A System for Notification of Road Accident, Fire and Injury Cases: Smart Emergency Notification System (SENS)

Emre Rifat Yıldız

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

Master of Science
in
Computer Engineering

Eastern Mediterranean University
January 2019
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Assoc. Prof. Dr. Ali Hakan Ulusoy
Acting Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science in Computer Engineering.

Prof. Dr. Hadi Işık Aybay
Chair, Department of Computer 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 Master of Science in Computer Engineering.

Asst. Prof. Dr. Yıltan Bitirim
Supervisor

Examining Committee

1. Assoc. Prof. Dr. Duygu Çelik Ertuğrul
2. Asst. Prof. Dr. Yıltan Bitirim
3. Asst. Prof. Dr. Mehtap Köse Ulukök

ABSTRACT

In this thesis, the system named Smart Emergency Notification System (SENS) is proposed for both the emergency responders and community. SENS detects the single/multiple emergency case(s), i.e. road accident, fire and injury, automatically from the image sent by a smartphone via Internet by the proposed promising approach that uses data mining and machine learning techniques with Cloud Vision API service of Google and afterwards, notifies police, fire brigade and/or ambulance. This system has three modules which are the mobile application SENSdroid, the Web application WebSENS and the software agent NotiSENS that uses the proposed approach. It is possible to say that this system would has positive effect on helping the harmed person, supporting the staff on duty, protecting the person who can be harmed and/or saving the nature. Additionally, this system would has high usability because of its easy-to-use features and high rates of smartphone and Internet users. It is believed that SENS could be an efficient and useful system.

Keywords: Emergency Case Detection, Emergency Notification, Machine Learning, Data Mining, Mobile Application, Web Application, Agent, Cloud Vision API, Smart System.

ÖZ

Bu tezde, toplum ve acil durum yanıtlayıcıları tarafından kullanılması amaçlanan Akıllı Acil Durum Bildirim Sistemi adlı bir sistem önerilmiştir. Bu sistem makine öğrenimi ve veri madenciliği tekniklerini Google Inc.'in bir servisi olan Cloud Vision API ile birlikte kullanan bir yaklaşıma dayalı olarak çalışır. Trafik kazası, yangın ve yaralanma acil durumları tekli/çoklu olarak, akıllı telefon aracılığıyla İnternet üzerinden gönderilen resimlerin önerilen yaklaşıma göre işlenmesiyle otomatik olarak tanımlanır ve polis, itfaiye ve/veya ambulans olmak üzere acil durum yanıtlayıcılarından ilgili olan(lar)a bildirilir. Sistemin, SENSdroid adlı bir mobil uygulama, WebSENS adlı bir İnternet uygulaması ve önerilen yaklaşıma dayalı olarak çalışan NotiSENS adlı bir yazılım ajanı olmak üzere üç modülü bulunmaktadır. Bu sistemin zarar gören kişilere yardım etme, görevli personeli destekleme, zarar görebilecek kişiyi koruma ve/veya doğayı koruma konularında olumlu etkilerinin olacağını söylemek mümkündür. Buna ek olarak, sistemin kolay kullanım özellikleri ve yüksek oranda akıllı telefon ve İnternet kullanıcısı olması nedeniyle geniş bir kullanıcı kitlesine sahip olacağı düşünülmektedir. Bu sebeple, sistemin etkili ve faydalı bir çözüm olabileceğine inanılmaktadır.

Anahtar Kelimeler: Acil Durum Tanımlama, Acil Durum Bildirimi, Makine Öğrenimi, Veri Madenciliği, Mobil Uygulama, Web Uygulaması, Yazılım Ajanı, Cloud Vision API, Akıllı Sistem.

To the ones who died alone...

ACKNOWLEDGEMENT

My sincere to thanks to Asst. Prof. Dr. Yıltan Bitirim for his guidance and for sharing his invaluable knowledge and experiences with me in the process of completing this thesis.

I would like to thank my friends Samet Dinçer, Mahmut Sevince, Tansel Sarıhan, Begüm Koru, İmren Toprak and Ömer Demir for their support and good wishes.

My special thanks to Ayşe Gürer who has a special place in my life for her support and her best wishes.

I owe my deepest gratitude to my family who has always believed in me and supported me.

I would also like to thank myself for never giving up, for always believing in myself and for spending countless days and sleepless nights enduring the hard work needed to complete this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

API	Application Programming Interface
BMW	Bayerische Motoren Werke
CFC	Confirm-Forward-Cancel
CTIF	International Association of Fire and Rescue Services
EENA	European Emergency Number Association
DB	Database
ER	Entity-Relationship
FN	False Negatives
FP	False Positives
GM	General Motors
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HTTP	Hyper-Text Transfer Protocol
ID	Identification Number
IMEI	International Mobile Equipment Identity
LD	Label Document
M-CC	Multi-Case Category
NFDTBNC	Notification with Faulty Decision on To-Be-Notified Center(s)
NF	Normal Form
PHP	Hypertext Preprocessor
S-CC	Single-Case Category
SENS	Smart Emergency Notification System
SF	Standardization File

SQL	Structured Query Language
TN	True Negatives
TP	True Positives
ULD	Updated Label Document
URL	Uniform Resource Locator
Wi-Fi	Wireless Fidelity

Chapter 1

INTRODUCTION

Accidents, fires and injuries cause a serious number of deaths worldwide. Accidental deaths are mainly road accidents and more than 1.3 million people die in road accidents every year; besides, 20-50 million people get vehicular-related injuries or disabilities as a result of road accidents [1]. According to the report of International Association of Fire and Rescue Services (CTIF), approximately 3 million fires in total occurred in 43 countries from 2011 to 2015 and these fires caused the death of over 23 thousand people [2]. Other than injuries occurred because of road accidents and fire, there are also accidental, drowning, poisoning, etc. type injuries.

When such an emergency case happens, it is obvious that the emergency responder(s) must be informed about the emergency case in order to help people and save as many lives as possible. In traditional way, a person notifies an emergency case by calling the corresponding emergency responder up and trying to explain the event occurred along with the help required. Each country has emergency call services to inform the emergency responders such as police, fire brigade and ambulance. As examples of the emergency call services, 911 is used in the USA, 999 is used in the UK and 112 is used in most of the countries in the world. Each of these numbers is mainly called for police, ambulance, fire brigade and coastguard services. The information that is delivered to the emergency responder(s) should be reliable, accurate and explanatory.

However, false alarms, such as misdials, prank calls and non-emergency calls, to the emergency call services are in exceeding amount. The 38% of 10.4 million of 911 calls during 2010 were false alarm calls which means average of 10,700 calls in a day [3]. In 2011, the false emergency call rate in 18 European countries was 50% in average and 43% in the UK according to the European Emergency Number Association's (EENA) report [4]. When the report of the US National Fire Protection Association in 2014 is considered, US fire departments responded over 2 million false alarms in a year (excluding good intent calls and smoke scares) [5].

Decreasing the response time, which is the time range starting from the event occurred to the first intervention moment, for a vehicular accident by 1 minute increases the chance of saving lives by 6% [6]. It is believed that decreasing the response time for any type of emergency at all would have positive effect on helping the harmed person, supporting the staff on duty, protecting the person who can be harmed and/or saving the nature. As long as the response time decreases, the positive effect increases. Using resources more efficiently is the main component that could contribute to decrease the response time. Delivering reliable, accurate and explanatory information to the emergency responders as well as preventing false alarms could contribute to more efficient use of resources.

Some systems that aim to detect road accident and notify automatically when a vehicle crash occurred have been proposed in the literature such as [7-11]. Besides, there are launched in-vehicle systems which are GM's OnStar, BMW's Assist and Mercedes Benz's mbrace, and this aim is one of their aims. Furthermore, another aim of the in-vehicle systems is manual notification of an emergency to the corresponding company's call center directly. Although smoke detectors have been used for many years to provide an alarm in case of fire, there have been systems proposed in the literature such as [12-14] that detect and notify automatically when a fire occurred. Several healthcare monitoring systems that detect the emergency based on heart activities, falls, epileptic seizures and/or so forth and notify the medical personnel automatically have been proposed in the literature such as [15-17]. The in-vehicle systems could be a partial solution since they are available for limited number of countries and for limited number of cars in the countries. (Note: The reader may need to make a further research in order to clarify the 'limited number' by answering the questions such as; "In which countries are these systems available?", "Are all BMW car models have Assist in the country?" or "Is there any other car brand that uses mbrace other that Mercedes Benz?".) All the proposed systems we encountered are focused on the detection and notification of one specific emergency type and these systems' implementations were developed. However, other than all, two more proposed systems given in [18-19] were encountered. These are only the proposed models that consider notification of single/multiple emergency case(s) without any detection mechanism and their implementations were not developed.

In this thesis, the system named Smart Emergency Notification System (SENS) is proposed for both the emergency responders and community that detects the emergencies road accident, fire and injury and informs the corresponding emergency responder(s). This system detects the single/multiple emergency case(s) automatically from the image sent by a smartphone via Internet by using the proposed approach -that uses popular data mining and machine learning techniques- and then, notifies police, fire brigade and/or ambulance. The system contains three modules. The mobile application named SENSdroid is one of the modules which was developed to capture an image, send it with other required information and display the response. The high rates of smartphone and Internet usage (53% of the world population uses Internet nowadays [20] and the number of people who use smartphone is expected to reach 2.71 billion in 2019 [21]) suggest that our system could be used by as many as possible people in community. The other module of the system is the software agent named NotiSENS that uses the proposed approach. It receives the image with other required information from SENSdroid, processes the image, decides which emergency responder(s) should be notified and so on. The Web application named WebSENS is the third module and developed for the emergency responders. It provides to see the emergency case notifications. For each notification, the information such as the image and GPS location are seen. With WebSENS, the responders would have clear information about the emergency cases. Furthermore, WebSENS has fault-tolerant improved-mechanism named Confirm-Forward-Cancel (CFC) mechanism which can overcome possible notifications that have faulty decision on to-be-notified emergency responder(s).

Our system allows delivering reliable, accurate and explanatory information to the emergency responders and naturally reduces false alarms. It also removes the duration spent for calling. All these could directly or indirectly decrease the response time. Consequently, it is possible to say that this system could be an efficient and useful.

The further chapters of the thesis are organized as follows: the next chapter describes our proposed approach, the methods used and the success of this approach based on the performance test results; the third chapter describes the system modules that were developed based on our proposed approach and presents the database design; the fourth chapter contains the implementation of this system; and the last chapter gives concluding remarks.

Chapter 2

THE PROPOSED APPROACH AND METHODS USED

To be able to automatically detect the emergency case(s) on an image, an approach that consists of several phases has been proposed. This approach consists of data mining and machine learning techniques and Cloud Vision API of Google Inc. Obtaining the characteristics of the emergency cases road accident, fire and injury has an importance in order to identify them. To do that, a dataset that consists of these emergency case images as training and test sets were created for the supervised learning of the proposed approach. The characteristics of these emergency cases were tried to be obtained by the labels of each image in the dataset. These labels are words or phrases that describe the events, objects or places in the images. In order to decide the emergency case on an image, the similarity scores between labels of the images were obtained by using a similarity metric. Also a performance evaluation was done by using the images in the test set to evaluate the success of the approach.

The proposed approach and the methods used are described in the following subsections.

2.1 Dataset Creation

Since no dataset that could be used for our study was encountered, the first step was to create a dataset. The dataset consists of three training sets for Single-Case Categories (S-CCs) and seven test sets for both S-CCs and Multi-Case Categories (M-

CCs). The S-CCs are “Accident”, “Fire” and “Injury” and the M-CCs are “Accident&Fire”, “Accident&Injury”, “Fire&Injury” and “Accident&Fire&Injury”.

Table 1. Queries and dataset details.

Case Category	**Type**	**Query**	The number of images collected				
			Google	**Bing**	**Training**	**Test**	**Total**
Accident	S-CC	traffic accident	150	No need	100	50	150
Fire	S-CC	forest fire	75	No need	50	25	150
		building fire	75	No need	50	25	
Injury	S-CC	injured people	39	33	100	35	135
		injured person	0	9			
		wounded people	34	9			
		people in blood	7	0			
		bleeding person	4	0			
Accident&Fire	M-CC	fire in traffic	50	No need	No need	50	50
Accident&Injury	M-CC	traffic accident injury	35	3	No need	38	50
		injury in traffic accident	10	0	No need	10	
		pedestrian injury	2	No need	No need	2	

Image search of Google was mainly used for obtaining the dataset since it is the most popular search engine [22]. Table 1 shows the queries and the dataset details per query. For each S-CC, it was aimed to have 150 images where 100 for training set and 50 for test set. This was achieved for “Accident” category with Google. For “Fire” category, more specific queries were needed to have meaningful images. Therefore, two fire types (i.e. forest and building) were decided to use with two queries. In order to have the balanced-amount of images in this category, 75 were collected (50 for training set and 25 for test set) from each query. For “Injury” category, one query (i.e. “injured people”) was not retrieved enough number of images, which is 150, on Google; so the same query was also run on image search of Bing which is the second most popular search engine [22]. However, since enough number of images still could not retrieved, the same step was repeated with the next query. This step was done for total five queries. It was stopped after five queries because: For training, 100 images (which was as decided) were obtained; 35 images were obtained for test and could be enough for testing; evaluating the retrieval outputs of search engines takes time and time saving was considered. For each of the three training sets, 100 images are required for our method. For the seven test sets, it was tried to have 50 images for each; however, for the cases that 50 could not be reached, it was tried to have as many as possible but at least 10. For M-CCs, no training set but test set was required. The same method that was used to obtain S-CCs was also used for M-CCs. 50 test images were collected for each of “Accident&Fire” and “Accident&Injury” categories. However, no related images could be retrieved at all for “Fire&Injury” and “Accident&Fire&Injury” case categories after related queries were searched on both search engines. It could be said that the possibility of having an image that contains fire and injury cases together and accident, fire and injury cases together is quite low. Nevertheless, for these two categories, 10 images were created for each by using Photoshop CS5. While this creation, particular parts were used from some appropriate images in “Accident”, “Fire” and “Injury” S-CCs’ test sets. For the "Fire & Injury" category, image pairs were determined by selecting one image from each of the "Fire" and "Injury" categories. A suitable part of the image has been cropped from one of the pairs. This cropped part was moved from one pair to the other on a suitable position and pasted. In order to create images in the "Accident&Fire& Injury" category, the same procedure was applied to the determined triples by selecting appropriate images from "Accident", "Fire" and "Injury" S-CCs' test sets. With the creation of these two categories, the dataset were completed. The structure of the created dataset is presented in Figure 1. It shows the categories with the number of training and test images that they contain.

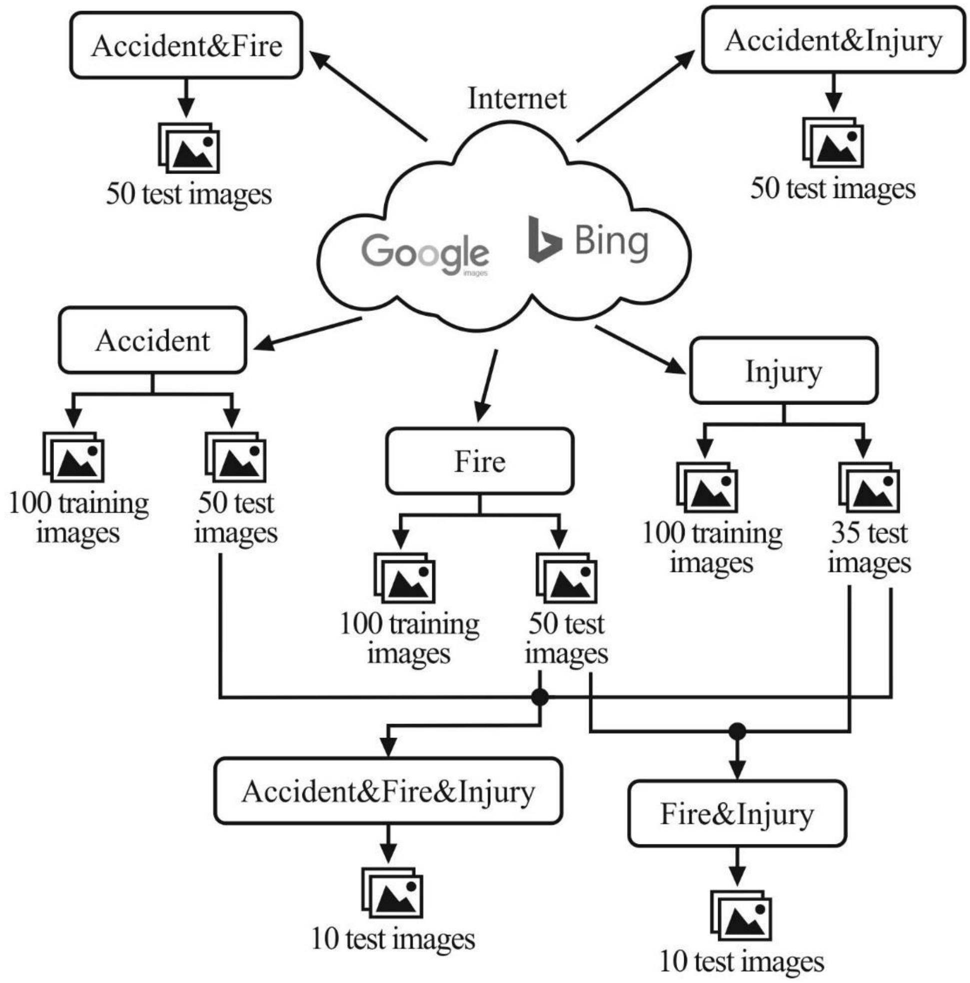


Figure 1. The structure of the created dataset.

When queries run on a search engine, relevant images were considered and these images were saved based on search-engine-rank order in separate folders in terms of categories. For each S-CCs, 100 images were split for training purpose. In order to make a fair selection between all images for training; the 1st, 4th, 7th, … and 147th images in both “Accident” and “Fire” S-CCs, and 1st, 5th, 9th, … and 133rd images in “Injury” S-CC were taken from the corresponding folders. The rest of the images were taken for test purpose. For M-CCs, all downloaded images were used for testing.

2.2 Forming the Label Documents

Three Label Documents (LDs) were formed as shown in Figure 2. The first one (LD1) includes all training -image-labels categorized in S-CCs. The second (LD2) includes labels for each of 300 training images. The last one (LD3) includes labels for each of 255 test images. All the labels in the documents were obtained from the Cloud Vision API [23] with an individual request per image. Cloud Vision API is an image content analysis service provided by Google Cloud Platform of Google Inc. Label detection, face detection and Handwriting Recognition are some of the Could Vision API features. In our study, label detection was used.

LD1 (“Training-Image-Labels_per_SCC.txt”)	LD2 (“Labels_per_training-image.txt”)	LD3 (“Labels_per_test-image.txt”)
<D ID=acc> motor vehicle car vehicle … </D > <D ID=fir> fire house home … </D > … <D ID=inj> crowd recreation fun … </D >	<Q ID=1> motor vehicle car vehicle … </Q> <Q ID=2> family car collision asphalt … </Q> … <Q ID=300> event product street … </Q>	<Q ID=1> motor vehicle vehicle car … </Q> <Q ID=2> motor vehicle transport mode of transport … </Q> … <Q ID=255> vehicle stunt performer smoke … </Q>

Figure 2. Label documents.

A list that includes each label once was formed from the label document LD1. (Only LD1 was used since LD1 and LD2 contain the same labels and LD3 contains the labels for test.) On the list, an appropriate common label was assigned to similar labels in terms of meaning. E.g.; the label "car" was assigned to the labels "family car", "luxury car", etc. Afterwards, another file called Standardization File (SF) was formed. SF includes every label that an appropriate label was assigned and assigned-new-label for each. SF was used to update LD1, LD2 and LD3.

A list that includes each label once was formed from the label document LD1. (Only LD1 was used since LD1 and LD2 contain the same labels and LD3 contains the labels for test.) On the list, an appropriate common label was assigned to similar labels in terms of meaning. E.g.; the label "car" was assigned to the labels "family car", "luxury car", etc. Afterwards, another file called Standardization File (SF) was formed. SF includes every label that an appropriate label was assigned and assigned-new-label for each. SF was used to update LD1, LD2 and LD3.

2.3 Similarity Measurement

There are various approaches to measure the similarities between texts. In the pre-research phase of this study, some of them, i.e. Jaccard, Euclidean, Cosine, Minkowski and Manhattan, were used with sample image labels. Cosine similarity provided the best results among these approaches based on the sample image labels. So, it was decided to use cosine similarity in this study.

Cosine similarity measures the similarity between two non-zero vectors and it is defined by the following formula;

$$similarity(A, B) = \cos(\theta) = \frac{A \bullet B}{||A||||B||} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}} \quad (1)$$

2.4 Determination of Threshold Values

It is possible for an image to belong to more than one S-CC. An image is always belong to one primary S-CC. However, if it has reasonable amount of content related to the other S-CC(s), it may also belong to the other(s) at the same time. Therefore, it was decided to use threshold values to determine the S-CCs of an image other than its primary S-CC.

Training images were used to calculate the threshold values. Two threshold values were determined for each S-CC. Calculations of threshold values are explained below for “Accident” S-CC. The same method was also used for “Fire” and “Injury” S-CCs.

“Accident” S-CC has 100 training images. Updated LD2 (ULD2) includes labels of each image. For each of the images, cosine similarity score between the corresponding image’s labels and “Fire” S-CC’s labels in Updated LD1 (ULD1) was calculated. These scores were scaled in terms of percentage based on the maximum and minimum of the scores. Then, the average of these scores is assigned as the threshold value of “Accident” S-CC for “Fire” S-CC. The same was also done to have the threshold value of “Accident” S-CC for “Injury” S-CC.

2.5 Testing the Performance

The test images were used to see how much our approach is successful to detect the S-CC/M-CC of an image correctly. Firstly, cosine similarity score was calculated between each test image’s labels in Updated LD3 (ULD3) and each S-CC’s labels in ULD1. Three scores were obtained for each test image since there are three S-CCs.

Every three scores were scaled in terms of percentage based on the highest one of the corresponding three scores. Every 100% score revealed the primary S-CC of the corresponding image. For each image, the other two scores were compared one by one with the corresponding aforementioned thresholds. When a score greater than the threshold was encountered, it was accepted that the image was also in the corresponding S-CC. This type of images are M-CC images, while the others are S-CC images. Finally, every image in the test set was categorized as “Accident”, “Fire”, “Injury”, “Accident&Fire”, “Accident&Injury”, “Fire&Injury” or “Accident&Fire&Injury”.

For the performance evaluation, firstly, a binary state table was constructed as shown in Table 2. This table includes results as well as ground truth of all test images with “1”s and “0”s based on S-CCs. “0” indicates that the image is not in the category, while “1” indicates that the image is in the category. For every S-CC image, “1” shown once in ground truth. For every M-CC image, “1” shown at least two times in ground truth. For every image, the binary state of each category in results was compared with the binary state of the same category in ground truth. Then, sensitivity, specificity and accuracy were calculated based on these comparisons. Sensitivity is the proportion of positive results that correctly identified, specificity is the proportion of negative results that correctly identified and accuracy is the proportion of correct identifications. Sensitivity, specificity and accuracy were calculated for each of the seven categories (i.e. S-CCs and M-CCs) with the following formulas.

$$sensitivity = TP/(TP + FN) \quad (2)$$

$$specificity = TN/(TN + FP) \quad (3)$$

$$accuracy = (TN + TP)/(TN + TP + FN + FP) \quad (4)$$

where TP is the total number of 1s in results that are also 1s in ground truth, TN is the total number of 0s in results that are also 0s in ground truth, FN is the total number of 0s in results that are 1s in ground truth, FP is the total number of 1s in results that are 0s in ground truth.

Table 2. Binary state table of test images.

		Result			Ground truth		
Image Category	**Image #**	**Accident**	**Fire**	**Injury**	**Accident**	**Fire**	**Injury**
Accident	1	1	0	0	1	0	0
	…	…	…	…	…	…	…
	50	1	0	0	1	0	0
Fire	51	0	1	0	0	1	0
	…	…	…	…	…	…	…
	100	0	1	0	0	1	0
Injury	101	0	0	1	0	0	1
	…	…	…	…	…	…	…
	135	0	0	1	0	0	1
Accident &Fire	136	1	1	0	1	1	0
	…						
	185	1	1	0	1	1	0
Accident &Injury	186	1	0	1	1	0	1
	…	…	…	…	…	…	…
	235	1	0	1	1	0	1
Fire &Injury	236	0	1	1	0	1	1
	…	…	…	…	…	…	…
	245	0	1	1	0	1	1
Accident& Fire&Injury	246	1	1	1	1	1	1
	…	…	…	…	…	…	…
	255	1	1	1	1	1	1

2.6 Results and Discussion

The success of our approach was evaluated in terms of sensitivity, specificity and accuracy. Sensitivity represents the success on identifying emergency cases that are actually exist in the images; specificity represents the success on not identifying emergency cases that are actually not exist in the images; and accuracy represents the success on correct identification of the emergency cases in the images. Sensitivity, specificity and accuracy were calculated for each of S-CCs and M-CCs as shown in Table 3.

Very close scores which are 97% or above were obtained at “Accident” and “Fire”. Sensitivity is 100% for “Accident” and “Fire”. “Injury” has the lowest score for each metric compared to the other S-CCs and has its lowest score that is 86% for specificity. As a result, for S-CCs, all scores are 86% or above and average metric scores are 94% or above.

Table 3. True and false categorization numbers and success scores.

Category Type	Category	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy
S-CC	Accident	50	99	1	0	1.00	0.99	0.99
	Fire	50	97	3	0	1.00	0.97	0.98
	Injury	33	60	10	2	0.94	0.86	0.89
M-CC	Accident&Fire	93	36	14	7	0.93	0.72	0.86
	Accident&Injury	58	49	1	42	0.58	0.98	0.71
	Fire&Injury	16	10	0	4	0.80	1.00	0.87
	Accident&Fire&Injury	17	0	0	13	0.57	-	0.57
Overall Success						0.84	0.92	0.88

For the M-CCs, “Accident&Fire” has the lowest specificity with 72%, but the highest sensitivity with 93%. “Accident&Fire&Injury” has the lowest sensitivity with 57% which is almost the same with the sensitivity score of “Accident&Injury”. “Fire&Injury” has the highest specificity, 100%, while “Accident&Injury” has very close to that with 98%. The sensitivity score of “Fire&Injury” is 80%. The specificity cannot be calculated for “Accident&Fire&Injury” since there is no category exists out of these three. Because of this, the accuracy always equals to the sensitivity of this category. The average accuracy of M-CCs is 75%, while the averages for sensitivity and specificity are 72% and 90%, respectively.

The most of the injury-contained-image labels returned from Cloud Vision API are not expressed the injuries well enough. One cause of this is that some injury labels were from the accident labels. As a result, for both S-CCs and M-CCs, it is possible to say that the approach: (*) has difficulties to distinguish accident and injury emergencies; (*) is not well enough to detect the presence and absence of injury event; and (*) is better at identifying the accident and fire emergency cases.

An image that contains all “Accident”, “Fire” and “Injury” events together could not be found on the most popular search engines Google and Bing. This could show us that the possibility to have such image might be low. Therefore, it could be better to tell the average scores of sensitivity, specificity and accuracy for M-CCs without the triple M-CC. These scores are 77%, 90% and 81%, respectively.

Our approach is more successful on S-CCs than M-CCs. Nevertheless, the overall sensitivity and specificity scores are 84% and 92%, respectively, while the overall accuracy is 88%. To sum up, it could be said that our approach seems good for overall success.

Chapter 3

THE PROPOSED SYSTEM DESIGN

Due to the performance evaluations of our approach have promising results, SENS has been developed based on this approach. SENS aims to enable people in the community to notify the emergency cases easily and without loss of time when an emergency case occurred, and to ensure that emergency responders receive reliable, accurate and explanatory emergency case notifications. SENS contains three modules which are the Android application "SENSdroid", the PHP-based Web application "WebSENS" and the PHP-based software agent (notifier script) "NotiSENS". Figure 3 shows the components (containing the modules as well) and communication network of the system.

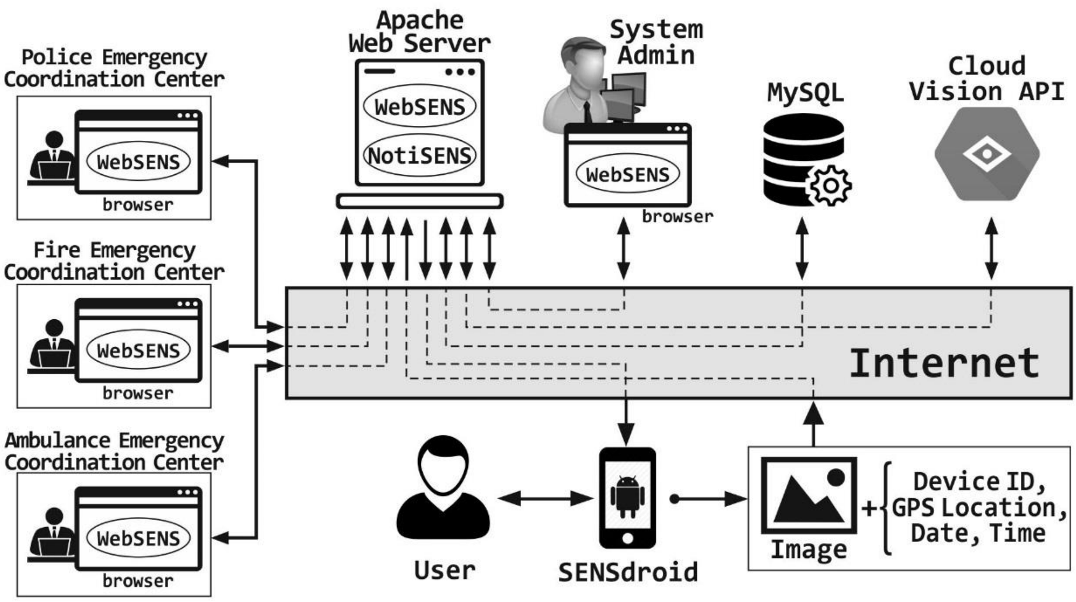


Figure 3. System architecture of SENS.

The system receives its input data from people in community who want to notify an emergency case to the relevant emergency responder(s). To do that, SENSdroid allows people to capture the emergency case's image and send it to the system. The captured image is sent with other information such that device ID (unique IMEI number associated with the GSM smartphone), GPS location and date & time on the device. All this information sent from SENSdroid is received by NotiSENS and processed to make a decision on the emergency case type to notify related emergency responder(s). NotiSENS uses the proposed approach for the detection and decision making. SENSdroid also receives a response from NotiSENS about whether the notification has been processed successfully or unsuccessfully and displays it. On the other hand, WebSENS allows emergency responders to reach these emergency notifications that contain accurate, reliable and explanatory information.

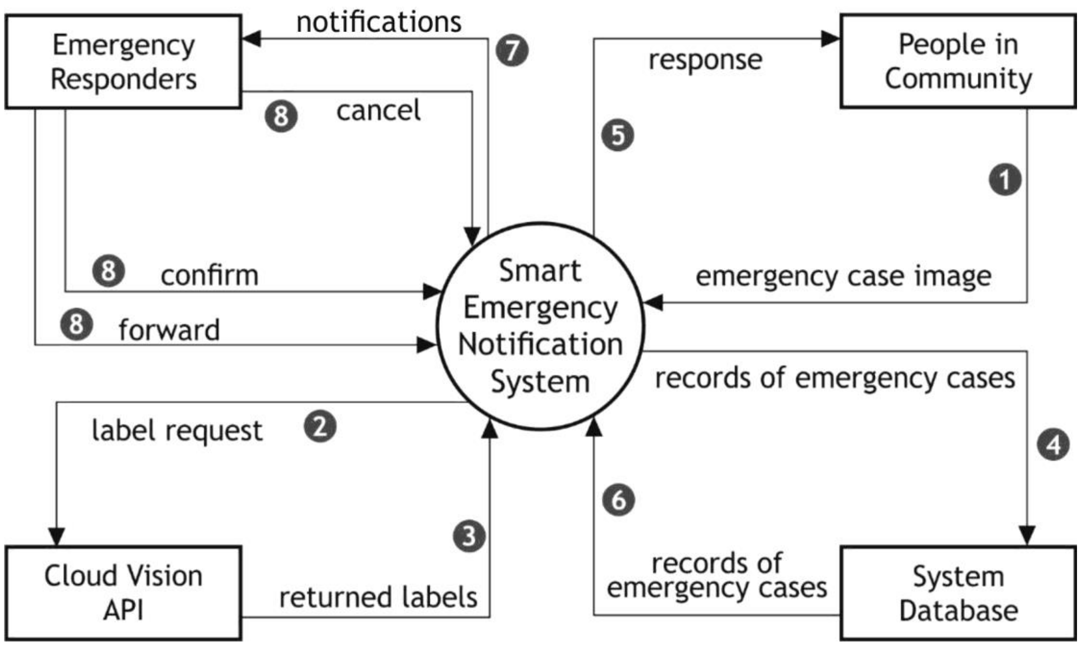


Figure 4. Context diagram of the system.

The elements of the system and the information exchange between these elements are shown in Figure 4. It represents the data stream for each notification and the numbers on the figure indicates the order of the processes. The same number used for several operations indicates the processes that can be done simultaneously. The details of these processes will be given in further sections.

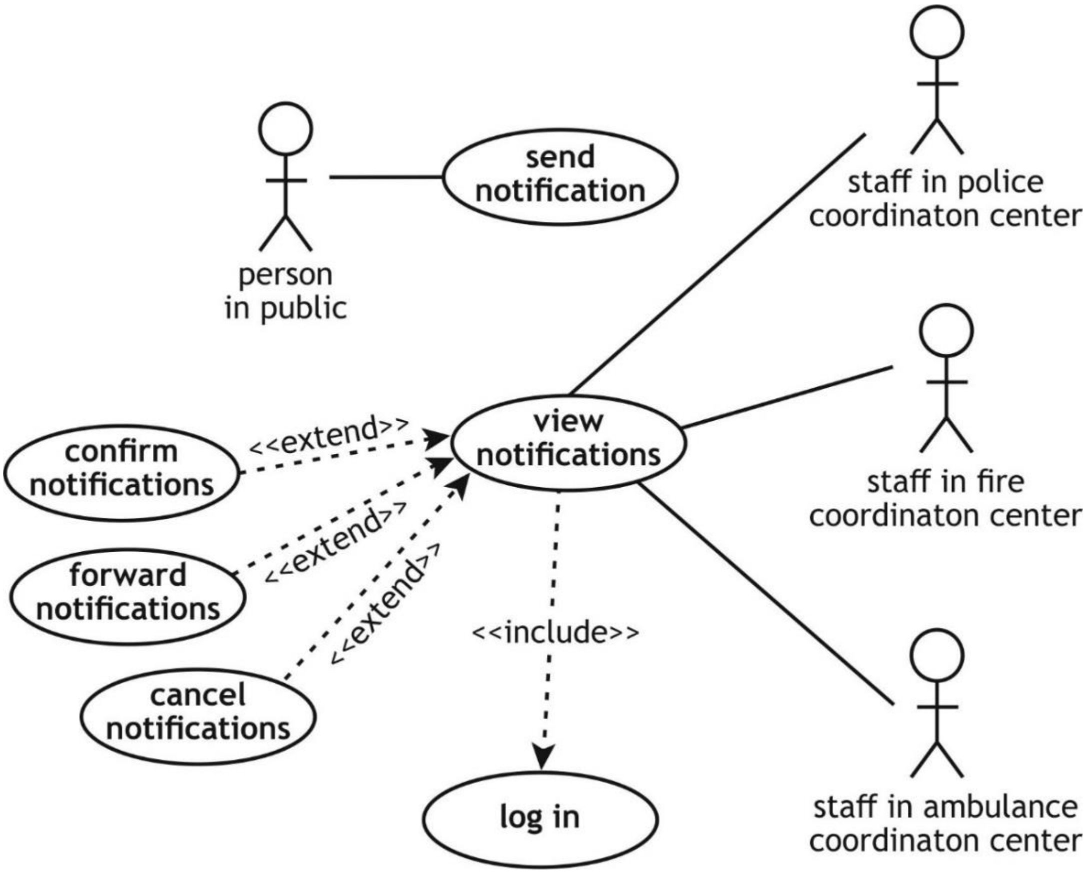


Figure 5. Use case diagram of the system.

Each user of the system such that SENSdroid user and WebSENS user has different use cases. For instance, the staff who has duty on emergency coordination centers can cancel, forward or confirm a notification other than viewing them in detail. Each coordination center can view the notifications that were sent by NotiSENS or forwarded from another coordination center. However the staff must be log in to WebSENS by a username and password. The Figure 5 shows the interactions of users and the different use cases that associated with the users.

SENS runs over Internet and its modules also communicates over Internet. The data that they processed/used is stored in a database. The following sub-sections contains the details of the modules SENSdroid, NotiSENS and WebSENS and the design of the database which used by the system.

3.1 The Android Application: SENSdroid

SENSdroid is a mobile application that to be used by community in case of emergencies to be able to inform emergency responders. It is developed for Android phones to ensure that it can be used by a large number of people in the community. Furthermore, it is designed with the necessity of having an easy to use application to ensure that an emergency case is easily notified without losing time. It also removes the duration spent for calling the emergency responders.

SENSdroid is used to capture an image of an emergency case and send the image with device ID (unique IMEI number associated with the GSM smartphone), GPS location and date & time on the device to NotiSENS. It also receives the response from NotiSENS about whether the notification has been processed successfully or unsuccessfully and displays it.

SENSdroid is coded with Java on Android Studio by targeting the latest Android version 9 (API Level 28). However, it can run on devices which has minimum Android version 5.0 (API Level 21).

3.2 The Software Agent: NotiSENS

A software agent may be a program or code script that acts as a user or program, performs the defined tasks automatically, and has artificial intelligence. The system has a software agent called NotiSENS to receive and process input data from SENSdroid and make a decision. The input data that is processed by NotiSENS is a single image file. Also, input data contains some other information such as the location or device ID, but they are unprocessed and has no effect on decision making. The working mechanism of the NotiSENS is presented with details in Figure 6.

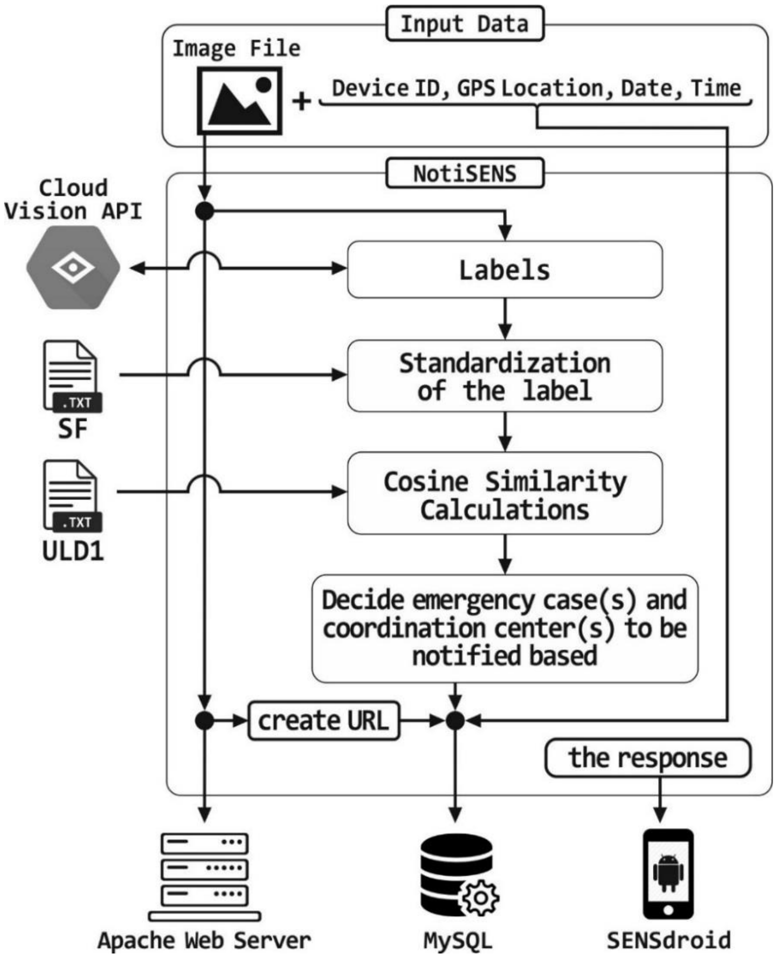


Figure 6. Working mechanism of NotiSENS.

NotiSENS uses past experiences and learnings from the proposed approach and makes a decision on input data based on these experiences. Past experiences are the characteristics of emergency case types that were obtained during the training phase of the proposed approach. These experiences are used by the NotiSENS to be able to decide the future inputs consists of an image.

NotiSENS is a code script which was written using PHP version 7.0 and it is compiled by Apache version 2.4.37 that runs on a Linux-based server. It uses HTTP post method to be able to receive input data and uses NlpTools library [24] for tokenization and cosine similarity calculations. Once an input receives to NotiSENS, it handles all incoming data and sends a requests to the Cloud Vision API for the corresponding image. After obtaining the labels associated with the corresponding image, these labels are standardized by using SF, as in the "Forming the Label Documents" phase of the approach. Then it measures the cosine similarity between the standardized labels and ULD1 (which was obtained from the approach) as in the "Testing the Performance" section. Afterwards, the image is being categorized as "Accident", "Fire", "Injury", "Accident&Fire", "Accident&Injury", "Fire&Injury" or "Accident&Fire&Injury" based on the threshold values which were obtained as given in the "Determination of Threshold Values" section and the cosine similarity scores. These categories are the possible decisions of NotiSENS that represent the emergency case(s) regarding to an image. NotiSENS also decides the emergency coordination center(s) to be notified by using the determined emergency case(s). NotiSENS stores the image on the Web server and records a notification that consists of URL of the image, ID of the device that sent the notification, GPS location, date & time on the device that sent the notification, date & time that NotiSENS received the notification and to-be-notified center(s) into database. URL of the image is kept in database instead of the image itself and the image is kept in the Web server, in order to make the proposed system to operate faster. Note that NotiSENS also responds to SENSdroid by the message that indicates that whether the notification has been processed successfully or unsuccessfully.

3.3 The Web Application: WebSENS

WebSENS is a Web application that was coded using PHP version 7.0 and it complied by Apache version 2.4.37 that runs on a Linux-based server. It requires a domain name and Web hosting service in order to be accessible. WebSENS has interfaces which can be accessed over a Web browser and allows users to view, manage and edit the pre-defined records in the system database.

Every emergency coordination center uses WebSENS to see notifications regarding to the corresponding center in descending order based on date & time that NotiSENS received notification. Every notification will be shown with the following information in WebSENS: The image (downloaded by using URL of the image), GPS location, date & time on the device that sent the notification, date & time that NotiSENS received the notification, notified emergency coordination center(s) and (if any) unnotified emergency coordination center(s) (determined by using to-be-notified center(s)). Although our system naturally reduces the number of false alarms, it is still possible. Only SENSdroid user can create a false alarm. When a false alarm is created, NotiSENS produce a Notification with Faulty Decision on To-Be-Notified Center(s) (NFDTBNC). Even there is no false alarm, NotiSENS still has possibility to create a NFDTBNC. WebSENS may produce a NFDTBNC when there is a false alarm or not. In WebSENS, a confirmation mechanism for notifications had been formed to be used by WebSENS users. However, in order to be able to overcome possible NFDTBNC caused by both NotiSENS and WebSENS users, this mechanism has been improved to be also fault-tolerant. For this, cancel and forward operations as also added into the mechanism. The final improved mechanism is called Confirm-Forward-Cancel (CFC) mechanism. It works on WebSENS and can be used by WebSENS user. With this mechanism, the WebSENS user in coordination center can do one of the followings for a notification: just confirm for the center; confirm for the center and forward to another related center; cancel for the center and forward to another related center; or just cancel. When a notification is forwarded, the center that the notification is forwarded sees the notification with WebSENS. Note that a forwarded notification may be forwarded again by the corresponding center's user. When a notification was reached to one or two centers other than police emergency coordination center and cancelled by the corresponding center(s), the notification will be shown by police emergency coordination center with WebSENS just in case. For cancel and forward operations, WebSENS updates to-be-notified center(s) for the corresponding notification in the database

Additionally, WebSENS has another interface for administrator that allows to do the operations such as monitoring system and user actions, editing threshold values and displaying all emergency cases.

3.4 The System Database

All the data that processed or used by the system is stored in a database. Since the system communicates and runs over Internet, the database is also stored on a Web server. For the designing of the system database; first, second, third and Boyce-Codd normal forms (NF) [25] were considered for the construction of a relational database. The database was created by using phpMyAdmin that works on a Linux server and the database server is MariaDB version 10.2.19. The entity-relationship (ER) diagram is shown in Figure 7. It describes the data relationships in the database which used by the system.

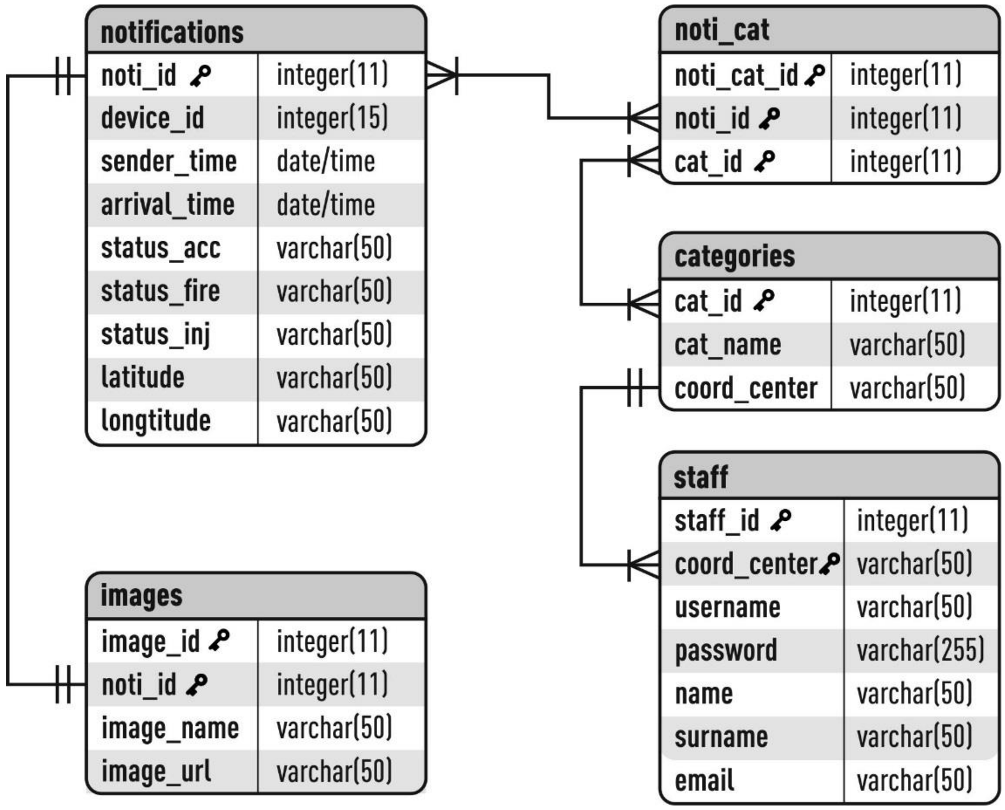


Figure 7. The entity-relationship diagram of the database.

The database consists of five tables in total which are “notifications”, “categories”, “images”, “noti_cat” and “staff”. The following set of tables which composes the data dictionary of the system defines all data objects in the system database with their details.

Table 4. Data dictionary of the images table.

images

Entity name	**Data Type**	**Length**	**Constraint**	**Description**
image_id	integer	11	Primary key	Auto generated record number
noti_id	integer	11	Foreign key	ID of the notification that image belongs
image_name	string	50	not null	A unique image name
image_url	string	50	not null	The path of the folder that contains the image

The images table contains the information related with images of the emergency case notifications. This information in this table is the URL, name, and the notification which the image belongs for each image as shown in Table 4. It has one primary key and one foreign key. Foreign key references the “noti_id” in the notification table.

Table 5. Data dictionary of notifications table.

notifications				
Entity name	**Data Type**	**Length**	**Constraint**	**Description**
noti_id	integer	11	Primary key	Auto generated record number
device_id	integer	15	not null	The IMEI number of the smartphone that sends notification
sender_time	datetime		not null	The date and time that smartphone sends the notification
arrival_time	datetime		not null	The date and time that the system receives the notification
status_acc	string	50	not null	The status of the notification in the police coordination center
status_fire	string	50	not null	The status of the notification in the fire coordination center
status_inj	string	50	not null	The status of the notification in the ambulance coordination center
latitude	string	50	not null	The latitude of the location which emergency happened
longitude	string	50	not null	The longitude of the location which emergency happened

The notifications table contains the information such as the device ID, date & time, location and detected emergency case type which are belong to a notification. Its details are given in Table 5. It has one primary key which is an auto incremented number that was defined for identification of each notification.

Table 6. Data dictionary of the categories table.

categories				
Entity name	**Data Type**	**Length**	**Constraint**	**Description**
cat_id	integer	11	Primary key	Auto generated record number
cat_name	string	50	not null	The type of the emergency case
coord_name	string	50	unique	The coordination center name associated to the emergency case type

As shown in Table 6, the categories table contains the name of the emergency case category's as well as the emergency coordination center's name. It stores the information that which coordination center(s) will be notified for each case.

Table 7. Data dictionary of the noti_cat table.

noti_cat				
Entity name	**Data Type**	**Length**	**Constraint**	**Description**
noti_cat_id	integer	11	Primary key	Auto generated record number
cat_id	integer	50	Foreign key	ID of the category that notification belongs
noti_id	integer	50	Foreign key	ID of the notification belong to a category

Since there is a many-to-many relation between coordination centers and emergency cases, existence of the noti_cat table becomes required. Many-to-many relation means that each coordination center may have one or more notifications, and each notification may belong one or more coordination centers. As shown in Table 7, it has one primary key and two foreign keys. The column "cat_id" references the categories table and column "noti_id" references the notifications table.

Table 8. Data dictionary of the staff table.

staff				
Entity name	**Data Type**	**Length**	**Constraint**	**Description**
staff_id	integer	11	Primary key	Auto generated record number
coord_center	string	50	Foreign Key	The coordination center name that staff works
username	string	50	unique	A unique noun represents person
password	string	255	not null	Special keyword defined by user and decrypted by system to enter to the system
name	string	50	not null	Name of the staff
surname	string	50	not null	Surname of the staff
email	string	50	not null	E-mail address of the staff

And finally, the staff table contains the information for each staff works in each coordination center. This table contains personal information such as name, surname or password as shown in Table 8. These information are required for the validation of the staff to log in to the system.

Chapter 4

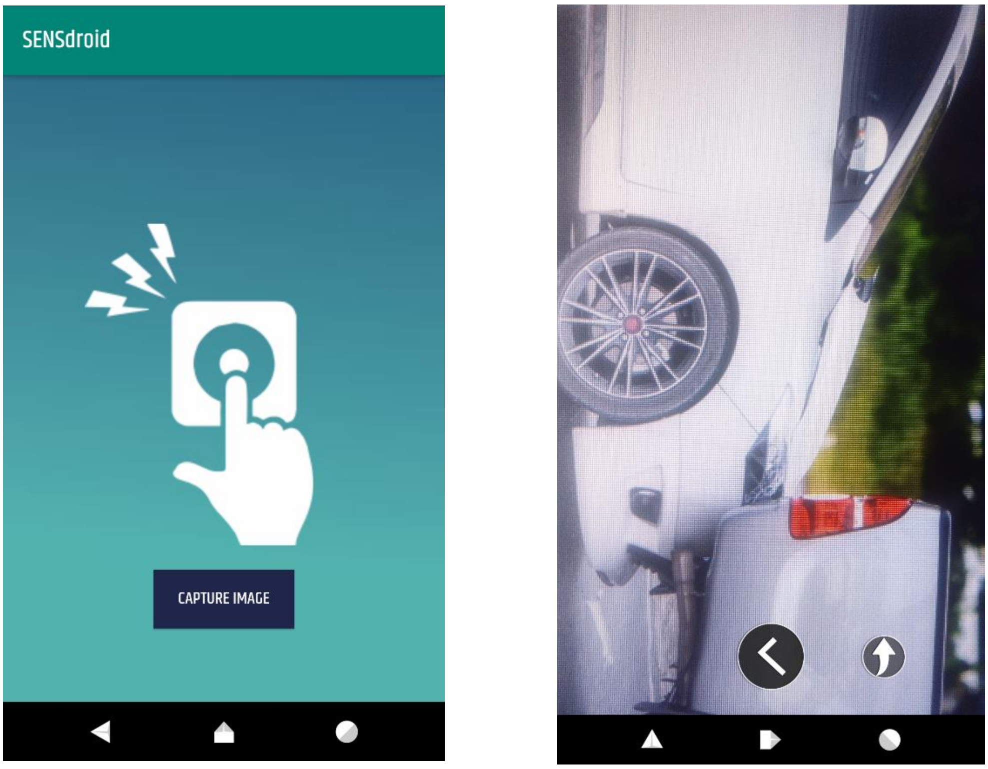
IMPLEMENTATION

The modules of the system were implemented in two different platforms such that Android and Web. Only WebSENS and SENSdroid have interfaces but no interface is required for NotiSENS. The following subsections present the implementations of each module SENSdroid and WebSENS by describing usage and the interfaces of these modules that users can see.

4.1 SENSdroid

SENSdroid has two activities (Android application screens) such that home activity and upload activity. It was designed to be easy and fast to use. As shown in Figure 8(a), home activity has only one button which is for opening the camera to capture an image. When user presses on “Capture Image” button, the camera is opened as shown in Figure 8(b), if device supports.

When the user confirms the captured image by pressing tick icon on the camera screen as in Figure 8(b), the upload activity is opened. This activity is for uploading the captured image (with other required information mentioned above -this is not visible for the user-) to the server by pressing the “Send Notification” button as shown in Figure 9(a). The progress bar on this activity shows that how many percentage of the image is uploaded. The duration of the upload process can be changed according to the Internet connection speed of the smartphone. When uploading process finished, NotiSENS receives the image file and other information. This activity also receives the response that sent from NotiSENS (after the image processed) and displays the message as shown in Figure 9(b).

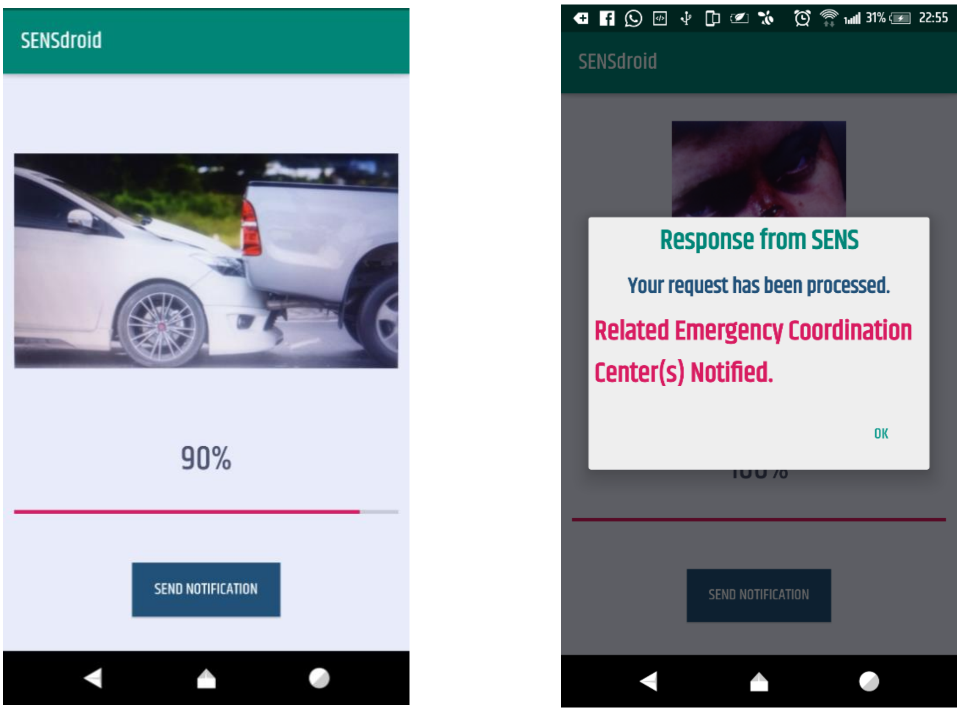


(a) (b)

Figure 8. SENSdroid's home and camera activities.

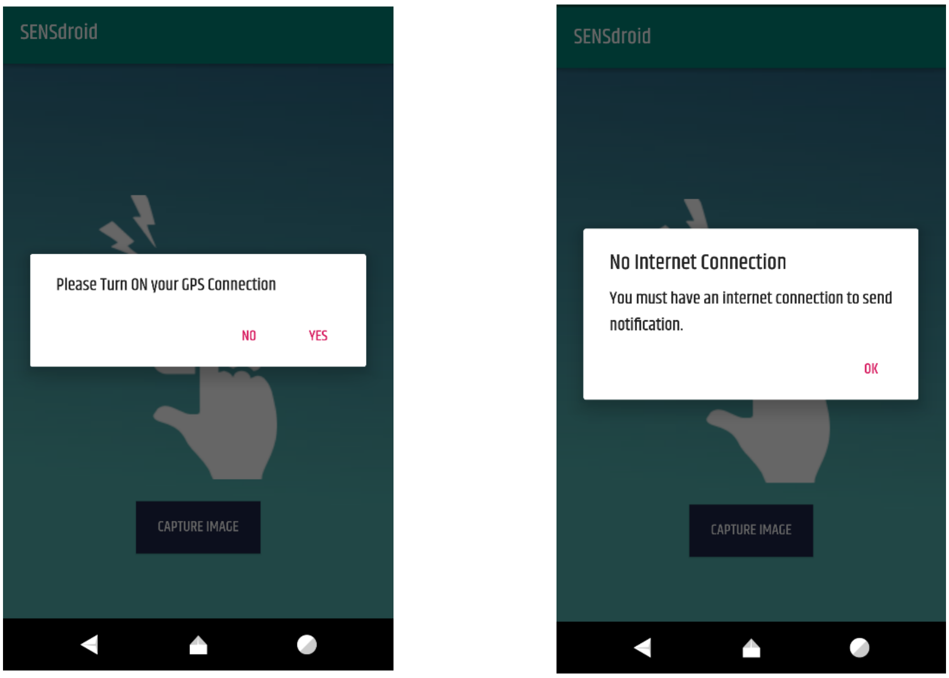
In order to be able to do capturing image and uploading processes, SENSdroid requires Internet service and storage usage permissions that must be given by the smartphone user when installing the application to the smartphone. Permissions for accessing GPS location and device ID are also required. These are also asked while installing the application. Besides that, if location service of the smartphone is not turned on, SENSdroid displays a message that asks to the user for this service to be turned on as in Figure 10(a). If the user presses “Yes” button, it refers the user to the related settings of the smartphone. Similarly, if smartphone is not connected to the Internet, user cannot open camera activity (Figure 10(b)). The user must have the Internet services

(Wi-Fi connection or cellular network which can access Internet) to be able to send notifications.



(a) (b)

Figure 9. SENSdroid's upload activity.

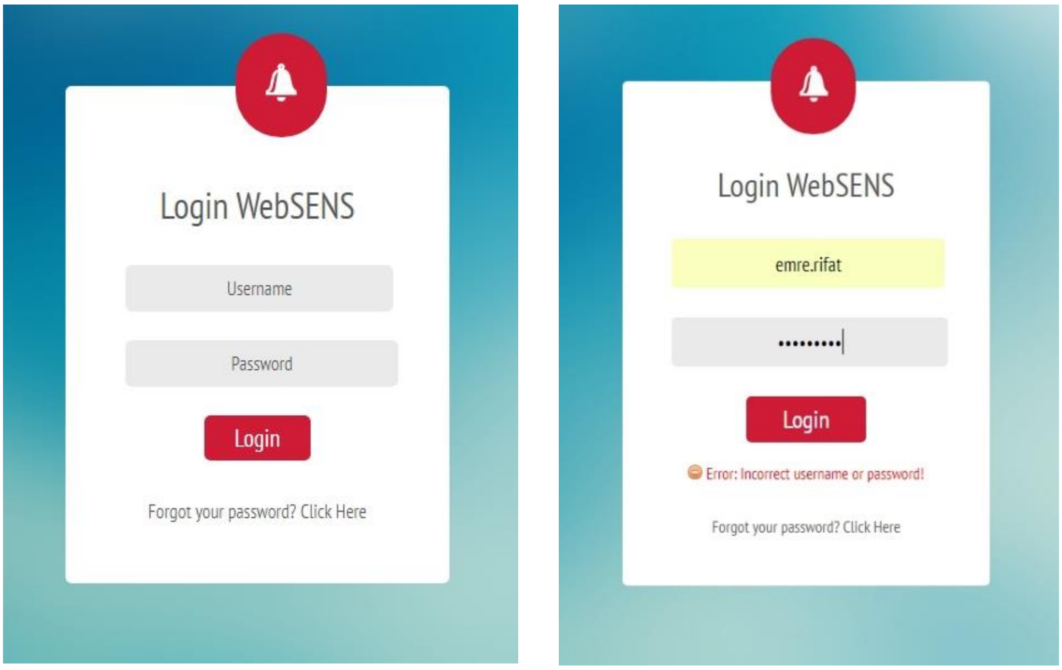


(a) (b)

Figure 10. Required phone services to be turned on.

4.2 WebSENS

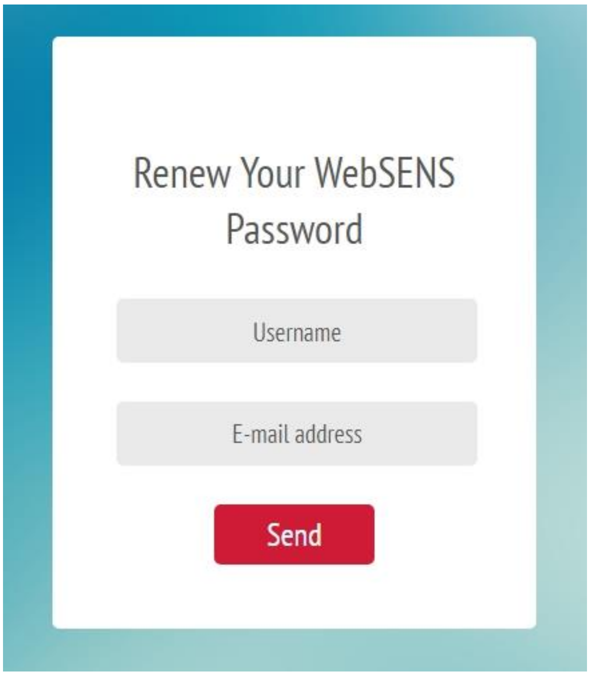
Each emergency coordination center uses WebSENS to monitor the emergency case notifications associated with corresponding center. To be able to access the graphical user interface of WebSENS, a login page is used validate the user by username and password as shown in Figure 11. If the username or password is incorrect, the users are faced with a warning message as shown in Figure 11(b) and they cannot access the system unless entering correct username and password.

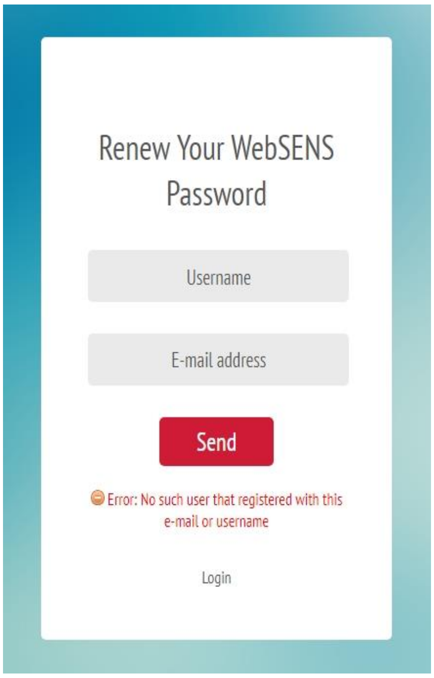


(a) (b)

Figure 11. Login page of WebSENS.

If users forget their passwords, they can access the randomly created new password assigned by the system by entering their username and e-mail address that registered in the system. The web page is shown in Figure 12(a) is accessed by clicking the "Forgot your password? Click Here" link which is shown in Figure 11. As shown in Figure 12(a), when a registered e-mail address is entered to the required field, the system sends the new password to this e-mail address, otherwise a message will be displayed indicating that the username or e-mail address is not registered to the system as shown in Figure 12 (b). If both the username and password are correct, the users can access one of the page that are shown in Figure 13(a), (b) or (c) depending on the coordination center they belong to.

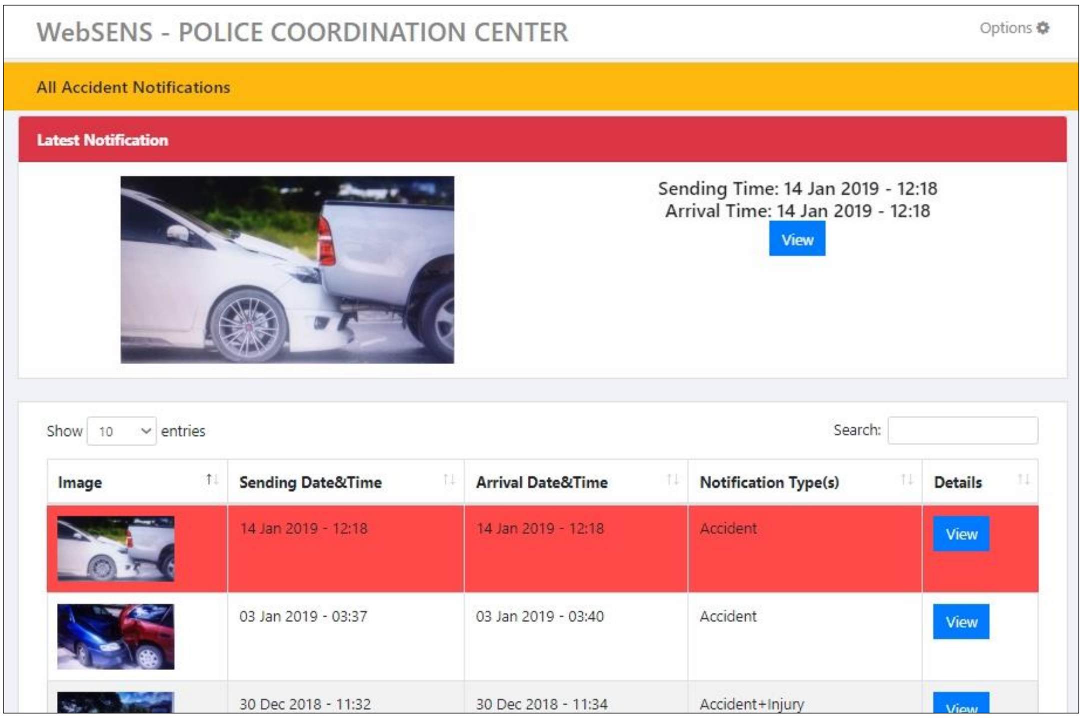




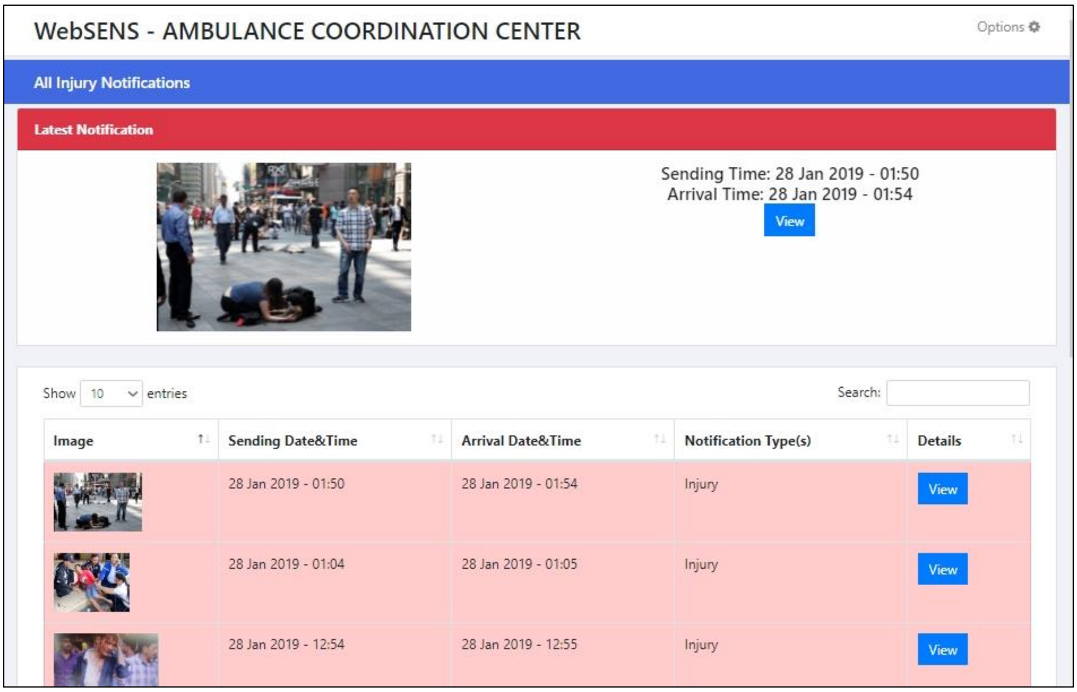
(a) (b)

Figure 12. Forgotten password renew page.

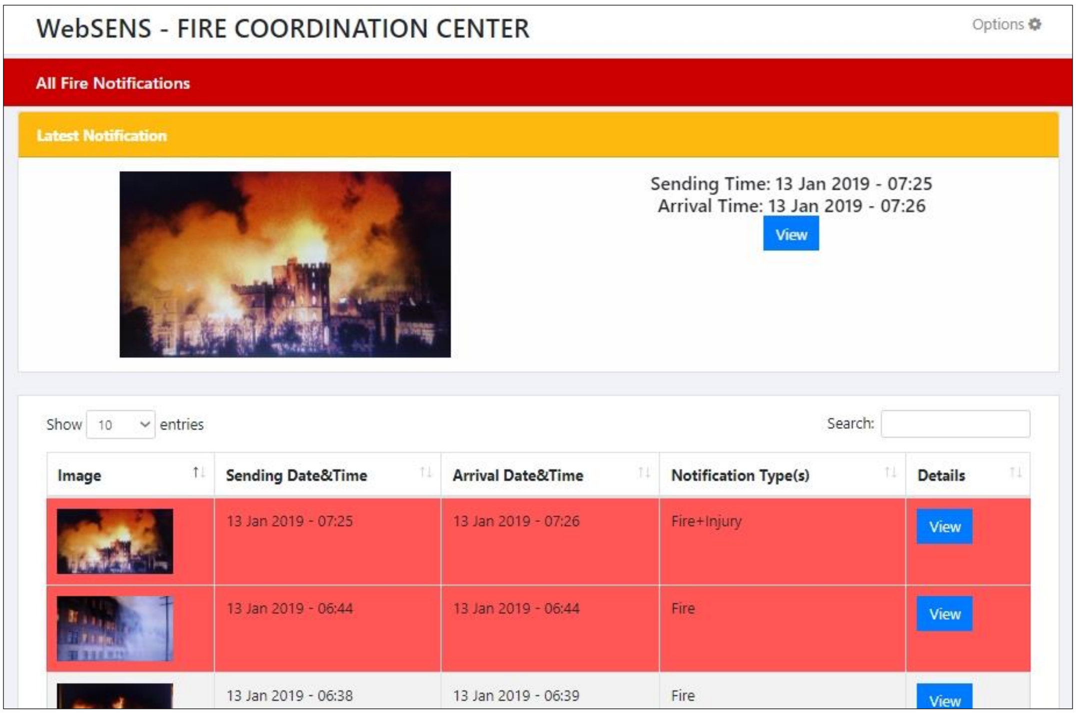
In Figure 13, the interfaces of police (Figure 13(a)), ambulance (Figure 13(b)) and fire (Figure 13(c)) coordination centers are presented. A dynamic table has been placed on this page that enables ordering, paging or searching actions. WebSENS displays the last arrived notification at top of the page and the dynamic table of notifications.


WebSENS - POLICE COORDINATION CENTER
Options
All Accident Notifications
Latest Notification
Sending Time: 14 Jan 2019 - 12:18
Arrival Time: 14 Jan 2019 - 12:18
View
Show 10 entries
Search:
Image
Sending Date&Time
Arrival Date&Time
Notification Type(s)
Details
14 Jan 2019 - 12:18
14 Jan 2019 - 12:18
Accident
View
03 Jan 2019 - 03:37
03 Jan 2019 - 03:40
Accident
View
30 Dec 2018 - 11:32
30 Dec 2018 - 11:34
Accident+Injury

(a)


WebSENS - AMBULANCE COORDINATION CENTER
Options
All Injury Notifications
Latest Notification
Sending Time: 28 Jan 2019 - 01:50
Arrival Time: 28 Jan 2019 - 01:54
View
Show 10 entries
Search:
Image
Sending Date&Time
Arrival Date&Time
Notification Type(s)
Details
28 Jan 2019 - 01:50
28 Jan 2019 - 01:54
Injury
View
28 Jan 2019 - 01:04
28 Jan 2019 - 01:05
Injury
View
28 Jan 2019 - 12:54
28 Jan 2019 - 12:55
Injury
View

(b)



(c)

Figure 13. Home pages of emergency coordination centers.

In the dynamic tables on Figure 13, notifications are ordered as descending based on date & time that NotiSENS received notification. The recently arrived and unseen notifications blink and are shown at the top of the table (Figure 13(a), (b) and (c)). Each notification can be monitored more detailed on a modal window (Figure 14(b)) by clicking the corresponding “View” button on Figure 13. On the modal window, the larger image of corresponding emergency case, the notified and unnotified coordination centers, sending and arrival times and the GPS location of the emergency case are shown. In this modal window CFC mechanism can also be used.

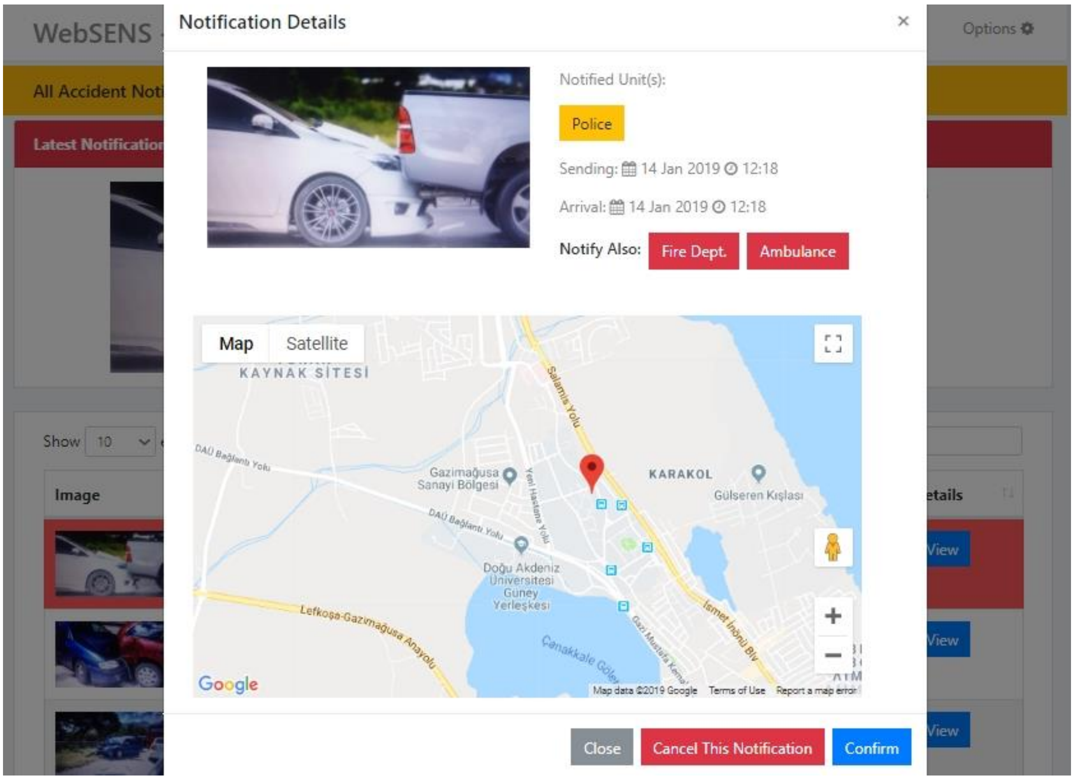


Figure 14. Monitoring a notification in details.

The WebSENS user can cancel the notification if he/she thinks it is an unrelated notification to the coordination center by clicking the “Cancel The Notification” button. When this button clicked, a modal windows appears (Figure 15) and asks the user for confirmation. If this modal window confirmed and the notification is cancelled by all coordination centers the corresponding notification automatically referred to the police coordination center (if the corresponding center is not police coordination center) and does not be listed in the dynamic table of corresponding coordination center.

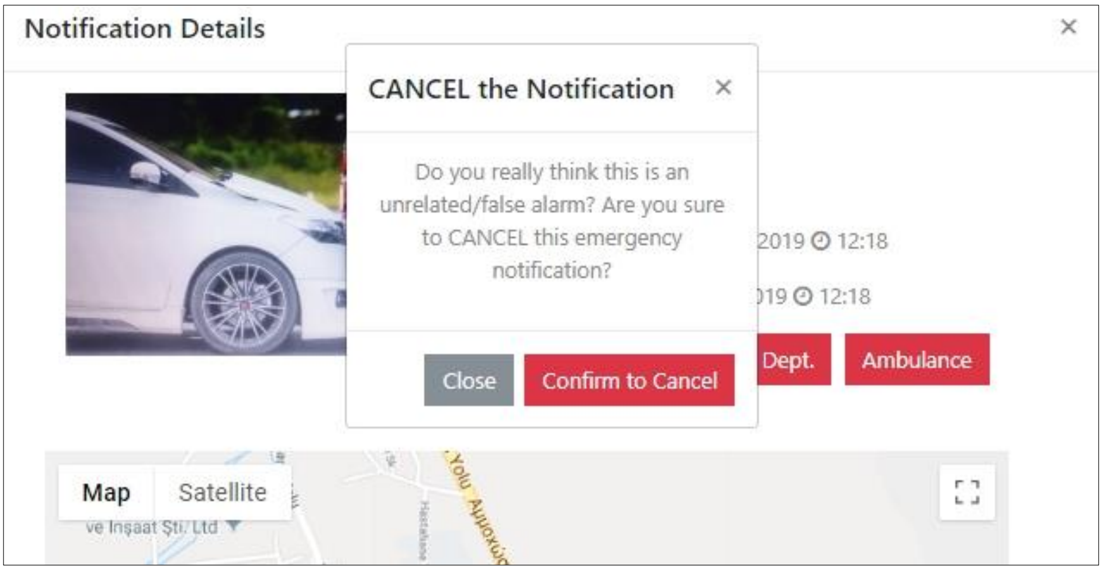


Figure 15. Cancelling a notification.

The notifications can also be forwarded to another unnotified coordination center(s) by clicking the corresponding button(s) placed next to "Notify Also" label on the modal window as shown in Figure 13. Forwarding process also asked to the user by a modal window for confirmation as in Figure 16.

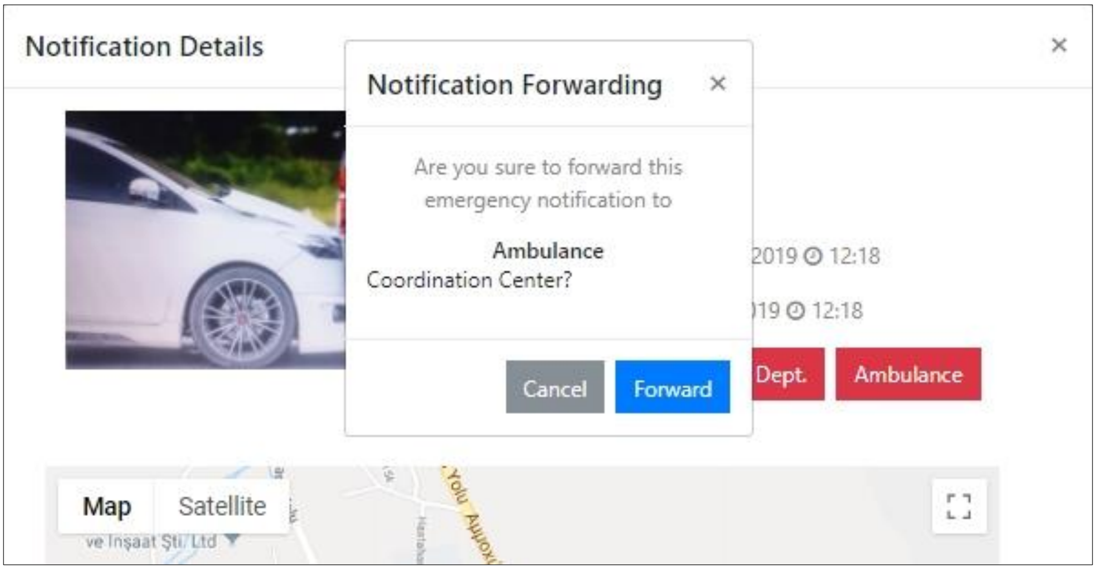


Figure 16. Forwarding a notification.

Other than cancelling and forwarding a notification, the user can also confirm the notifications by clicking "Confirm" button (Figure 14) as shown in Figure 17.

Confirming means, the corresponding notification is related to the coordination center and emergency responders will intervene the emergency case.

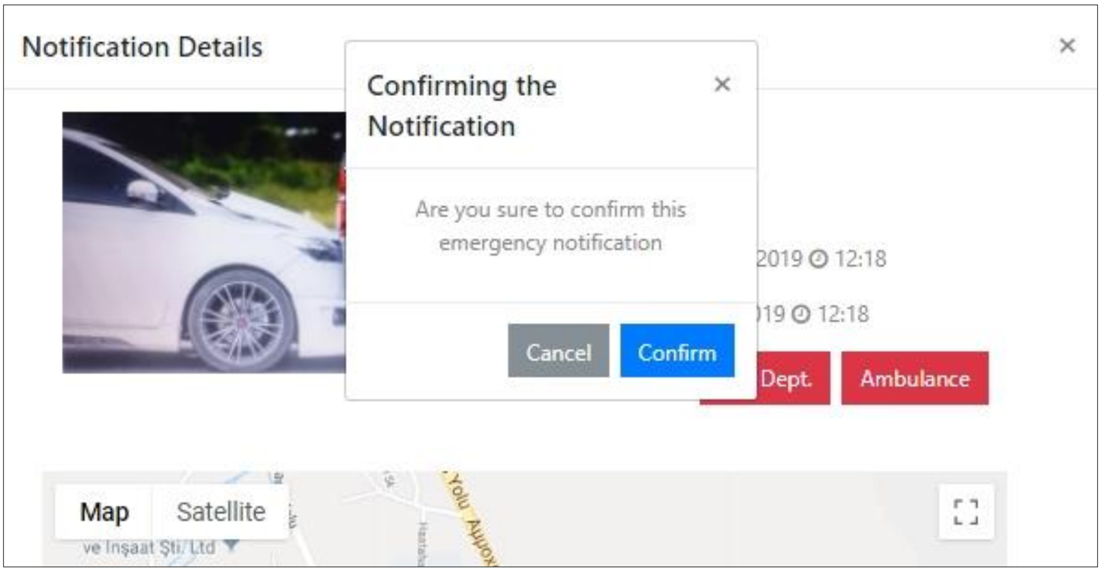


Figure 17. Confirming a notification.

Chapter 5

CONCLUSION AND FUTURE WORK

An approach has been proposed to be able to automatically detect the emergency cases road accident, fire and injury. This approach uses machine learning and data mining techniques with Cloud Vision API service of Google to detect the emergency case(s) on images. Since promising results were obtained from this approach with the accuracy of 88%, SENS has been developed based on this approach to be used by the emergency responders and community. This proposed system detects the single/multiple emergency case(s), i.e. road accident, fire and injury, automatically from the image sent by a smartphone via Internet and then, notifies the corresponding emergency responder(s), i.e. police, fire brigade and ambulance. SENS has three modules which are the mobile application SENSdroid, the Web application WebSENS and the software agent NotiSENS. NotiSENS uses the proposed approach. WebSENS module has also fault-tolerant improved-mechanism named Confirm-Forward-Cancel (CFC) mechanism which can overcome possible notifications that have faulty decision on to-be-notified emergency responder(s).

SENS delivers reliable, accurate and explanatory information to the responders, naturally prevents false alarms such as misdials and prank calls as much as possible and removes the duration spent for calling. All these would have positive effect on helping the harmed person, supporting the staff on duty, protecting the person who can be harmed and/or saving the nature. Furthermore, this system would has high usability because of its easy-to-use features and high rates of smartphone and Internet users. As a result, it is believed that SENS could be an efficient and useful system.

As future works; the system could be improved to detect more emergency case types with additional responders, to capture multiple images for a notification in order to be able to make more accurate decisions, to be able to capture video and use it for a notification and to be able to detect spoofed image(s) in a notification. In addition to these, iOS version of the mobile application would be developed.

REFERENCES

[1] Road traffic accidents. (2018, December 7). Retrieved Dec 20, 2018 from https://www.who.int/en/news-room/fact-sheets/detail/road-traffic-injuries

[2] International Association of Fire and Rescue Services. (2017). World Fire Statistics. [PDF File]. Center of Fire Statistics. Retrieved Dec 17, 2018 from https://www.ctif.org/sites/default/files/ctif_report22_world_fire_statistics_2017.pdf

[3] Gonzalez, J. (2012, May 09). City flooded with nearly 4 million inadvertent 911 calls on cell phones a year. New York Daily News. Retrieved Dec 27, 2018 from https://www.nydailynews.com/new-york/city-flooded-4-million-inadvertent-911-calls-cell-phones-year-article-1.1074752?barcprox=true

[4] European Emergency Number Association. (2011). False emergency calls [PDF file]. Retrieved Dec 12, 2018 from https://eena.org/wp-content/uploads/2018/11/False-Emergency-Calls.pdf

[5] Ahrens, M. (2004). False alarms and unwanted activations from US experience with smoke alarms and other fire detection/alarm equipment. [PDF file]. *National Fire Protection Association*. Retrieved Dec 26, 2018 from http://www.homefrontalarms.com/downloads/research/005.pdf

[6] Evanco, W. M. (1996). *The impact of rapid incident detection on freeway accident fatalities*. McLean, VA: Mitretek.

[7] Amin, M. S., Jalil, J., & Reaz, M. B. I. (2012, May). Accident detection and reporting system using GPS, GPRS and GSM technology. In *2012 International Conference on Informatics, Electronics & Vision (ICIEV),* (pp. 640-643). IEEE.

[8] Khan, A., Bibi, F., Dilshad, M., Ahmed, S., Ullah, Z. and Ali, H. (2018). Accident detection and smart rescue system using Android smartphone with real-time location tracking. *International Journal of Advanced Computer Science and Applications, 9*(6), pp. 341-355.

[9] Ali, H., Alwan, Z. (2015). Car accident detection and notification system using smartphone. *International Journal of Computer Science and Mobile Computing. 4*(4), pp. 620-635.

[10] Patel, K.H. (2013). Utilizing the emergence of android smartphones for public welfare by providing advance accident detection and remedy by 108 ambulances. *International Journal of Advanced Research Trends in Engineering and Technology (IJARTET), 2*(9), pp. 1340-1342.

[11] White, J., Thompson, C., Turner, H., Dougherty, B., & Schmidt, D. C. (2011). Wreckwatch: Automatic traffic accident detection and notification with smartphones. *Mobile Networks and Applications, 16*(3), pp. 285-303.

[12] Sowah, R. A., Ofoli, A. R., Krakani, S. N., & Fiawoo, S. Y. (2017). Hardware design and Web-based communication modules of a real-time multisensor fire detection and notification system using fuzzy logic. *IEEE Transactions on Industry Applications, 53*(1), pp. 559-566.

[13] Derbel, F. (2003, March). Reliable wireless communication for fire detection systems in commercial and residential areas. In *Wireless Communications and Networking, 2003. WCNC 2003. 2003 IEEE* (Vol. 1, pp. 654-659). IEEE.

[14] Sowah, R., Ampadu, K. O., Ofoli, A., Koumadi, K., Mills, G. A., & Nortey, J. (2016, October). Design and implementation of a fire detection and control system for automobiles using fuzzy logic. In *Industry Applications Society Annual Meeting, 2016 IEEE* (pp. 1-8). IEEE.

[15] Costa, S. E. P., Rodrigues, J. J. P. C., Silva, B. M. C., Isento, J. N., Corchado, J. M. (2015). Integration of wearable solutions in AAL environments with mobility support. *Journal of Medical Systems, 39*(12), pp. 184-191

[16] Otto, J., Milenković, A., Sanders, C., Jovanov, E. (2006). System architecture of a wireless body area sensor network for ubiquitous health monitoring. *Journal of Mobile Multimedia, 1*(4), pp. 307-326.

[17] Abdellatif, A. A., Emam, A., Chiasserini, C. F., Mohamed, A., Jaoua, A., Ward, R. (2019). Edge-based compression and classification for smart healthcare systems: Concept, implementation and evaluation. *Expert Systems with Applications, 117*, pp. 1-14.

[18] Monares, A., Ochoa, S., Santos, R., Orozco, J., Meseguer, R. (2014). Modeling IoT-based solutions using human-centric wireless sensor networks. *Sensors, 14*(9), pp. 15687-15713.

[19] Nikolic, V., Savic, S., Stankovic, M. (2007). Designing a multimedia platform for emergency management. *Management of Environmental Quality: An International Journal*, *18*(2), pp. 198-210.

[20] Kemp, S. (2018, January 30). Digital in 2018: World's Internet users pass the 4 billion mark. Retrieved Dec 27, 2018 from https://wearesocial.com/blog/2018/01/global-digital-report-2018

[21] Worldwide Internet and mobile users: eMarketer's updated estimates and forecast for 2017–2021. (2017, December 1). Retrieved Jan 4, 2019 from https://www.emarketer.com/Report/Worldwide-Internet-Mobile-Users-eMarketers-Updated-Estimates-Forecast-20172021/2002147

[22] Search engine market share worldwide. (n.d.). Retrieved 4 Jan, 2019 from http://gs.statcounter.com/search-engine-market-share

[23] Google, Inc. (2017, May 18). AI & Machine Learning Products: Label Detection. [Cloud Service] San Francisco, CA.

[24] NlpTools. (2016, November 3). Natural language processing in php. [Software Library]. Retrieved Dec 11, 2018 from http://php-nlp-tools.com

[25] Elmasri, R., & Navathe, S. B. (2014). *Fundamentals of database systems* (7th ed.). Retrieved Jan 12, 2019, from http://lms.uop.edu.jo/lms/pluginfile.php/124872/mod_resource/content/0/fundamentals-of-database-systems-7th.pdf