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Automatic Accident Detection System Using IoT Compared to the Systems that a Traffic Centre Uses for Accident Detection

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Abstract

In recent years, vehicle traffic has become a major issue with a significant increase in the number of vehicles, leading to congestion on urban roads and motorways. This has resulted in an increase in accidents, causing more injuries and fatalities. There are many steps in managing an accident, it can be said assuring that one of the most important steps is the rapid detection of the incident and its exact location. Quick and accurate information enables emergency services to act quickly at the incident location and reduce their response times. This paper tries to compare the automatic accident detection system with traditional traffic center systems and analyze the importance of implementing this system to reduce accident detection times and accurately detect their location. The detection of the accident time and its location are crucial links in the accident management chain.

Keywords: Traffic Safety; Accident Detection; Repsonse times;Accidnet Management; Emergency Services

1. Introduction

Nowadays, there is an increase in the number of accidents that happen in the world. As the population grows, so do the number of cars on the roads, leading to daily serious severe accidents. Around 80% of accidents contribute to

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the loss of many lives. Mostly, the growing countries are being targeted by day-to-day road accidents [3]. The major reason is the lack of infrastructure, lack of traffic control and accident management. Out of all the developing countries, India has been listed as the country with a higher number of accidents [1]. The main reason for the loss of a life during an accident is the unavailability of immediate help that can save a person's life in a few seconds. The moment an accident occurs, the life of all passengers travelling in the vehicle is at stake. It all depends on the response time that can save their lives by a few minutes or seconds. According to the statistics, reducing accident delay time by even 1 minute can save 6 per cent of lives. Hence, this response time is very crucial, and it needs to be reduced or at least improved to save their lives [2]. To contribute to our society and reduce the number of accidents happening in our day-to-day life, there are several techniques and mechanisms that can drop down the rate of accidents and can save lots of lives. Living in a tech world that is growing day by day with new technologies, we can apply these techniques in our society and help them overcome such problems [3].

Traditionally, traffic incidents came to be known in only a few different ways, the most common being reports from other drivers via phone emergency numbers, such as 122 [9]. Other methods included receiving notice by police or other officials or notice by traffic center operators via closed-circuit television (CCTV) monitoring [4]. The advent of ITS (intelligent transportation systems) technologies, such as traffic detectors, paved the way for the development of AIDs (automatic incident detection). Traffic detectors are installed on motorways to measure traffic characteristics, such as flow, speed, and occupancy. These data served as the traditional source of data for automatic incident detection algorithms. One common approach for detecting incidents from point-based traffic data is to compare and analyze traffic stream characteristics obtained from detectors both upstream and downstream of a motorway segment [9]. One disadvantage of this method is that the exact location of an incident often cannot be determined [5]. If the link lengths are short or the detectors are closely spaced, then the approximate location of the incident can be known. However, a dense deployment of detectors is expensive, not only in capital costs but also in maintenance costs [6]. In addition to point-based sensor data, link travel times obtained from automatic vehicle identification (AVI) [7] and automatic vehicle location (AVL) [8] have been utilized to develop automatic incident detection methods.

Preventing an accident is important, however it is very difficult, if not impossible to provide an accident-free road vehicle transportation system. Even though it may not be possible to avoid accidents altogether, early detection of and reaction to accidents are very important in saving lives and reducing accident-related costs [10].

2. Literature Review

Concerning the automatic accident detection system, in very simple words, the main objective is to control accidents by sending a message to the registered mobile numbers, and especially to the emergency services. When an accident occurs in a city or on the motorway, then a message is sent to a registered phone number, in less time, including information about the location of the accident.

Reading the literature, we found different implementations of the automatic accident detection system. Aishwarya et al [11] presented a novel IoT system for the prevention and the tracking of accidents for night drivers. They also provide an eye blink monitoring system which alerts the subject while it is in a state of drowsiness. Sadhana [12] explained that a smart helmet and intelligent safety mechanism for motorcyclist can be implemented by using the raspberry pi and an open CV. A major idea has been obtained after knowing that there is an increased number of fatal road accidents over the years. Their work has been designed and introduced as safety mechanisms for the motorcyclist to wear the helmet properly [20].

Namrata H. Sane et al [13] explained that an advanced embedded system of vehicle accident detection and tracking system. The main objective of their system is to first detect the accident location and call for the emergency services. Vehicle accident detection is possible with the help of sensors. A GPS and GSM module helps to trace the vehicle. Shailesh Bhavthankar and Sayyed [14] explained wireless system for vehicle accident detection and reporting using GSM. Jagdish A. Patel [15] explained Raspberry Pi based smart home.

An IoT based vehicle tracking and accident detection system has been introduced in E Krishna Priya et al [16] for avoiding road accidents. According to Arun Francis G, et al [17], an IoT based accident identification and alerting system has been proposed for alerting the drivers. In Harish Kumar N and Deepak G system [18], an accident detection and an intelligent agent-based navigation system for avoiding accident by using IoT. Finally, in S. Suganya

et al system [20], a new tracking system for avoiding vehicle collision detection and messaging system by using devices such as GPS and GSM [20].

3. Motivation of the Study

For the last 14 years working at the management centre of the Aegean Motorway in Greece, each year the centre manages more than 15,000 incidents [21]. According to the internal statistics, of these approximately 4-6% are traffic accidents and more than 40% are incidents that may cause a traffic accident (stray animals, obstacles etc.).

One of the major problems is that many accidents which occur in the road and lead to injuries or even death, happen because of not being reported at the correct time. If an accident has been detected and reported on time, giving accurate information about it, life of many people can be saved, and secondary accidents can be avoided.

4. Study Area

4.1. Aegean Motorway - Greece

Aegean Motorway has its registered seat in Larissa (Moschochori, Post Code 41500); where the main administration offices and the motorway management centre are also located. There are two operation and maintenance centres along the motorway, (in Moschochori and Leptokarya) as well as two technical bases, (in Korinos and Drymonas). The main network of toll stations along the length of the main axle includes five (5) frontal toll stations at Pelasgia, Moschochori, Makrychori, Leptokarya and Kleidi [21].

The “Maliakos-Kleidi” section (Fig. 1) crosses 3 Regions (Sterea Ellada, Thessaly and Central Makedonia), 5 prefectures (Fthiotida, Magnesia, Larissa, Pieria and Imathia) and 12 municipalities (Stylida, Almyros, Volos, Rigas Ferraios, Killeler, Tempi, Agia, Dion-Olympus, Katerini, Pydna-Kolindros and Alexandreia) [21].

The Aegean Motorway expands over 230 km of motorway (each direction), 34 km of old national road and 11.8 km of twin tunnels (the T2 tunnel is the longest tunnel in the Balkans) [21]. It operates throughout the year, on a 24/7 basis, providing drivers with a high level of service during their journeys.

4.2. Aegean Motorway - Traffic Data

In Table 1 we report a traffic data summary for the last three years. In 2020 there was an annual average of daily traffic of 8.587 vehicles consisting of 6.087 light vehicles and 2.500 heavy vehicles. In 2021 we see an increase of 12.5% on annual average daily traffic with 9.665 vehicles. Regarding the light vehicles we see an increase of 12.6% with 6.854 vehicles and an increase of 12.1% with 2.811 heavy vehicles [21]. Finally, in 2022 we see an increase of 46.6% in total annual average daily traffic compared to 2020. Regarding light vehicles we see an increase of 52.1% with 9.263 light vehicles and an increase of 33.2% with 3.332 heavy vehicles [21].

Table 1. Aegean Motorway Traffic Data

Year	Total Annual Average Daily Traffic	Annual Average Daily Traffic-Light Vehicles	Annual Average Daily Traffic - Heavy Vehicles	Vehicle Kilometers Travelled ($10^{\wedge 6}$ veh-km travelled)
2020	8.587	6.087	2.500	829
2021	9.665	6.854	2.811	930
2022	12.594	9.263	3.332	1.071

4.3. Aegean Motorway - Incident Data

Table 2 presents the report on incident data for the last three years. To be able to better record all the incidents, there is a categorization of them. The categories are for immobilized vehicles, obstacles, animals, and all other events in the last category [24]. The last category includes incidents with adverse weather conditions, inverse direction vehicles etc. In 2020, due to the decreased traffic because of the coronavirus, we managed only 12.551

incidents with 397 accidents, 4.895 immobilized vehicles, 1.502 incidents with obstacles, 2.190 incidents involving animals and in the last category we had 3.567 incidents. In 2021 and 2022 there was an increase of 24.5% on the incidents because of the increased traffic. Looking all the categories for the last two years we see that the numbers in almost all categories are the same with slight differences, except the accidents which will be analyzed in the next paragraph [21].

Table 2. Aegean Motorway Incident Data

Year	Total Number of Incidents	Accidents	Immobilized Vehicles	Obstacle on the Pavement	Animal	Other Incidents
2020	12.551	397	4.895	1.502	2.190	3.567
2021	15.636	587	5.587	2.080	2.627	4.755
2022	15.582	642	5.795	2.145	2.773	4.227

4.4. Aegean Motorway - Accidents Data

In Table 3 are reported Accidents data for the last three years. In 2020 from a total of 12.551 incidents, 397 accidents were reported, out of which 39 were accidents with casualties and 358 material damages only accidents. Of the 39 casualties' accidents, only 4 were fatal accidents and the rest 35 were with injuries [21].

Table 3. Aegean Motorway Accidents Data

Year	Total Number of Incidents	Accidents	Accidents with Casualties	Material Damages Only	Accidents with Injuries	Accidents with Fatalities
2020	12.551	397	39	358	35	4
2021	15.636	587	51	536	47	4
2022	15.582	642	41	601	38	3

In 2021 there was an increase of 47.8% in accidents due to the increased traffic on the motorway. Of a total of 15.636 incidents, 587 were accidents, whereas only 51 were accidents with casualties and the rest 536 material damages only accidents [21]. Of the 51 casualties' accidents, only 4 were fatal accidents and the rest 38 were accidents with injuries. The most recent data, in 2022 shows an increase of 9.3% in accidents compared to 2021. Of a total of 15.582 incidents, 642 were stated as accidents, whereas only 41 were accidents with casualties and the rest 601 material damages only accidents. Out of the 41 casualties' accidents, only 3 were fatal accidents and the rest 38 resulted in injuries. Although there was an increase of almost 10% in total accidents there was a reduction in accidents with casualties [21].

4.5. Aegean Motorway – Accidents Detection and Notification

Accidents' detection and notification are important procedures in the chain called accident management. At Aegean Motorway two are the main sources of accident detection:

- Human Source (company staff, road users etc.)
- Various Systems

In Table 4 we present all the ways that the motorway management center (MMC) of Aegean Motorway can be informed about an incident. Before dwelling into analysis, we need to mention that in 2020 the network coverage from traffic monitoring was 67% and from 2021 until nowadays this percentage increased by 4% leading to 71%. Regarding ERTs (emergency road telephones), they are positioned every 2,5 kilometers across the motorway in each direction [21].

Table 4. Aegean Motorway Detection and Notification Sources

		Incidents Detected By				
Year	Total Number of Incidents	Patrol/Company Staff	Emergency Four Digit Number	ERT	CCTV & AID	Police & Road Assistance
2020	12.551	4.915	3.674	114	2.416	1.432
2021	15.636	5.930	4.424	83	3.669	1.530
2022	15.582	5.771	4.771	65	3.206	1.769

In 2020, from a total of 12.551 incidents, 4.915 incidents detected by patrol/ company staff, 3.674 by the emergency four-digit number, 114 detected by ERTs, 2.416 by CCTV (closed circuit television) & AID (automatic incident detection) and the rest of 1.432 by police and road assistance [21]. In 2021, from a total of 15.636 incidents, 5.930 incidents detected by patrol/ company staff, 4.414 by the emergency four-digit number, 83 detected by ERTs, 3.669 by CCTV & AID and the rest of 1.530 by police and road assistance [21]. Finally, in 2022, from a total of 15.582 incidents, 5.771 incidents detected by patrol/ company staff, 4.771 by the emergency four-digit number, 65 detected by ERTs, 3.206 by CCTV & AID and the rest of 1.769 by police and road assistance [21]. In 2021 and 2022 we see an increase between 32% and 51% on incidents detected by the CCTV & AID because of the increase of the CCTV coverage.

Although there are different ways in incident detection, as it is mentioned before, two are the main categories, human source, and systems. In Fig. 2 we tried to separate human sources and systems to have a clearer picture about the ways the MMC (motorway management center) got informed about an incident. In 2020, from a total of 12.551 incidents, 10.021 incidents detected by human source including the patrol/ company staff, the emergency four-digit number where road users call and inform about an incident and police & road assistance. Only 2.530 incidents have been detected by a system, including ERT and CCTV & AID [21]. In 2021, from a total of 15.636 incidents, 11.884 incidents detected by human source including the patrol/ company staff, the emergency four-digit number where road users call and inform about an incident and police & road assistance. Only 3.752 incidents have been detected by a system, including ERT and CCTV & AID. [21] Finally, in 2022, from a total of 15.582 incidents, 12.311 incidents detected by human source including the patrol/ company staff, the emergency four-digit number where road users call and inform about an incident and police & road assistance. Only 3.271 incidents have been detected by the system, including ERT and CCTV & AID [21]. ERTs are also included in the category of systems, although to detect an event someone must call from a specific phone. The major difference here compared to the four-digit number is that in case someone calls from ERTs, can automatically be detected by the system, something that is not applicable on emergency four-digit number call [21].

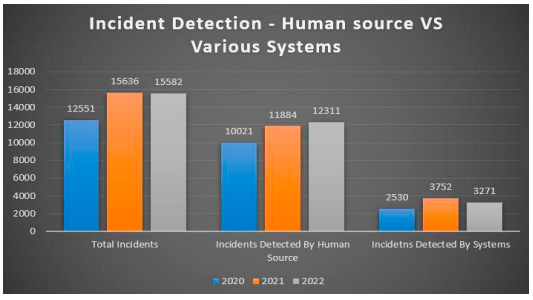

Fig. 1. Incident Detection Sources Comparison

In general, it can be stated that in 2020 79.8% of incidents were detected by human sources while only 20.2% were detected by the systems using the Aegean Motorway. In 2021 76% of incidents detected by human source while 24% detected by the systems. We see an increase in systems detection since we had an increase on CCTV coverage increase by 4%. Finally, in 2022 79% of incidents were detected by human sources while 21% detected by the systems.

5. Comparison Between Automatic Accident Detection System and MMC detection sources

The significance of accident detection and notification systems is very prominent for our society. The most important advantages of this technology are shown below:

- There is efficient consumption of time
- It reduces the possibility of human error
- There is great accuracy and immediate information
- The life of the victim involved in the accident, can be saved quickly [22]

At Aegean Motorway, two are the main sources of accident detection and both analyzed in previous paragraph. In this paragraph we will focus on human sources since all systems can instantly detect an incident. The most important disadvantages regarding the human source are shown below:

- Inaccurate information about the incident location
- Delay in calling to inform about an incident

These two factors play a significant role in the progress of an incident and due to the delay or inaccurate information, the response times of the emergency services become quite long without such good results. According to the observations of the research conducted by Mahama M. N. et. al. [23], a response time less than 17 minutes was associated with 95% survival.

In terms of systems, the main disadvantage is that there is not 100% network coverage. It is understood that the information from the systems is immediate and accurate, it is simply not possible to cover the entire network, at least as far as the Aegean Motorway is concerned.

5.1. Aegean Motorway Incident Detection Times

In this paragraph we will identify and analyze the time it takes to detect an event from all sources other than systems, using the Aegean Motorway raw data. To be able to calculate the incident detection time we just abstract the incident start time from the incident record time. These two time periods could be different. For instance, there is a chance that we will be informed about an incident much later than its start time [21].

Looking at Fig. 2, we notice three different time values for the last three years. We see the detection mean time, the maximum and minimum detection times. The mean detection time, ranges from 2.69 minutes up to 3.21 minutes. The specific range of values suggests that the human source incident detection is not very high. Looking at the maximum detection mean times we observe long time periods until the motorway management center gets informed about an incident. More specifically, mean detection time ranges from 13.23 minutes up to 14.68 minutes. Parenthetically, the above values represent detection of traffic congestion incidents. Finally, we see the minimum detection mean time ranges from 1.12 up to 1.5 minutes. Contemplating on this it is arguable that these are generally acceptable ranges, although there is always place for improvement.

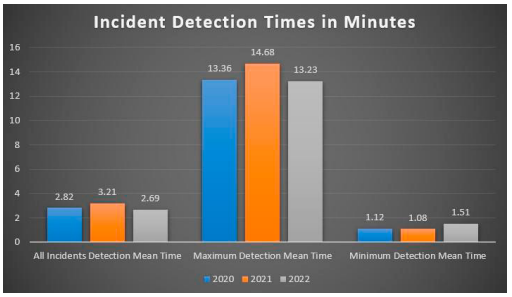

Fig. 2. Incident Detection Time Values

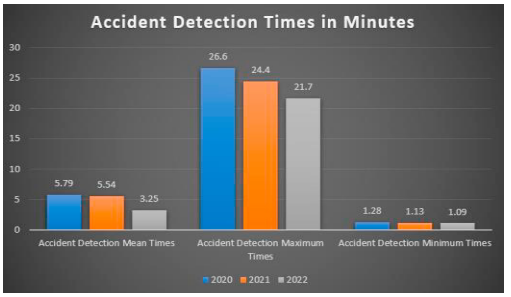

Fig. 3. Accident Detection Time Values

Specifically, we will focus on Fig. 3, namely on accident detection times. Firstly, we observe the accident detection means time values for each year. In 2020 the data show a mean time of 5.79 minutes which implies that the motorway management center is informed about traffic accidents on average after 5.79 minutes. In 2021 we see a mean time of 5.54 minutes and finally in 2022 there is a reduction of the accident detection mean time of around 2.5 minutes.

Regarding accident detection maximum times it is noticeable that in some traffic accidents there was a very long delay in informing the traffic center. In 2020 data show a detection time of 26.6 minutes what indicates that in case of an accident with serious injuries, the chances of survival would be very low. In 2021 the detection time was 24.4 minutes and in 2022 a reduction of about 3 minutes is present. The specific times are very high, especially when we refer to traffic accidents. Lastly, observing the minimum accident detection time values, we see that the time intervals are relatively short.

However, observing the maximum detection times, we can clearly notice that there is a problem. This leads to questioning the reason behind the long response time which often implies one of the following:

- In the night hours there is less vehicle traffic, so the notification of an incident will take time to reach the control center
- Incident location without CCTV coverage and low traffic
- Reduced sense of responsibility by motorway users
- It has been observed, in several incidents, that even the drivers involved in the incident do not inform the control centre [21] [24]

6. Conclusions

In this research, we compare automatic accident detection systems with systems that inform a traffic center of incidents on the motorway. The incident detection in terms of systems is immediate and accurate, providing precise location information. However, when it comes to notifying personnel and emergency services, there may be a delay until the traffic control center is informed. The motorway management center's incident detection systems cannot cover the entire network completely due to the costly implementation. Moreover, the personnel responsible for motorway control and emergency services do not have sufficient staff to continuously monitor the entire network During our analysis of Aegean Motorway data, we noticed that the average notification times for incidents are quite lengthy. Particularly in the case of traffic accidents, these delays can have severe consequences if there are serious injuries involved. Prolonged notification times are also led to delayed response times for emergency services and increase the likelihood of secondary accidents.

The article further highlights the significant problem of delayed incident notification and the associated issues it creates. Implementing automatic accident detection systems is essential to mitigate these problems by reducing incident management delays and improving emergency services response times. Shorter response time directly translates to increased chances of survival for the injured. By utilizing such a system, we can significantly enhance the survival rates of injured road users, decrease the severity of injuries, reduce fatalities, and mitigate the occurrence of secondary accidents.

Through the analysis conducted with the data received from Aegean Motorway, we noticed several fluctuations in terms of meantime and notification to response time. The findings of the study suggest that there are specific issues and reasons behind the response rates. Accident detection time and accident location detection are crucial links in the accident management chain, and therefore highlight the need and the importance of automatic accident detection systems.

Due to the above, we believe that a system for early notification of accidents should be created, but which will provide additional information for passengers, e.g. number of passengers, type of vehicle, and perhaps information on the health of the patients, so that all emergency services have available from the first moment, all the information they need to better deal with the accident.

References

[1] Andrea Z and Lorenzo V., “Internet of Things for Smart Cities,” *IEEE Internet of Things Journal*, vol/issue: 1(1), Feb 2014.

[2] Isna K. and S. D. Sawant, “Integration of Cloud Computing and Internet of Things,” *International Journal of Advanced Research in Computer and Communication Engineering*, vol/issue: 5(4), Apr 2016.

[3] Shivani S. and Shoney S., “IoT Based Car Accident Detection and Notification Algorithm for General Road Accidents”, *International Journal of electrical and Computer Engineering (IJECE),* vol: 9, Oct 2019, pp. 4020-4026

[4] Thomas, S.S.; Gupta, S.; Subramanian, V.K. Event Detection on Roads Using Perceptual Video Summarization. IEEE Trans. Intell. Transp. Syst. 2018, 19, 2944–2954.

[5] Zhang, Z. “Traffic Event Detection from Consumer Vehicle Sensor Data: An Autonomous Vehicle Study”. Transp. Res. Rec. 2022.

[6] Ta, V.T.; Dvir, A. A Secure Road Traffic Congestion Detection and Notification Concept Based on V2I Communications. Veh. Common. 2020, 25, 100283.

[7] Bhaskar, A.; Chung, E. Fundamental Understanding on the Use of Bluetooth Scanner as a Complementary Transport Data. Transp. Res. Part C Emerg. Technol. 2013, 37, 42–72.

Saunders, Harry (2009) “Theoretical Foundations of the Rebound Effect”', in Joanne Evans and Lester Hunt (eds) *International Handbook on the Economics of Energy*, Cheltenham, Edward Elgar

[8] D’Andrea, E.; Marcelloni, F. Detection of Traffic Congestion and Incidents from GPS Trace Analysis. Expert Syst. Appl. 2017, 73, 43–56.

[9] Zhang K. and Kianfar J. “An Automatic Incident Detection Method for a Vehicle -to-Infrastructure Communication Environment: Case Study of Interstate 64 in Missouri”, Sensors 2022, 22, 9197. https:// doi.org/10.3390/s22239197

[10] Ozbayoglu M., Kucukayan G., Dogdu E., “A Real-Time Autonomous Highway Accident Detection Model Based on Big Data Processing and Computational Intelligence”, *Institute of Electrical and Electronics Engineers*, doi: 10.1109/BigData.2016.7840798, Feb 2017

[11] Aishwarya S.R, Ashish Rai, Charitha, Prasanth M.A,and Savitha S.C “An IoT based vehicle accident prevention and tracking System for night drivers” , International Journal of Innovative Research in Computer and Communication Engineering, vol.3,no.4, pp.3493-3499, 2015

[12] Shabrin, Bhagyashree Jagadish Nikharge, Maithri M Poojary, T Pooja, Sadhana B,, “Smart helmetintelligentsafety for motorcyclist using raspberry pi and open CV”, International Research Journal of Engineering and Technology (IRJET), Vol.3, No.3, pp. 589-593, 2016

[13] Namrata H. Sane, Damini S. Patil, Snehal D. Thakare, Aditi V. Rokade, "Real Time Vehicle Accident Detection and Tracking Using GPS and GSM", International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 4, No. 4, pp. 479-482, 2016

[14] Shailesh Bhavthankar, H.G.Sayyed, "Wireless System for Vehicle Accident Detection and Reporting using Accelerometer and GPS", International Journal of Scientific & Engineering Research, Vol. 6, No. 8, pp. 1069-1072, 2015

[15] Jagdish A. Patel, Aringale Shubhangi, Shweta Joshi,Aarti Pawar and Namrata Bari, “Raspberry Pi based smart home”, Proc. IEEE, vol.6, no.3, pp.2321-2361, 2016

[16] E Krishna Priya, P Manju, V Mythra, S Umamaheswari, "IoT Based Vehicle Tracking and Accident Detection System", International Journal of Innovative Research in Computer and Communication Engineering, Vol.5, No.3, pp. 4424-4430, 2017

[17] Arun Francis G, Dharani S K, Manikandan P, Monica R J, Vaishahi S K, "IOT based Accident Identification and Alerting System", International Journal of Pure and Applied Mathematics, Vol. 118 No. 20, pp. 547-551, 2018

[18] Harish Kumar N, Deepak G, "Accident Detection and Intelligent Navigation System for Emergency vehicles in Urban Areas using IoT", International Journal of Engineering and Techniques, Vol. 3, No.6, pp. 330-334, 2017

[19] S.Suganya, T.Divya, M.Subha Sankari, P.Gomathi, "Tracking down the Vehicle Collision Detection and Messaging System using GPS and GSM", International Journal of Engineering Research & Science (IJOER), Vol.4, No.3, pp. 61-66, 2018

[20] Ramasamy J., “An Intelligent Accident Detection Information System Using IoT”, *International Journal of Engineering and Advanced Technology,* ISSN: 2249-8958, vol: 9, Issue: 1, Oct 2019

[21] “Traffic Volume Data (Unpublished Raw Data)’. Aegean Motorway., 2022

[22] Baballe Ahmad M., “Accident Detection and Alerting systems: A Review”, *Global Journal of Research in Engineering and Computer Sciences*, ISSN: 2583-2727, vol: 2, Issue: 4, Aug. 2022

[23] M. -N. Mahama, E. Kenu, D. A. Bandoh, and A. N. Zakariah, ‘Emergency response time and pre-hospital trauma survival rate of the national ambulance service, Greater Accra (January – December 2014)’, *BMC Emerg Med*, vol. 18, no. 1, p. 33, Dec. 2018, doi: 10.1186/s12873-018-0184-3

[24] Natalia Kryvinska, Aneta Poniszewska-Maranda and Michal Gregus “An Approach towards Service System Building for Road Traffic Signs Detection and Recognition”, Procedia Computer Science, Volume 141, 2018, Pages 64-71, ISSN 1877-0509