPU, either set that envvar, or use experimental_jit_scope to enable
XLA:CPU.  To confirm that XLA is active, pass --vmodule=xla_compilation_cache=1
(as a proper command-line flag, not via TF_XLA_FLAGS) or set the envvar
XLA_FLAGS=--xla_hlo_profile.
280/280 [==============================] - 0s 1ms/step - loss: 0.1554
Epoch 2/205
280/280 [==============================] - 0s 295us/step - loss: 0.1584
Epoch 3/205
280/280 [==============================] - 0s 302us/step - loss: 0.1517
Epoch 4/205
280/280 [==============================] - 0s 298us/step - loss: 0.1405
Epoch 5/205
280/280 [==============================] - 0s 299us/step - loss: 0.1442
Epoch 6/205
280/280 [==============================] - 0s 280us/step - loss: 0.1388
Epoch 7/205
280/280 [==============================] - 0s 280us/step - loss: 0.1485
Epoch 8/205
280/280 [==============================] - 0s 292us/step - loss: 0.1392
Epoch 9/205
280/280 [==============================] - 0s 284us/step - loss: 0.1392
Epoch 10/205
280/280 [==============================] - 0s 292us/step - loss: 0.1424
Epoch 11/205
280/280 [==============================] - 0s 335us/step - loss: 0.1391
Epoch 12/205
280/280 [==============================] - 0s 390us/step - loss: 0.1358
Epoch 13/205
280/280 [==============================] - 0s 392us/step - loss: 0.1372
Epoch 14/205
280/280 [==============================] - 0s 304us/step - loss: 0.1351
Epoch 15/205
280/280 [==============================] - 0s 313us/step - loss: 0.1377
Epoch 16/205
280/280 [==============================] - 0s 333us/step - loss: 0.1361
Epoch 17/205
280/280 [==============================] - 0s 285us/step - loss: 0.1375
Epoch 18/205
280/280 [==============================] - 0s 290us/step - loss: 0.1377
```

3

```
Epoch 19/205
280/280 [==============================] - 0s 311us/step - loss: 0.1355
Epoch 20/205
280/280 [==============================] - 0s 377us/step - loss: 0.1403
Epoch 21/205
280/280 [==============================] - 0s 359us/step - loss: 0.1395
Epoch 22/205
280/280 [==============================] - 0s 304us/step - loss: 0.1385
Epoch 23/205
280/280 [==============================] - 0s 592us/step - loss: 0.1398
Epoch 24/205
280/280 [==============================] - 0s 526us/step - loss: 0.1360
Epoch 25/205
280/280 [==============================] - 0s 933us/step - loss: 0.1376
Epoch 26/205
280/280 [==============================] - 0s 713us/step - loss: 0.1324
Epoch 27/205
280/280 [==============================] - 0s 472us/step - loss: 0.1318
Epoch 28/205
280/280 [==============================] - 0s 523us/step - loss: 0.1381
Epoch 29/205
280/280 [==============================] - 0s 497us/step - loss: 0.1377
Epoch 30/205
280/280 [==============================] - 0s 358us/step - loss: 0.1367
Epoch 31/205
280/280 [==============================] - 0s 302us/step - loss: 0.1368
Epoch 32/205
280/280 [==============================] - 0s 300us/step - loss: 0.1321
Epoch 33/205
280/280 [==============================] - 0s 305us/step - loss: 0.1346
Epoch 34/205
280/280 [==============================] - 0s 276us/step - loss: 0.1325
Epoch 35/205
280/280 [==============================] - 0s 286us/step - loss: 0.1352
Epoch 36/205
280/280 [==============================] - 0s 300us/step - loss: 0.1344
Epoch 37/205
280/280 [==============================] - 0s 288us/step - loss: 0.1326
Epoch 38/205
280/280 [==============================] - 0s 325us/step - loss: 0.1339
Epoch 39/205
280/280 [==============================] - 0s 410us/step - loss: 0.1334
Epoch 40/205
280/280 [==============================] - 0s 485us/step - loss: 0.1339
Epoch 41/205
280/280 [==============================] - 0s 498us/step - loss: 0.1330
Epoch 42/205
280/280 [==============================] - 0s 533us/step - loss: 0.1346
Epoch 43/205
280/280 [==============================] - 0s 493us/step - loss: 0.1315
Epoch 44/205
280/280 [==============================] - 0s 478us/step - loss: 0.1322
Epoch 45/205
280/280 [==============================] - 0s 470us/step - loss: 0.1319
Epoch 46/205
280/280 [==============================] - 0s 420us/step - loss: 0.1336
Epoch 47/205
280/280 [==============================] - 0s 281us/step - loss: 0.1319
Epoch 48/205
```

4

```
280/280 [==============================] - 0s 307us/step - loss: 0.1321
Epoch 49/205
280/280 [==============================] - 0s 282us/step - loss: 0.1319
Epoch 50/205
280/280 [==============================] - 0s 295us/step - loss: 0.1331
Epoch 51/205
280/280 [==============================] - 0s 295us/step - loss: 0.1307
Epoch 52/205
280/280 [==============================] - 0s 272us/step - loss: 0.1292
Epoch 53/205
280/280 [==============================] - 0s 301us/step - loss: 0.1279
Epoch 54/205
280/280 [==============================] - 0s 284us/step - loss: 0.1421
Epoch 55/205
280/280 [==============================] - 0s 311us/step - loss: 0.1320
Epoch 56/205
280/280 [==============================] - 0s 298us/step - loss: 0.1282
Epoch 57/205
280/280 [==============================] - 0s 311us/step - loss: 0.1301
Epoch 58/205
280/280 [==============================] - 0s 436us/step - loss: 0.1328
Epoch 59/205
280/280 [==============================] - 0s 484us/step - loss: 0.1296
Epoch 60/205
280/280 [==============================] - 0s 472us/step - loss: 0.1270
Epoch 61/205
280/280 [==============================] - 0s 488us/step - loss: 0.1298
Epoch 62/205
280/280 [==============================] - 0s 490us/step - loss: 0.1324
Epoch 63/205
280/280 [==============================] - 0s 558us/step - loss: 0.1284
Epoch 64/205
280/280 [==============================] - 0s 468us/step - loss: 0.1276
Epoch 65/205
280/280 [==============================] - 0s 403us/step - loss: 0.1313
Epoch 66/205
280/280 [==============================] - 0s 308us/step - loss: 0.1263
Epoch 67/205
280/280 [==============================] - 0s 293us/step - loss: 0.1324
Epoch 68/205
280/280 [==============================] - 0s 281us/step - loss: 0.1340
Epoch 69/205
280/280 [==============================] - 0s 280us/step - loss: 0.1288
Epoch 70/205
280/280 [==============================] - 0s 286us/step - loss: 0.1284
Epoch 71/205
280/280 [==============================] - 0s 281us/step - loss: 0.1277
Epoch 72/205
280/280 [==============================] - 0s 312us/step - loss: 0.1302
Epoch 73/205
280/280 [==============================] - 0s 332us/step - loss: 0.1319
Epoch 74/205
280/280 [==============================] - 0s 347us/step - loss: 0.1276
Epoch 75/205
280/280 [==============================] - 0s 356us/step - loss: 0.1281
Epoch 76/205
280/280 [==============================] - 0s 426us/step - loss: 0.1236
Epoch 77/205
280/280 [==============================] - 0s 571us/step - loss: 0.1273
```

```
Epoch 78/205
280/280 [==============================] - 0s 634us/step - loss: 0.1296
Epoch 79/205
280/280 [==============================] - 0s 624us/step - loss: 0.1285
Epoch 80/205
280/280 [==============================] - 0s 891us/step - loss: 0.1287
Epoch 81/205
280/280 [==============================] - 0s 967us/step - loss: 0.1273
Epoch 82/205
280/280 [==============================] - 0s 997us/step - loss: 0.1301
Epoch 83/205
280/280 [==============================] - 0s 794us/step - loss: 0.1238
Epoch 84/205
280/280 [==============================] - 0s 787us/step - loss: 0.1282
Epoch 85/205
280/280 [==============================] - 0s 506us/step - loss: 0.1287
Epoch 86/205
280/280 [==============================] - 0s 406us/step - loss: 0.1275
Epoch 87/205
280/280 [==============================] - 0s 404us/step - loss: 0.1280
Epoch 88/205
280/280 [==============================] - 0s 288us/step - loss: 0.1247
Epoch 89/205
280/280 [==============================] - 0s 281us/step - loss: 0.1227
Epoch 90/205
280/280 [==============================] - 0s 284us/step - loss: 0.1334
Epoch 91/205
280/280 [==============================] - 0s 293us/step - loss: 0.1317
Epoch 92/205
280/280 [==============================] - 0s 303us/step - loss: 0.1280
Epoch 93/205
280/280 [==============================] - 0s 285us/step - loss: 0.1311
Epoch 94/205
280/280 [==============================] - 0s 298us/step - loss: 0.1317
Epoch 95/205
280/280 [==============================] - 0s 438us/step - loss: 0.1296
Epoch 96/205
280/280 [==============================] - 0s 527us/step - loss: 0.1297
Epoch 97/205
280/280 [==============================] - 0s 567us/step - loss: 0.1276
Epoch 98/205
280/280 [==============================] - 0s 505us/step - loss: 0.1250
Epoch 99/205
280/280 [==============================] - 0s 547us/step - loss: 0.1284
Epoch 100/205
280/280 [==============================] - 0s 560us/step - loss: 0.1266
Epoch 101/205
280/280 [==============================] - 0s 543us/step - loss: 0.1269
Epoch 102/205
280/280 [==============================] - 0s 278us/step - loss: 0.1240
Epoch 103/205
280/280 [==============================] - 0s 326us/step - loss: 0.1320
Epoch 104/205
280/280 [==============================] - 0s 275us/step - loss: 0.1277
Epoch 105/205
280/280 [==============================] - 0s 283us/step - loss: 0.1237
Epoch 106/205
280/280 [==============================] - 0s 289us/step - loss: 0.1258
Epoch 107/205
```

6

```
280/280 [==============================] - 0s 288us/step - loss: 0.1289
Epoch 108/205
280/280 [==============================] - 0s 344us/step - loss: 0.1296
Epoch 109/205
280/280 [==============================] - 0s 316us/step - loss: 0.1259
Epoch 110/205
280/280 [==============================] - 0s 341us/step - loss: 0.1287
Epoch 111/205
280/280 [==============================] - 0s 333us/step - loss: 0.1262
Epoch 112/205
280/280 [==============================] - 0s 307us/step - loss: 0.1327
Epoch 113/205
280/280 [==============================] - 0s 301us/step - loss: 0.1277
Epoch 114/205
280/280 [==============================] - 0s 279us/step - loss: 0.1266
Epoch 115/205
280/280 [==============================] - 0s 448us/step - loss: 0.1232
Epoch 116/205
280/280 [==============================] - 0s 472us/step - loss: 0.1226
Epoch 117/205
280/280 [==============================] - 0s 455us/step - loss: 0.1281
Epoch 118/205
280/280 [==============================] - 0s 492us/step - loss: 0.1251
Epoch 119/205
280/280 [==============================] - 0s 524us/step - loss: 0.1238
Epoch 120/205
280/280 [==============================] - 0s 614us/step - loss: 0.1255
Epoch 121/205
280/280 [==============================] - 0s 527us/step - loss: 0.1272
Epoch 122/205
280/280 [==============================] - 0s 477us/step - loss: 0.1275
Epoch 123/205
280/280 [==============================] - 0s 511us/step - loss: 0.1298
Epoch 124/205
280/280 [==============================] - 0s 514us/step - loss: 0.1308
Epoch 125/205
280/280 [==============================] - 0s 530us/step - loss: 0.1287
Epoch 126/205
280/280 [==============================] - 0s 523us/step - loss: 0.1274
Epoch 127/205
280/280 [==============================] - 0s 539us/step - loss: 0.1240
Epoch 128/205
280/280 [==============================] - 0s 475us/step - loss: 0.1261
Epoch 129/205
280/280 [==============================] - 0s 283us/step - loss: 0.1293
Epoch 130/205
280/280 [==============================] - 0s 273us/step - loss: 0.1250
Epoch 131/205
280/280 [==============================] - 0s 311us/step - loss: 0.1249
Epoch 132/205
280/280 [==============================] - 0s 307us/step - loss: 0.1261
Epoch 133/205
280/280 [==============================] - 0s 314us/step - loss: 0.1253
Epoch 134/205
280/280 [==============================] - 0s 295us/step - loss: 0.1273
Epoch 135/205
280/280 [==============================] - 0s 301us/step - loss: 0.1254
Epoch 136/205
280/280 [==============================] - 0s 297us/step - loss: 0.1267
```

```
Epoch 137/205
280/280 [==============================] - 0s 297us/step - loss: 0.1265
Epoch 138/205
280/280 [==============================] - 0s 372us/step - loss: 0.1331
Epoch 139/205
280/280 [==============================] - 0s 369us/step - loss: 0.1293
Epoch 140/205
280/280 [==============================] - 0s 471us/step - loss: 0.1252
Epoch 141/205
280/280 [==============================] - 0s 492us/step - loss: 0.1256
Epoch 142/205
280/280 [==============================] - 0s 504us/step - loss: 0.1273
Epoch 143/205
280/280 [==============================] - 0s 581us/step - loss: 0.1260
Epoch 144/205
280/280 [==============================] - 0s 566us/step - loss: 0.1250
Epoch 145/205
280/280 [==============================] - 0s 511us/step - loss: 0.1257
Epoch 146/205
280/280 [==============================] - 0s 539us/step - loss: 0.1261
Epoch 147/205
280/280 [==============================] - 0s 312us/step - loss: 0.1243
Epoch 148/205
280/280 [==============================] - 0s 318us/step - loss: 0.1243
Epoch 149/205
280/280 [==============================] - 0s 350us/step - loss: 0.1254
Epoch 150/205
280/280 [==============================] - 0s 398us/step - loss: 0.1251
Epoch 151/205
280/280 [==============================] - 0s 410us/step - loss: 0.1268
Epoch 152/205
280/280 [==============================] - 0s 822us/step - loss: 0.1269
Epoch 153/205
280/280 [==============================] - 0s 848us/step - loss: 0.1252
Epoch 154/205
280/280 [==============================] - 0s 704us/step - loss: 0.1258
Epoch 155/205
280/280 [==============================] - 0s 444us/step - loss: 0.1264
Epoch 156/205
280/280 [==============================] - 0s 367us/step - loss: 0.1218
Epoch 157/205
280/280 [==============================] - 0s 390us/step - loss: 0.1265
Epoch 158/205
280/280 [==============================] - 0s 370us/step - loss: 0.1286
Epoch 159/205
280/280 [==============================] - 0s 446us/step - loss: 0.1280
Epoch 160/205
280/280 [==============================] - 0s 382us/step - loss: 0.1247
Epoch 161/205
280/280 [==============================] - 0s 359us/step - loss: 0.1218
Epoch 162/205
280/280 [==============================] - 0s 419us/step - loss: 0.1242
Epoch 163/205
280/280 [==============================] - 0s 477us/step - loss: 0.1267
Epoch 164/205
280/280 [==============================] - 0s 509us/step - loss: 0.1267
Epoch 165/205
280/280 [==============================] - 0s 476us/step - loss: 0.1326
Epoch 166/205
```

```
280/280 [==============================] - 0s 510us/step - loss: 0.1292
Epoch 167/205
280/280 [==============================] - 0s 518us/step - loss: 0.1246
Epoch 168/205
280/280 [==============================] - 0s 493us/step - loss: 0.1248
Epoch 169/205
280/280 [==============================] - 0s 416us/step - loss: 0.1263
Epoch 170/205
280/280 [==============================] - 0s 282us/step - loss: 0.1217
Epoch 171/205
280/280 [==============================] - 0s 280us/step - loss: 0.1232
Epoch 172/205
280/280 [==============================] - 0s 377us/step - loss: 0.1253
Epoch 173/205
280/280 [==============================] - 0s 676us/step - loss: 0.1232
Epoch 174/205
280/280 [==============================] - 0s 554us/step - loss: 0.1265
Epoch 175/205
280/280 [==============================] - 0s 578us/step - loss: 0.1278
Epoch 176/205
280/280 [==============================] - 0s 601us/step - loss: 0.1261
Epoch 177/205
280/280 [==============================] - 0s 442us/step - loss: 0.1216
Epoch 178/205
280/280 [==============================] - 0s 469us/step - loss: 0.1249
Epoch 179/205
280/280 [==============================] - 0s 458us/step - loss: 0.1258
Epoch 180/205
280/280 [==============================] - 0s 507us/step - loss: 0.1272
Epoch 181/205
280/280 [==============================] - 0s 1ms/step - loss: 0.1291
Epoch 182/205
280/280 [==============================] - 0s 794us/step - loss: 0.1255
Epoch 183/205
280/280 [==============================] - 0s 541us/step - loss: 0.1264
Epoch 184/205
280/280 [==============================] - 0s 391us/step - loss: 0.1239
Epoch 185/205
280/280 [==============================] - 0s 368us/step - loss: 0.1258
Epoch 186/205
280/280 [==============================] - 0s 376us/step - loss: 0.1254
Epoch 187/205
280/280 [==============================] - 0s 362us/step - loss: 0.1257
Epoch 188/205
280/280 [==============================] - 0s 352us/step - loss: 0.1254
Epoch 189/205
280/280 [==============================] - 0s 403us/step - loss: 0.1254
Epoch 190/205
280/280 [==============================] - 0s 373us/step - loss: 0.1254
Epoch 191/205
280/280 [==============================] - 0s 396us/step - loss: 0.1247
Epoch 192/205
280/280 [==============================] - 0s 456us/step - loss: 0.1262
Epoch 193/205
280/280 [==============================] - 0s 462us/step - loss: 0.1264
Epoch 194/205
280/280 [==============================] - 0s 470us/step - loss: 0.1242
Epoch 195/205
280/280 [==============================] - 0s 464us/step - loss: 0.1242
```

9

```
Epoch 196/205
280/280 [==============================] - 0s 460us/step - loss: 0.1253
Epoch 197/205
280/280 [==============================] - 0s 479us/step - loss: 0.1243
Epoch 198/205
280/280 [==============================] - 0s 451us/step - loss: 0.1251
Epoch 199/205
280/280 [==============================] - 0s 490us/step - loss: 0.1245
Epoch 200/205
280/280 [==============================] - 0s 448us/step - loss: 0.1272
Epoch 201/205
280/280 [==============================] - 0s 478us/step - loss: 0.1256
Epoch 202/205
280/280 [==============================] - 0s 473us/step - loss: 0.1257
Epoch 203/205
280/280 [==============================] - 0s 478us/step - loss: 0.1245
Epoch 204/205
280/280 [==============================] - 0s 458us/step - loss: 0.1247
Epoch 205/205
280/280 [==============================] - 0s 460us/step - loss: 0.1247
MSE: 0.35625000 MSE
0.35625
R Score: -1.6338082402772427
EV Score: -0.950 (initial)
0.675
```

```
Figures now render in the Plots pane by default. To make them also appear inline
in the Console, uncheck "Mute Inline Plotting" under the Plots pane options menu.
```

```
In [2]:
```

10

```
iteration = 2999
Loss: 0.054005
iteration = 2999
Loss: 0.053819
iteration = 2999
Loss: 0.044777
iteration = 2999
Loss: 0.038143
iteration = 2999
Loss: 0.024487
iteration = 2999
Loss: 0.013426
iteration = 2999
Loss: 0.000003
iteration = 2999
Loss: 0.000003
iteration = 2999
Loss: 0.004325
iteration = 2999
Loss: 0.008137
iteration = 2999
Loss: 0.031520
iteration = 2999
Loss: 0.037833
iteration = 2999
Loss: 0.100959
iteration = 2999
Loss: 0.177256
iteration = 2999
Loss: 0.115628
iteration = 2999
Loss: 0.094939
iteration = 2999
Loss: 0.029180
iteration = 2999
Loss: 0.018360
iteration = 2999
Loss: 0.007284
iteration = 2999
Loss: 0.002629
iteration = 2999
Loss: 0.001067
iteration = 2999
Loss: 0.000000
iteration = 2999
Loss: 0.002069
iteration = 2999
Loss: 0.004832
iteration = 2999
Loss: 0.020910
iteration = 2999
Loss: 0.022371
iteration = 2999
Loss: 0.025226
iteration = 2999
Loss: 0.025117
iteration = 2999
Loss: 0.023972
iteration = 2999
```

1

```
Loss: 0.006013
iteration = 2999
Loss: 0.004334
iteration = 2999
Loss: 0.032401
iteration = 2999
Loss: 0.028762
iteration = 2999
Loss: 0.053401
iteration = 2999
Loss: 0.065854
iteration = 2999
Loss: 0.033547
iteration = 2999
Loss: 0.021382
iteration = 2999
Loss: 0.011576
iteration = 2999
Loss: 0.007936
iteration = 2999
Loss: 0.004298
iteration = 2999
Loss: 0.000509
iteration = 2999
Loss: 0.003070
iteration = 2999
Loss: 0.015201
iteration = 2999
Loss: 0.028441
iteration = 2999
Loss: 0.034967
iteration = 2999
Loss: 0.012405
iteration = 2999
Loss: 0.000090
iteration = 2999
Loss: 0.000616
iteration = 2999
Loss: 0.009381
iteration = 2999
Loss: 0.016895
iteration = 2999
Loss: 0.034435
iteration = 2999
Loss: 0.048821
iteration = 2999
Loss: 0.042751
iteration = 2999
Loss: 0.030462
iteration = 2999
Loss: 0.009881
iteration = 2999
Loss: 0.000200
iteration = 2999
Loss: 0.003083
iteration = 2999
Loss: 0.003241
iteration = 2999
Loss: 0.003188
```

2

```
iteration = 2999
Loss: 0.005345
iteration = 2999
Loss: 0.001828
iteration = 2999
Loss: 0.001314
iteration = 2999
Loss: 0.000301
iteration = 2999
Loss: 0.000550
iteration = 2999
Loss: 0.000091
iteration = 2999
Loss: 0.000387
iteration = 2999
Loss: 0.000178
iteration = 2999
Loss: 0.002012
iteration = 2999
Loss: 0.001977
iteration = 2999
Loss: 0.001184
iteration = 2999
Loss: 0.000190
iteration = 2999
Loss: 0.000926
iteration = 2999
Loss: 0.001216
iteration = 2999
Loss: 0.001492
iteration = 2999
Loss: 0.000685
iteration = 2999
Loss: 0.000027
iteration = 2999
Loss: 0.000052
iteration = 2999
Loss: 0.000012
iteration = 2999
Loss: 0.001279
iteration = 2999
Loss: 0.003010
iteration = 2999
Loss: 0.002374
iteration = 2999
Loss: 0.001492
iteration = 2999
Loss: 0.000224
iteration = 2999
Loss: 0.000015
iteration = 2999
Loss: 0.000132
iteration = 2999
Loss: 0.000554
iteration = 2999
Loss: 0.000298
iteration = 2999
Loss: 0.000274
iteration = 2999
```

3

```
Loss: 0.000418
iteration = 2999
Loss: 0.000035
iteration = 2999
Loss: 0.000001
iteration = 2999
Loss: 0.000003
iteration = 2999
Loss: 0.001053
iteration = 2999
Loss: 0.000740
iteration = 2999
Loss: 0.000719
iteration = 2999
Loss: 0.000436
iteration = 2999
Loss: 0.000399
iteration = 2999
Loss: 0.000307
iteration = 2999
Loss: 0.000182
iteration = 2999
Loss: 0.000033
iteration = 2999
Loss: 0.000010
iteration = 2999
Loss: 0.000342
iteration = 2999
Loss: 0.000838
iteration = 2999
Loss: 0.000858
iteration = 2999
Loss: 0.000780
iteration = 2999
Loss: 0.000533
iteration = 2999
Loss: 0.000484
iteration = 2999
Loss: 0.000049
iteration = 2999
Loss: 0.000036
iteration = 2999
Loss: 0.000007
iteration = 2999
Loss: 0.000059
iteration = 2999
Loss: 0.000057
iteration = 2999
Loss: 0.000832
iteration = 2999
Loss: 0.001839
iteration = 2999
Loss: 0.000745
iteration = 2999
Loss: 0.000895
iteration = 2999
Loss: 0.000506
iteration = 2999
Loss: 0.000143
```

4

```
iteration = 2999
Loss: 0.000002
iteration = 2999
Loss: 0.000640
iteration = 2999
Loss: 0.009886
iteration = 2999
Loss: 0.011201
iteration = 2999
Loss: 0.013708
iteration = 2999
Loss: 0.014495
iteration = 2999
Loss: 0.020843
iteration = 2999
Loss: 0.000328
iteration = 2999
Loss: 0.000358
iteration = 2999
Loss: 0.000507
iteration = 2999
Loss: 0.002062
iteration = 2999
Loss: 0.000533
iteration = 2999
Loss: 0.000133
iteration = 2999
Loss: 0.000027
iteration = 2999
Loss: 0.001362
iteration = 2999
Loss: 0.004529
iteration = 2999
Loss: 0.023488
iteration = 2999
Loss: 0.018487
iteration = 2999
Loss: 0.005933
iteration = 2999
Loss: 0.000500
iteration = 2999
Loss: 0.002992
iteration = 2999
Loss: 0.002697
iteration = 2999
Loss: 0.001234
iteration = 2999
Loss: 0.001566
iteration = 2999
Loss: 0.001150
iteration = 2999
Loss: 0.001733
iteration = 2999
Loss: 0.016802
iteration = 2999
Loss: 0.028485
iteration = 2999
Loss: 0.022114
iteration = 2999
```

```
Loss: 0.011613
iteration = 2999
Loss: 0.007303
iteration = 2999
Loss: 0.001632
iteration = 2999
Loss: 0.006939
iteration = 2999
Loss: 0.008392
iteration = 2999
Loss: 0.008222
iteration = 2999
Loss: 0.004618
iteration = 2999
Loss: 0.000659
iteration = 2999
Loss: 0.000350
iteration = 2999
Loss: 0.000912
iteration = 2999
Loss: 0.013334
iteration = 2999
Loss: 0.110507
iteration = 2999
Loss: 0.123265
iteration = 2999
Loss: 0.026827
iteration = 2999
Loss: 0.001094
iteration = 2999
Loss: 0.000890
iteration = 2999
Loss: 0.004456
iteration = 2999
Loss: 0.005433
iteration = 2999
Loss: 0.004562
iteration = 2999
Loss: 0.003825
iteration = 2999
Loss: 0.000428
iteration = 2999
Loss: 0.000526
iteration = 2999
Loss: 0.000880
iteration = 2999
Loss: 0.013856
iteration = 2999
Loss: 0.031323
iteration = 2999
Loss: 0.032248
iteration = 2999
Loss: 0.026590
iteration = 2999
Loss: 0.000954
iteration = 2999
Loss: 0.012036
iteration = 2999
Loss: 0.017026
```

6

```
iteration = 2999
Loss: 0.020801
iteration = 2999
Loss: 0.000021
iteration = 2999
Loss: 0.001002
iteration = 2999
Loss: 0.027356
iteration = 2999
Loss: 0.077748
iteration = 2999
Loss: 0.089921
iteration = 2999
Loss: 0.085348
iteration = 2999
Loss: 0.064368
iteration = 2999
Loss: 0.001915
iteration = 2999
Loss: 0.000555
iteration = 2999
Loss: 0.007116
iteration = 2999
Loss: 0.006762
iteration = 2999
Loss: 0.007043
iteration = 2999
Loss: 0.018600
iteration = 2999
Loss: 0.017154
iteration = 2999
Loss: 0.016003
iteration = 2999
Loss: 0.006580
iteration = 2999
Loss: 0.000334
iteration = 2999
Loss: 0.001350
iteration = 2999
Loss: 0.014301
iteration = 2999
Loss: 0.091370
iteration = 2999
Loss: 0.105520
iteration = 2999
Loss: 0.183002
iteration = 2999
Loss: 0.131521
iteration = 2999
Loss: 0.094132
iteration = 2999
Loss: 0.077327
iteration = 2999
Loss: 0.025673
iteration = 2999
Loss: 0.012022
iteration = 2999
Loss: 0.000308
iteration = 2999
```

```
Loss: 0.001306
iteration = 2999
Loss: 0.013519
iteration = 2999
Loss: 0.020195
iteration = 2999
Loss: 0.020072
iteration = 2999
Loss: 0.024764
iteration = 2999
Loss: 0.022821
iteration = 2999
Loss: 0.021435
iteration = 2999
Loss: 0.019122
iteration = 2999
Loss: 0.008355
iteration = 2999
Loss: 0.000753
iteration = 2999
Loss: 0.005265
iteration = 2999
Loss: 0.008132
iteration = 2999
Loss: 0.086836
iteration = 2999
Loss: 0.173365
iteration = 2999
Loss: 0.195870
iteration = 2999
Loss: 0.209817
iteration = 2999
Loss: 0.171580
iteration = 2999
Loss: 0.078915
iteration = 2999
Loss: 0.034811
iteration = 2999
Loss: 0.023662
iteration = 2999
Loss: 0.000965
iteration = 2999
Loss: 0.019521
iteration = 2999
Loss: 0.046576
iteration = 2999
Loss: 0.084669
iteration = 2999
Loss: 0.115971
iteration = 2999
Loss: 0.109239
iteration = 2999
Loss: 0.013441
iteration = 2999
Loss: 0.010302
iteration = 2999
Loss: 0.028931
iteration = 2999
Loss: 0.055157
```

```
iteration = 2999
Loss: 0.110751
iteration = 2999
Loss: 0.130014
iteration = 2999
Loss: 0.204375
(280, 18)
(280,)
(120, 18)
(120,)
MSE: 0.20000000 MSE
R Score: 0.6189643022040777
EV Score: 0.622 (initial)
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 2. 2. 2. 2. 2. 2. 2. 2.
 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2.
 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2.
 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2.]
0.8

In [23]:
```

Appendix E: Simulation Source Codes and Results of ML (n= 544)

Support Vector Machine Algorithm

```
Python 3.7.3 (default, Oct  7 2019, 12:56:13)
Type "copyright", "credits" or "license" for more information.

IPython 7.9.0 -- An enhanced Interactive Python.

In [1]:          '/home/kan/Documents/ORHAN/ORHAN/SVM.py'       ='/home/kan/
Documents/ORHAN/ORHAN'
Using TensorFlow backend.
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:516: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:517: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:518: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:519: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:520: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorflow/python/framework/
dtypes.py:525: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:541: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:542: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:543: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:544: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:545: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
                                                                                1
```

```
'(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
/home/kan/.local/lib/python3.7/site-packages/tensorboard/compat/tensorflow_stub/
dtypes.py:550: FutureWarning: Passing (type, 1) or '1type' as a synonym of type is
deprecated; in a future version of numpy, it will be understood as (type, (1,)) /
'(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
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accuracy
0.6341463414634146
/home/kan/.local/lib/python3.7/site-packages/sklearn/utils/validation.py:724:
```

8

```
DataConversionWarning: A column-vector y was passed when a 1d array was expected.
Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

```
Figures now render in the Plots pane by default. To make them also appear inline
in the Console, uncheck "Mute Inline Plotting" under the Plots pane options menu.
```

```
 MSE: 0.36585366 MSE
Train:(380, 18)
Test: (164, 1)

In [2]:
```

9

```
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
Epoch 1/100
435/435 [==============================] - 29s 67ms/step - loss: 0.1347
Epoch 2/100
435/435 [==============================] - 23s 53ms/step - loss: 0.1349
Epoch 3/100
435/435 [==============================] - 23s 52ms/step - loss: 0.1323
Epoch 4/100
435/435 [==============================] - 23s 52ms/step - loss: 0.1322
Epoch 5/100
435/435 [==============================] - 23s 53ms/step - loss: 0.1342
Epoch 6/100
435/435 [==============================] - 24s 56ms/step - loss: 0.1322
Epoch 7/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1320
Epoch 8/100
435/435 [==============================] - 24s 56ms/step - loss: 0.1325
Epoch 9/100
435/435 [==============================] - 25s 57ms/step - loss: 0.1304
Epoch 10/100
435/435 [==============================] - 26s 59ms/step - loss: 0.1318
Epoch 11/100
435/435 [==============================] - 25s 57ms/step - loss: 0.1322
Epoch 12/100
435/435 [==============================] - 26s 59ms/step - loss: 0.1306
Epoch 13/100
435/435 [==============================] - 25s 57ms/step - loss: 0.1326
Epoch 14/100
435/435 [==============================] - 26s 59ms/step - loss: 0.1315
Epoch 15/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1327
Epoch 16/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1310
Epoch 17/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1315
Epoch 18/100
435/435 [==============================] - 26s 60ms/step - loss: 0.1362
Epoch 19/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1313
Epoch 20/100
435/435 [==============================] - 26s 60ms/step - loss: 0.1310
Epoch 21/100
435/435 [==============================] - 26s 59ms/step - loss: 0.1301
Epoch 22/100
435/435 [==============================] - 26s 61ms/step - loss: 0.1320
Epoch 23/100
435/435 [==============================] - 26s 59ms/step - loss: 0.1301
Epoch 24/100
435/435 [==============================] - 35s 81ms/step - loss: 0.1308
Epoch 25/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1313
Epoch 26/100
435/435 [==============================] - 33s 77ms/step - loss: 0.1306
Epoch 27/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1311
Epoch 28/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1301
Epoch 29/100
```

6

```
435/435 [==============================] - 32s 75ms/step - loss: 0.1301
Epoch 30/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1302
Epoch 31/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1301
Epoch 32/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1301
Epoch 33/100
435/435 [==============================] - 33s 76ms/step - loss: 0.1302
Epoch 34/100
435/435 [==============================] - 32s 75ms/step - loss: 0.1318
Epoch 35/100
435/435 [==============================] - 31s 72ms/step - loss: 0.1295
Epoch 36/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1289
Epoch 37/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1294
Epoch 38/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1339
Epoch 39/100
435/435 [==============================] - 30s 68ms/step - loss: 0.1320
Epoch 40/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1304
Epoch 41/100
435/435 [==============================] - 30s 68ms/step - loss: 0.1307
Epoch 42/100
435/435 [==============================] - 30s 69ms/step - loss: 0.1286
Epoch 43/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1286
Epoch 44/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1280
Epoch 45/100
435/435 [==============================] - 30s 68ms/step - loss: 0.1326
Epoch 46/100
435/435 [==============================] - 29s 68ms/step - loss: 0.1291
Epoch 47/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1290
Epoch 48/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1284
Epoch 49/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1292
Epoch 50/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1351
Epoch 51/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1302
Epoch 52/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1298
Epoch 53/100
435/435 [==============================] - 28s 64ms/step - loss: 0.1296
Epoch 54/100
435/435 [==============================] - 24s 56ms/step - loss: 0.1291
Epoch 55/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1297
Epoch 56/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1279
Epoch 57/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1281
Epoch 58/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1292
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Epoch 59/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1297
Epoch 60/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1295
Epoch 61/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1296
Epoch 62/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1260
Epoch 63/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1282
Epoch 64/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1246
Epoch 65/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1229
Epoch 66/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1302
Epoch 67/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1268
Epoch 68/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1259
Epoch 69/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1318
Epoch 70/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1265
Epoch 71/100
435/435 [==============================] - 24s 54ms/step - loss: 0.1296
Epoch 72/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1310
Epoch 73/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1339
Epoch 74/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1385
Epoch 75/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1365
Epoch 76/100
435/435 [==============================] - 24s 55ms/step - loss: 0.1347
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Epoch 78/100
435/435 [==============================] - 24s 56ms/step - loss: 0.1346
Epoch 79/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1310
Epoch 80/100
435/435 [==============================] - 25s 57ms/step - loss: 0.1337
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435/435 [==============================] - 25s 57ms/step - loss: 0.1329
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435/435 [==============================] - 25s 57ms/step - loss: 0.1330
Epoch 83/100
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Epoch 84/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1325
Epoch 85/100
435/435 [==============================] - 25s 58ms/step - loss: 0.1317
Epoch 86/100
435/435 [==============================] - 26s 60ms/step - loss: 0.1320
Epoch 87/100
435/435 [==============================] - 26s 61ms/step - loss: 0.1318
Epoch 88/100
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435/435 [==============================] - 26s 61ms/step - loss: 0.1325
Epoch 89/100
435/435 [==============================] - 28s 63ms/step - loss: 0.1336
Epoch 90/100
435/435 [==============================] - 27s 62ms/step - loss: 0.1326
Epoch 91/100
435/435 [==============================] - 27s 63ms/step - loss: 0.1317
Epoch 92/100
435/435 [==============================] - 27s 63ms/step - loss: 0.1317
Epoch 93/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1324
Epoch 94/100
435/435 [==============================] - 32s 75ms/step - loss: 0.1315
Epoch 95/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1329
Epoch 96/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1302
Epoch 97/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1317
Epoch 98/100
435/435 [==============================] - 33s 75ms/step - loss: 0.1318
Epoch 99/100
435/435 [==============================] - 32s 74ms/step - loss: 0.1323
Epoch 100/100
435/435 [==============================] - 33s 76ms/step - loss: 0.1331
MSE: 0.13376305 MSE
0.13376304766394187
R Score: -0.011609655821319897
EV Score: -0.009 (initial)
0.7981651376146789

In [7]:
```

```
72/72 [==============================] - 0s 732us/step - loss: 0.0292
Epoch 134/150
72/72 [==============================] - 0s 780us/step - loss: 0.0248
Epoch 135/150
72/72 [==============================] - 0s 715us/step - loss: 0.0301
Epoch 136/150
72/72 [==============================] - 0s 757us/step - loss: 0.0298
Epoch 137/150
72/72 [==============================] - 0s 748us/step - loss: 0.0320
Epoch 138/150
72/72 [==============================] - 0s 707us/step - loss: 0.0275
Epoch 139/150
72/72 [==============================] - 0s 669us/step - loss: 0.0283
Epoch 140/150
72/72 [==============================] - 0s 739us/step - loss: 0.0290
Epoch 141/150
72/72 [==============================] - 0s 811us/step - loss: 0.0287
Epoch 142/150
72/72 [==============================] - 0s 809us/step - loss: 0.0249
Epoch 143/150
72/72 [==============================] - 0s 756us/step - loss: 0.0286
Epoch 144/150
72/72 [==============================] - 0s 974us/step - loss: 0.0294
Epoch 145/150
72/72 [==============================] - 0s 869us/step - loss: 0.0293
Epoch 146/150
72/72 [==============================] - 0s 751us/step - loss: 0.0303
Epoch 147/150
72/72 [==============================] - 0s 856us/step - loss: 0.0243
Epoch 148/150
72/72 [==============================] - 0s 715us/step - loss: 0.0272
Epoch 149/150
72/72 [==============================] - 0s 766us/step - loss: 0.0274
Epoch 150/150
72/72 [==============================] - 0s 723us/step - loss: 0.0285
MSE: 0.08243728 MSE
0.0824372759856631
R Score: -1.9957983193277316
EV Score: -1.487 (initial)
0.967741935483871
```

```
Figures now render in the Plots pane by default. To make them also appear inline
in the Console, uncheck "Mute Inline Plotting" under the Plots pane options menu.
```

```
In [2]:         '/home/kan/Documents/ORHAN/ORHAN/bpcl.py'       ='/home/kan/
Documents/ORHAN/ORHAN'
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 0.  1.  0.5 0.5 0.  0.5 0.  0.5 0.5 0.  0.5 1.  0.5 0.5 0.5 0.5 0.  1.
 0.  1.  1.  0.5 0.5 0.5 0.  0.5 0.5 1.  0.5 0.  0.  0.5 0.5 0.  0.5 1.
 1.  0.5 0.5 0.5 0.5 0.5 0.  0.5 0.5 0.5 0.  0.  0.  0.5 0.5 0.5 0.5 1.
 0.5 0.  1.  1.  0.  0.  0.5 0.  0.  0.5 0.5 0.5 0.  0.  0.  0.5 0.  0.5
 0.  0.5 0.5 0. ]
(380, 18)
(380,)
(164, 18)
(164,)
Epoch 1/205
380/380 [==============================] - 1s 3ms/step - loss: 0.1460
Epoch 2/205
380/380 [==============================] - 0s 610us/step - loss: 0.1419
Epoch 3/205
380/380 [==============================] - 0s 586us/step - loss: 0.1331
Epoch 4/205
380/380 [==============================] - 0s 586us/step - loss: 0.1337
Epoch 5/205
380/380 [==============================] - 0s 611us/step - loss: 0.1326
Epoch 6/205
380/380 [==============================] - 0s 586us/step - loss: 0.1326
Epoch 7/205
380/380 [==============================] - 0s 578us/step - loss: 0.1318
Epoch 8/205
380/380 [==============================] - 0s 580us/step - loss: 0.1365
Epoch 9/205
380/380 [==============================] - 0s 659us/step - loss: 0.1354
Epoch 10/205
380/380 [==============================] - 0s 714us/step - loss: 0.1350
Epoch 11/205
380/380 [==============================] - 0s 592us/step - loss: 0.1281
Epoch 12/205
380/380 [==============================] - 0s 651us/step - loss: 0.1321
Epoch 13/205
380/380 [==============================] - 0s 704us/step - loss: 0.1317
Epoch 14/205
380/380 [==============================] - 0s 661us/step - loss: 0.1367
Epoch 15/205
380/380 [==============================] - 0s 586us/step - loss: 0.1315
Epoch 16/205
```

2

```
380/380 [==============================] - 0s 584us/step - loss: 0.1281
Epoch 17/205
380/380 [==============================] - 0s 603us/step - loss: 0.1272
Epoch 18/205
380/380 [==============================] - 0s 598us/step - loss: 0.1258
Epoch 19/205
380/380 [==============================] - 0s 608us/step - loss: 0.1310
Epoch 20/205
380/380 [==============================] - 0s 572us/step - loss: 0.1285
Epoch 21/205
380/380 [==============================] - 0s 593us/step - loss: 0.1267
Epoch 22/205
380/380 [==============================] - 0s 622us/step - loss: 0.1296
Epoch 23/205
380/380 [==============================] - 0s 587us/step - loss: 0.1370
Epoch 24/205
380/380 [==============================] - 0s 623us/step - loss: 0.1293
Epoch 25/205
380/380 [==============================] - 0s 597us/step - loss: 0.1269
Epoch 26/205
380/380 [==============================] - 0s 577us/step - loss: 0.1295
Epoch 27/205
380/380 [==============================] - 0s 627us/step - loss: 0.1278
Epoch 28/205
380/380 [==============================] - 0s 585us/step - loss: 0.1282
Epoch 29/205
380/380 [==============================] - 0s 602us/step - loss: 0.1302
Epoch 30/205
380/380 [==============================] - 0s 604us/step - loss: 0.1287
Epoch 31/205
380/380 [==============================] - 0s 626us/step - loss: 0.1229
Epoch 32/205
380/380 [==============================] - 0s 735us/step - loss: 0.1265
Epoch 33/205
380/380 [==============================] - 0s 824us/step - loss: 0.1249
Epoch 34/205
380/380 [==============================] - 0s 796us/step - loss: 0.1250
Epoch 35/205
380/380 [==============================] - 0s 1ms/step - loss: 0.1267
Epoch 36/205
380/380 [==============================] - 0s 775us/step - loss: 0.1266
Epoch 37/205
380/380 [==============================] - 0s 690us/step - loss: 0.1252
Epoch 38/205
380/380 [==============================] - 0s 925us/step - loss: 0.1283
Epoch 39/205
380/380 [==============================] - 0s 794us/step - loss: 0.1271
Epoch 40/205
380/380 [==============================] - 0s 747us/step - loss: 0.1262
Epoch 41/205
380/380 [==============================] - 0s 701us/step - loss: 0.1235
Epoch 42/205
380/380 [==============================] - 0s 796us/step - loss: 0.1259
Epoch 43/205
380/380 [==============================] - 0s 665us/step - loss: 0.1244
Epoch 44/205
380/380 [==============================] - 0s 708us/step - loss: 0.1230
Epoch 45/205
380/380 [==============================] - 0s 842us/step - loss: 0.1257
```

3

```
Epoch 46/205
380/380 [==============================] - 0s 804us/step - loss: 0.1242
Epoch 47/205
380/380 [==============================] - 0s 879us/step - loss: 0.1242
Epoch 48/205
380/380 [==============================] - 0s 695us/step - loss: 0.1242
Epoch 49/205
380/380 [==============================] - 0s 668us/step - loss: 0.1243
Epoch 50/205
380/380 [==============================] - 0s 676us/step - loss: 0.1279
Epoch 51/205
380/380 [==============================] - 0s 678us/step - loss: 0.1297
Epoch 52/205
380/380 [==============================] - 0s 812us/step - loss: 0.1263
Epoch 53/205
380/380 [==============================] - 0s 767us/step - loss: 0.1224
Epoch 54/205
380/380 [==============================] - 0s 776us/step - loss: 0.1258
Epoch 55/205
380/380 [==============================] - 0s 750us/step - loss: 0.1235
Epoch 56/205
380/380 [==============================] - 0s 708us/step - loss: 0.1241
Epoch 57/205
380/380 [==============================] - 0s 1ms/step - loss: 0.1243
Epoch 58/205
380/380 [==============================] - 0s 1ms/step - loss: 0.1226
Epoch 59/205
380/380 [==============================] - 0s 697us/step - loss: 0.1233
Epoch 60/205
380/380 [==============================] - 0s 779us/step - loss: 0.1265
Epoch 61/205
380/380 [==============================] - 0s 751us/step - loss: 0.1256
Epoch 62/205
380/380 [==============================] - 0s 773us/step - loss: 0.1226
Epoch 63/205
380/380 [==============================] - 0s 695us/step - loss: 0.1275
Epoch 64/205
380/380 [==============================] - 0s 630us/step - loss: 0.1214
Epoch 65/205
380/380 [==============================] - 0s 622us/step - loss: 0.1235
Epoch 66/205
380/380 [==============================] - 0s 725us/step - loss: 0.1241
Epoch 67/205
380/380 [==============================] - 0s 647us/step - loss: 0.1237
Epoch 68/205
380/380 [==============================] - 0s 636us/step - loss: 0.1214
Epoch 69/205
380/380 [==============================] - 0s 620us/step - loss: 0.1236
Epoch 70/205
380/380 [==============================] - 0s 599us/step - loss: 0.1235
Epoch 71/205
380/380 [==============================] - 0s 589us/step - loss: 0.1238
Epoch 72/205
380/380 [==============================] - 0s 629us/step - loss: 0.1225
Epoch 73/205
380/380 [==============================] - 0s 589us/step - loss: 0.1234
Epoch 74/205
380/380 [==============================] - 0s 593us/step - loss: 0.1244
Epoch 75/205
```

4

```
380/380 [==============================] - 0s 610us/step - loss: 0.1252
Epoch 76/205
380/380 [==============================] - 0s 582us/step - loss: 0.1248
Epoch 77/205
380/380 [==============================] - 0s 639us/step - loss: 0.1218
Epoch 78/205
380/380 [==============================] - 0s 599us/step - loss: 0.1225
Epoch 79/205
380/380 [==============================] - 0s 615us/step - loss: 0.1223
Epoch 80/205
380/380 [==============================] - 0s 635us/step - loss: 0.1231
Epoch 81/205
380/380 [==============================] - 0s 604us/step - loss: 0.1226
Epoch 82/205
380/380 [==============================] - 0s 597us/step - loss: 0.1232
Epoch 83/205
380/380 [==============================] - 0s 595us/step - loss: 0.1216
Epoch 84/205
380/380 [==============================] - 0s 586us/step - loss: 0.1231
Epoch 85/205
380/380 [==============================] - 0s 625us/step - loss: 0.1216
Epoch 86/205
380/380 [==============================] - 0s 590us/step - loss: 0.1264
Epoch 87/205
380/380 [==============================] - 0s 606us/step - loss: 0.1248
Epoch 88/205
380/380 [==============================] - 0s 605us/step - loss: 0.1278
Epoch 89/205
380/380 [==============================] - 0s 588us/step - loss: 0.1225
Epoch 90/205
380/380 [==============================] - 0s 616us/step - loss: 0.1233
Epoch 91/205
380/380 [==============================] - 0s 617us/step - loss: 0.1216
Epoch 92/205
380/380 [==============================] - 0s 597us/step - loss: 0.1234
Epoch 93/205
380/380 [==============================] - 0s 617us/step - loss: 0.1222
Epoch 94/205
380/380 [==============================] - 0s 596us/step - loss: 0.1232
Epoch 95/205
380/380 [==============================] - 0s 614us/step - loss: 0.1221
Epoch 96/205
380/380 [==============================] - 0s 584us/step - loss: 0.1231
Epoch 97/205
380/380 [==============================] - 0s 611us/step - loss: 0.1219
Epoch 98/205
380/380 [==============================] - 0s 575us/step - loss: 0.1210
Epoch 99/205
380/380 [==============================] - 0s 617us/step - loss: 0.1225
Epoch 100/205
380/380 [==============================] - 0s 595us/step - loss: 0.1209
Epoch 101/205
380/380 [==============================] - 0s 630us/step - loss: 0.1198
Epoch 102/205
380/380 [==============================] - 0s 607us/step - loss: 0.1220
Epoch 103/205
380/380 [==============================] - 0s 613us/step - loss: 0.1252
Epoch 104/205
380/380 [==============================] - 0s 585us/step - loss: 0.1215
```

```
Epoch 105/205
380/380 [==============================] - 0s 594us/step - loss: 0.1227
Epoch 106/205
380/380 [==============================] - 0s 600us/step - loss: 0.1203
Epoch 107/205
380/380 [==============================] - 0s 585us/step - loss: 0.1220
Epoch 108/205
380/380 [==============================] - 0s 609us/step - loss: 0.1203
Epoch 109/205
380/380 [==============================] - 0s 625us/step - loss: 0.1218
Epoch 110/205
380/380 [==============================] - 0s 618us/step - loss: 0.1232
Epoch 111/205
380/380 [==============================] - 0s 599us/step - loss: 0.1206
Epoch 112/205
380/380 [==============================] - 0s 579us/step - loss: 0.1236
Epoch 113/205
380/380 [==============================] - 0s 617us/step - loss: 0.1233
Epoch 114/205
380/380 [==============================] - 0s 608us/step - loss: 0.1205
Epoch 115/205
380/380 [==============================] - 0s 631us/step - loss: 0.1213
Epoch 116/205
380/380 [==============================] - 0s 577us/step - loss: 0.1209
Epoch 117/205
380/380 [==============================] - 0s 600us/step - loss: 0.1206
Epoch 118/205
380/380 [==============================] - 0s 619us/step - loss: 0.1221
Epoch 119/205
380/380 [==============================] - 0s 599us/step - loss: 0.1229
Epoch 120/205
380/380 [==============================] - 0s 602us/step - loss: 0.1231
Epoch 121/205
380/380 [==============================] - 0s 593us/step - loss: 0.1214
Epoch 122/205
380/380 [==============================] - 0s 604us/step - loss: 0.1206
Epoch 123/205
380/380 [==============================] - 0s 598us/step - loss: 0.1201
Epoch 124/205
380/380 [==============================] - 0s 593us/step - loss: 0.1210
Epoch 125/205
380/380 [==============================] - 0s 602us/step - loss: 0.1223
Epoch 126/205
380/380 [==============================] - 0s 589us/step - loss: 0.1226
Epoch 127/205
380/380 [==============================] - 0s 607us/step - loss: 0.1213
Epoch 128/205
380/380 [==============================] - 0s 624us/step - loss: 0.1203
Epoch 129/205
380/380 [==============================] - 0s 643us/step - loss: 0.1219
Epoch 130/205
380/380 [==============================] - 0s 587us/step - loss: 0.1227
Epoch 131/205
380/380 [==============================] - 0s 602us/step - loss: 0.1204
Epoch 132/205
380/380 [==============================] - 0s 587us/step - loss: 0.1230
Epoch 133/205
380/380 [==============================] - 0s 578us/step - loss: 0.1206
Epoch 134/205
```

```
380/380 [==============================] - 0s 626us/step - loss: 0.1203
Epoch 135/205
380/380 [==============================] - 0s 586us/step - loss: 0.1211
Epoch 136/205
380/380 [==============================] - 0s 664us/step - loss: 0.1226
Epoch 137/205
380/380 [==============================] - 0s 597us/step - loss: 0.1212
Epoch 138/205
380/380 [==============================] - 0s 593us/step - loss: 0.1209
Epoch 139/205
380/380 [==============================] - 0s 615us/step - loss: 0.1212
Epoch 140/205
380/380 [==============================] - 0s 594us/step - loss: 0.1214
Epoch 141/205
380/380 [==============================] - 0s 578us/step - loss: 0.1217
Epoch 142/205
380/380 [==============================] - 0s 611us/step - loss: 0.1224
Epoch 143/205
380/380 [==============================] - 0s 615us/step - loss: 0.1194
Epoch 144/205
380/380 [==============================] - 0s 673us/step - loss: 0.1204
Epoch 145/205
380/380 [==============================] - 0s 609us/step - loss: 0.1214
Epoch 146/205
380/380 [==============================] - 0s 568us/step - loss: 0.1208
Epoch 147/205
380/380 [==============================] - 0s 620us/step - loss: 0.1209
Epoch 148/205
380/380 [==============================] - 0s 592us/step - loss: 0.1203
Epoch 149/205
380/380 [==============================] - 0s 616us/step - loss: 0.1219
Epoch 150/205
380/380 [==============================] - 0s 609us/step - loss: 0.1215
Epoch 151/205
380/380 [==============================] - 0s 581us/step - loss: 0.1221
Epoch 152/205
380/380 [==============================] - 0s 631us/step - loss: 0.1239
Epoch 153/205
380/380 [==============================] - 0s 586us/step - loss: 0.1211
Epoch 154/205
380/380 [==============================] - 0s 624us/step - loss: 0.1201
Epoch 155/205
380/380 [==============================] - 0s 584us/step - loss: 0.1208
Epoch 156/205
380/380 [==============================] - 0s 584us/step - loss: 0.1233
Epoch 157/205
380/380 [==============================] - 0s 635us/step - loss: 0.1214
Epoch 158/205
380/380 [==============================] - 0s 581us/step - loss: 0.1214
Epoch 159/205
380/380 [==============================] - 0s 596us/step - loss: 0.1213
Epoch 160/205
380/380 [==============================] - 0s 632us/step - loss: 0.1204
Epoch 161/205
380/380 [==============================] - 0s 579us/step - loss: 0.1198
Epoch 162/205
380/380 [==============================] - 0s 599us/step - loss: 0.1199
Epoch 163/205
380/380 [==============================] - 0s 612us/step - loss: 0.1211
```

```
Epoch 164/205
380/380 [==============================] - 0s 564us/step - loss: 0.1199
Epoch 165/205
380/380 [==============================] - 0s 611us/step - loss: 0.1209
Epoch 166/205
380/380 [==============================] - 0s 594us/step - loss: 0.1215
Epoch 167/205
380/380 [==============================] - 0s 610us/step - loss: 0.1212
Epoch 168/205
380/380 [==============================] - 0s 606us/step - loss: 0.1226
Epoch 169/205
380/380 [==============================] - 0s 582us/step - loss: 0.1209
Epoch 170/205
380/380 [==============================] - 0s 621us/step - loss: 0.1219
Epoch 171/205
380/380 [==============================] - 0s 592us/step - loss: 0.1204
Epoch 172/205
380/380 [==============================] - 0s 595us/step - loss: 0.1223
Epoch 173/205
380/380 [==============================] - 0s 608us/step - loss: 0.1216
Epoch 174/205
380/380 [==============================] - 0s 596us/step - loss: 0.1208
Epoch 175/205
380/380 [==============================] - 0s 611us/step - loss: 0.1201
Epoch 176/205
380/380 [==============================] - 0s 599us/step - loss: 0.1211
Epoch 177/205
380/380 [==============================] - 0s 605us/step - loss: 0.1206
Epoch 178/205
380/380 [==============================] - 0s 623us/step - loss: 0.1206
Epoch 179/205
380/380 [==============================] - 0s 579us/step - loss: 0.1205
Epoch 180/205
380/380 [==============================] - 0s 607us/step - loss: 0.1205
Epoch 181/205
380/380 [==============================] - 0s 629us/step - loss: 0.1197
Epoch 182/205
380/380 [==============================] - 0s 616us/step - loss: 0.1198
Epoch 183/205
380/380 [==============================] - 0s 597us/step - loss: 0.1220
Epoch 184/205
380/380 [==============================] - 0s 615us/step - loss: 0.1191
Epoch 185/205
380/380 [==============================] - 0s 650us/step - loss: 0.1193
Epoch 186/205
380/380 [==============================] - 0s 611us/step - loss: 0.1207
Epoch 187/205
380/380 [==============================] - 0s 580us/step - loss: 0.1219
Epoch 188/205
380/380 [==============================] - 0s 606us/step - loss: 0.1206
Epoch 189/205
380/380 [==============================] - 0s 594us/step - loss: 0.1197
Epoch 190/205
380/380 [==============================] - 0s 609us/step - loss: 0.1195
Epoch 191/205
380/380 [==============================] - 0s 613us/step - loss: 0.1188
Epoch 192/205
380/380 [==============================] - 0s 594us/step - loss: 0.1203
Epoch 193/205
```

```
380/380 [==============================] - 0s 599us/step - loss: 0.1209
Epoch 194/205
380/380 [==============================] - 0s 594us/step - loss: 0.1202
Epoch 195/205
380/380 [==============================] - 0s 584us/step - loss: 0.1195
Epoch 196/205
380/380 [==============================] - 0s 617us/step - loss: 0.1212
Epoch 197/205
380/380 [==============================] - 0s 582us/step - loss: 0.1193
Epoch 198/205
380/380 [==============================] - 0s 619us/step - loss: 0.1209
Epoch 199/205
380/380 [==============================] - 0s 609us/step - loss: 0.1218
Epoch 200/205
380/380 [==============================] - 0s 604us/step - loss: 0.1208
Epoch 201/205
380/380 [==============================] - 0s 594us/step - loss: 0.1205
Epoch 202/205
380/380 [==============================] - 0s 625us/step - loss: 0.1199
Epoch 203/205
380/380 [==============================] - 0s 606us/step - loss: 0.1206
Epoch 204/205
380/380 [==============================] - 0s 608us/step - loss: 0.1200
Epoch 205/205
380/380 [==============================] - 0s 600us/step - loss: 0.1193
MSE: 0.32317073 MSE
0.3231707317073171
R Score: -1.367102396514161
EV Score: -0.482 (initial)
0.7378048780487805

In [3]:
```

```
iteration = 2999
Loss: 0.038386
iteration = 2999
Loss: 0.021432
iteration = 2999
Loss: 0.000284
iteration = 2999
Loss: 0.000339
iteration = 2999
Loss: 0.003976
iteration = 2999
Loss: 0.009017
iteration = 2999
Loss: 0.001058
iteration = 2999
Loss: 0.000011
iteration = 2999
Loss: 0.000589
iteration = 2999
Loss: 0.000833
iteration = 2999
Loss: 0.041132
iteration = 2999
Loss: 0.031771
iteration = 2999
Loss: 0.025527
iteration = 2999
Loss: 0.006818
iteration = 2999
Loss: 0.007245
iteration = 2999
Loss: 0.001341
iteration = 2999
Loss: 0.003849
iteration = 2999
Loss: 0.005149
iteration = 2999
Loss: 0.009316
iteration = 2999
Loss: 0.018743
iteration = 2999
Loss: 0.012259
iteration = 2999
Loss: 0.003416
iteration = 2999
Loss: 0.000019
iteration = 2999
Loss: 0.000148
iteration = 2999
Loss: 0.003032
iteration = 2999
Loss: 0.006233
iteration = 2999
Loss: 0.042601
iteration = 2999
Loss: 0.042168
iteration = 2999
Loss: 0.026760
iteration = 2999
```

1

```
Loss: 0.015849
iteration = 2999
Loss: 0.009464
iteration = 2999
Loss: 0.003970
iteration = 2999
Loss: 0.003244
iteration = 2999
Loss: 0.003303
iteration = 2999
Loss: 0.000063
iteration = 2999
Loss: 0.000159
iteration = 2999
Loss: 0.000003
iteration = 2999
Loss: 0.000618
iteration = 2999
Loss: 0.002887
iteration = 2999
Loss: 0.011576
iteration = 2999
Loss: 0.041725
iteration = 2999
Loss: 0.044359
iteration = 2999
Loss: 0.034373
iteration = 2999
Loss: 0.023455
iteration = 2999
Loss: 0.016881
iteration = 2999
Loss: 0.009646
iteration = 2999
Loss: 0.000477
iteration = 2999
Loss: 0.004515
iteration = 2999
Loss: 0.007254
iteration = 2999
Loss: 0.016488
iteration = 2999
Loss: 0.045260
iteration = 2999
Loss: 0.093697
iteration = 2999
Loss: 0.111868
iteration = 2999
Loss: 0.139068
iteration = 2999
Loss: 0.168697
iteration = 2999
Loss: 0.156782
iteration = 2999
Loss: 0.102913
iteration = 2999
Loss: 0.032791
iteration = 2999
Loss: 0.012345
```

2

```
iteration = 2999
Loss: 0.004398
iteration = 2999
Loss: 0.008197
iteration = 2999
Loss: 0.012618
iteration = 2999
Loss: 0.014336
iteration = 2999
Loss: 0.020276
iteration = 2999
Loss: 0.037168
iteration = 2999
Loss: 0.061429
iteration = 2999
Loss: 0.010434
iteration = 2999
Loss: 0.000886
iteration = 2999
Loss: 0.000138
iteration = 2999
Loss: 0.004523
iteration = 2999
Loss: 0.016781
iteration = 2999
Loss: 0.020024
iteration = 2999
Loss: 0.030301
iteration = 2999
Loss: 0.058365
iteration = 2999
Loss: 0.063917
iteration = 2999
Loss: 0.064860
iteration = 2999
Loss: 0.052955
iteration = 2999
Loss: 0.000854
iteration = 2999
Loss: 0.001049
iteration = 2999
Loss: 0.008397
iteration = 2999
Loss: 0.011263
iteration = 2999
Loss: 0.016006
iteration = 2999
Loss: 0.023294
iteration = 2999
Loss: 0.043869
iteration = 2999
Loss: 0.027845
iteration = 2999
Loss: 0.018588
iteration = 2999
Loss: 0.002371
iteration = 2999
Loss: 0.119648
iteration = 2999
```

```
Loss: 0.187004
iteration = 2999
Loss: 0.222179
iteration = 2999
Loss: 0.256302
iteration = 2999
Loss: 0.285325
iteration = 2999
Loss: 0.066055
iteration = 2999
Loss: 0.031426
iteration = 2999
Loss: 0.033297
iteration = 2999
Loss: 0.064869
iteration = 2999
Loss: 0.013200
iteration = 2999
Loss: 0.000960
iteration = 2999
Loss: 0.084329
iteration = 2999
Loss: 0.108800
iteration = 2999
Loss: 0.131988
iteration = 2999
Loss: 0.028039
iteration = 2999
Loss: 0.030111
iteration = 2999
Loss: 0.020616
iteration = 2999
Loss: 0.008349
iteration = 2999
Loss: 0.000705
iteration = 2999
Loss: 0.113058
iteration = 2999
Loss: 0.085602
iteration = 2999
Loss: 0.001809
iteration = 2999
Loss: 0.000891
iteration = 2999
Loss: 0.000930
iteration = 2999
Loss: 0.008414
iteration = 2999
Loss: 0.027259
iteration = 2999
Loss: 0.043989
iteration = 2999
Loss: 0.023098
iteration = 2999
Loss: 0.008445
iteration = 2999
Loss: 0.077520
iteration = 2999
Loss: 0.551665
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4

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iteration = 2999
Loss: 0.533707
iteration = 2999
Loss: 0.425446
iteration = 2999
Loss: 0.023429
iteration = 2999
Loss: 0.057761
iteration = 2999
Loss: 0.058509
iteration = 2999
Loss: 0.051264
iteration = 2999
Loss: 0.019474
iteration = 2999
Loss: 0.004595
iteration = 2999
Loss: 0.000033
iteration = 2999
Loss: 0.035218
iteration = 2999
Loss: 0.066944
iteration = 2999
Loss: 0.174882
(380, 18)
(380,)
(164, 18)
(164,)
MSE: 0.15789474 MSE
R Score: 0.7046479092180942
EV Score: 0.710 (initial)
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
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0.8421052631578947
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