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Development of Embedded System Software for Emergency Calls on Vehicles

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ABSTRACT

The number of vehicles on the highways increases every year. It is estimated that there are 1,400 billion vehicles on the road today. This number is increasing every day. The increasing number of vehicles has a high potential for traffic accidents. It is known that an average of 1.2 million people die in accidents worldwide every year. In 2020, there were 150,275 traffic accidents with deaths and injuries in Turkey.

In case of traffic accidents, it is important to provide first aid in time after the accident. The location of the accident site determines the time in which the first aid service can be reached. The chance of survival of the injured depends on the timely presence of the first aid team at the scene of the accident. Although the first-aid service teams reached the scene of accidents within the settlement in a very short time, 47.4% of deaths occurred in the settlement in 2020. In the same year, the death rate in accidents outside the settlement was 52.6%. The loss of life is increasing because first aid cannot be provided in time due to the high percentage of accidents outside the settlement.

It is difficult for the injured and unconscious victims to survive for a long time in traffic accidents on the highways outside the abandoned and cliffside settlements. With the developed software, in case of an accident, the vehicle status, license plate number and location information were sent via SMS to the 112 emergency number in Turkey. The embedded system was developed using an Arduino Mega microcontroller and a SIM808 module and the emergency call software was realized.

KEYWORDS: *Embedded system, Accident, Emergency, GSM, GPRS*

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I. INTRODUCTION

Traffic accidents are events that result in property damage or injury on the road and death. There are three important factors in traffic accidents. Driver's error, vehicle malfunction and road defects are effective for the occurrence of accidents. Traffic accidents cause economic losses in Turkey and all over the world. They also cause the loss of human lives. According to the studies of the Turkish Institute of Statistics, a total of 983,808 traffic accidents occurred in Turkey in 2020. 150,275 of these accidents were traffic accidents with deaths and injuries [1].

Today, wireless communication is strengthened not only by the expansion of GSM networks, but also by the increase of mobile communication devices and the growing number of satellite systems. Today, vehicles traveling on the highway can be monitored and even controlled by satellite systems. New generation vehicles have devices that can make calls in the event of an accident. These vehicles are monitored by the manufacturer with a system, and in the event of an accident, the emergency call center is informed. However, there is no requirement to have an emergency call system in pre-2007 models in European Union countries, and in pre-2018 vehicle models in Turkey. For older vehicle models, similar systems that are now used in new generation vehicles are called "black box" solutions. This solution is used in Turkey and Eastern European countries by rental companies and for private purposes. However, these systems are known to be prone to false alarms.

Another approach to emergency call systems is the model of wireless connection between the vehicle and the cell phone. Despite the practicality and low cost of this method, there is a high probability that the cell phone will be damaged in an accident. In addition, the possibility of accessing the vehicle's operating system via the cell phone and the possibility of listening to the occupants' surroundings raises concerns about this option.

In Turkey, the Ministry of Science, Industry and Technology have started studies to make the emergency call system mandatory for cars and light commercial vehicles from 2018. The regulation on this study was published in the Turkish Official Gazette on August 19, 2016, as number 29806 [2]. Since this date, devices that comply with the regulations have been installed in newly produced cars and light commercial vehicles in Turkey. In this study, it is recommended to develop embedded system software for a low-cost emergency call system that can be used in vehicles.

II. METHOD

The embedded system proposed in the study consists of a microcontrol unit, a GSM module, a GPS module, and sensors placed around the vehicle. It is important to ensure that the system is widely available and accessible to everyone. For this reason, a low-cost microcontroller system was chosen. The Arduino Mega that was chosen as the microcontroller system uses the Atmega2560 microcontroller. The recommended board has 54 digital inputs/outputs, 16 analog inputs/outputs, and 4 UART ports [3].

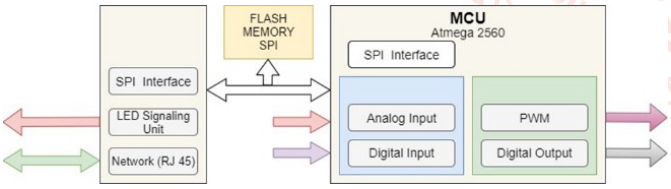

Figure 1. Atmega 2560 Block schema

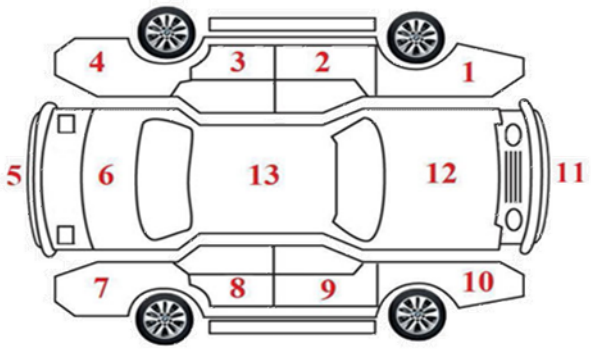

Figure 2. Possible accident points on the vehicle

There are four serial communication interfaces that can be used in the proposed system and fifty-four digital data interfaces that we can use for sensor connections. The proposed study is based on accident report documents issued by insurance companies for the vehicle. The impact sensors are located at 13 accident points specified in the accident reports.

When the impact sensor on the vehicle becomes active in the event of an accident, the microcomputer system to which it is connected triggers the digital interface. After the impact sensors detect the area of the vehicle where the accident occurred, the location of the vehicle is determined by the GPS module. Using the American National Marine Electronics Association (NMEA) data standard, the coordinate information can be retrieved using GPS receivers of various makes and models [4].

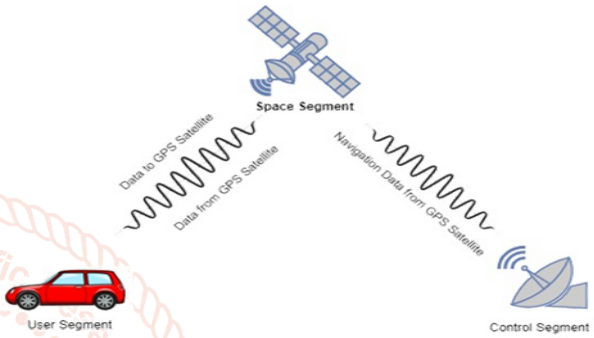

Figure 3. Car Gps System

With this coordinate information, the location can be determined immediately. Since this data is instantaneous, even if the location changes, the data cannot automatically renew itself every second [5]. In this study, the SIM808 module from SIMCom was used. The SIM808 module has a GSM/GPRS module and a Bluetooth module. SIM808 operates on GSM 850MHz, EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz frequencies. It is a module that supports various GSM operators with quad-band support and provides wireless applications and monitoring solutions. This module supports both 6-pin and 8-pin SIM cards.

The developed system tests the GSM and GPS functions by sending AT commands through the serial interface [6]. After determining the location of the GPS module, the Arduino Micro Controller and the GPS module enable the immediate display of the coordinates (latitude, longitude) of the vehicle in the system. This system is similar to the structure used in navigation and vehicle tracking systems [6]. However, the GPS systems we use also have some disadvantages. The systems from GPS may take a long time to display data in closed environments, and the incoming data is not completely smooth. For my data to be fully displayed on the screen, GPS must be used in an open environment [7]. To get the most accurate data in systems to be used in vehicles, the GPS antennas must be positioned to see the sky

through the windows. Detection of location information occurs within 10-15 seconds in open terrain. The module used in the study receives location information in about 10 seconds. However, since the received data is a very long data series, it is necessary to extract the latitude and longitude information from this data [8]. An NMEA record begins with a '$' character and ends with a '$' character. The data is separated by commas. NMEA data is a ASCII text. The content of the data may vary depending on the level of precision [9]. After the detection of the accident site in the vehicle, a message with the commands AT is sent to the emergency service and the owner of the vehicle via the GSM module.

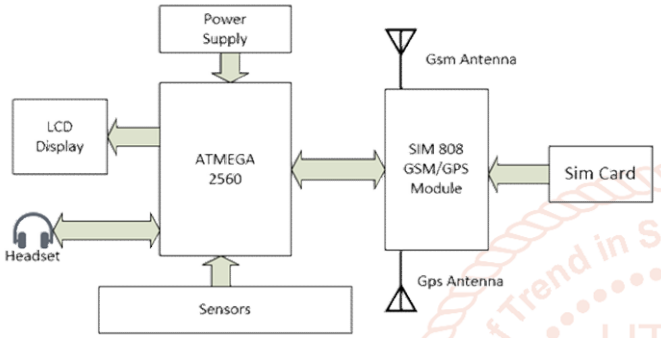

Figure 4. Proposed system architecture

A. Reading the Accident Signal

By placing impact sensors at points on the vehicle where an accident may occur, it can be determined that an accident has occurred. By their nature, these sensors consist of an insulating plate between two conductive plates. In the study, this situation was simulated using a button. The button is normally in the insulating state, and when it is pressed, it changes to the conducting state. For the study, 13 impact sensors are connected to the vehicle and 13 digital inputs in the Arduino system. Thanks to the signal detected at the digital inputs, the system receives the accident signal through the sensor from which the signal originates. The flowchart of the proposed architecture is shown in Figure 5.

B. Triggering the GPS Modulea

In the event of an accident, the GPS module is triggered using the appropriate sensor and location determination begins. During location determination, a lot of data comes from the GPS module. In the study, only longitude and latitude information was taken from the received GPS data and other data was ignored.

C. Sending SMS with GSM Module

After the accident, the longitude, latitude and license plate number of the vehicle involved in the accident, as determined by the GPS module, are sent as an SMS message to the 112 emergency service via AT commands.

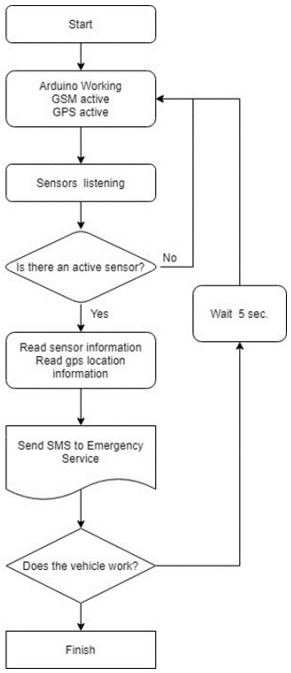

Figure 5. Vehicle Accident Notification System flow chart

III. RELATED WORKS

Numerous studies have already been conducted in this area. Costanzo has implemented real traffic flow monitoring using Arduino-based system GPS [10]. On the other hand, Khin et al. developed a real-time vehicle tracking system using GSM, GPS and web technologies with Arduino [11]. Alshamsi et al. used Arduino Mega for real-time vehicle tracking. It was found that the study will create a security measure for vehicle thefts and accidents. On the other hand, Kim et al. developed a LBS /GPS-based bicycle security application using Arduino [12]. Htwe et al. developed an Arduino Uno-based tracking system using GPS and GSM [13]. Kaya et al. developed a GSM-GPS and camera-based vehicle tracking system. In his studies, he proposed the use of cameras for real-time monitoring and reduction of vehicle-related crimes using a vehicle geographic information system (GIS) [14]. Salunke et al. developed a vehicle tracking system for school busses. An Aduino Uno module is used in the developed system [15]. On the other hand, Samuel et al. performed digitization of Arduino-based speedometer and location tracking using GPS in railroads [16]. Arduino-based monitoring systems are not limited to vehicles. Satria et al. developed the prototype of Google-based flood monitoring system using Arduino and GSM module. Similar studies in Turkey were conducted by Demircan et al. in 2013. In the study, a system was developed that is triggered by the explosion of the airbags of the vehicles involved in the accident. In the study, information such as the number of exploded airbags, the license plate number

of the vehicle, its age, and its location were sent to the emergency teams as a short message using the GSM module [17]. It is suitable for vehicles in which only airbags are in use. Not suitable for vehicles without airbags.

In contrast to similar studies in the literature, this study developed a system that sends accident status and location information of vehicles that are actively participating in road traffic, do not have airbags, and where there are few accident models to the 112 emergency call. After the sensors attached to the system's vehicles were triggered, the accident location was detected and the location information was retrieved from GPS and sent to the emergency service through the GSM module. In cases where the weather conditions are unsuitable, it snows and rains heavily and there are no GSM stations, there are interruptions in the operation of the system. In addition, it was found that the digital inputs of the embedded Arduino Mega system used in the study are more affected by magnetic interference. This can lead to false alarms.

IV. CONCLUSION

In the software developed in this study, the coordinate data received from the GPS module was extracted and the coordinate message information was transferred as PDU so that it could be transmitted via SMS. Since the developed system uses the SMS infrastructure, no Internet is required. Filter circuits can be used to eliminate the magnetic interference problem encountered in the study. Device wiring can also be improved. Instead of the preferred embedded system, the use of other embedded systems that are not affected by magnetic interference will positively affect the performance of the system. The architecture designed in the study can be made more powerful by adding new modules. Even if Arduino-based systems are not sufficient, other embedded systems can be used. Raspberry Pi and similar microcomputer systems can be used to create software in various programming languages other than C++.

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