Early Car Accident Detection and Notification Based on Multi-Agents Approach

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ABSTRACT: Fatal road traffic accidents constitute a significant public health problem in many countries around the world. In Saudi Arabia, road accidents are one of the leading causes of death. The delay in detecting and caring for people who have been exposed to traffic accidents increases the risk of injuries. Injury care after the accident is severely affected by time; a few minutes may separate life from death.

Several solutions have been proposed to reduce the incidence of accidents or to reduce the mortality rate at a high financial cost. Recent approaches are using built-in vehicle automatic accident detection and notification system. While these approaches work in pleasing manner, they are expensive, maintenance complex task, and are not available in all cars. However, there is a lack of methods and solutions used to detect the rapid occurrence of accidents and thus speed in transfer of patients to medical centres.

The previous problems motivate the researcher to look deeper and find appropriate solution. In this paper, an intelligent method based on multi-agent system is proposed. The proposed system will mainly consist of multi-agents system cooperated with hardware components such as sensor to sense and detect when and where accident occurs and accordingly send the data to arduion. A gateway device will be used to wirelessly receive Short Message Service (SMS) via GSM (Global System for Mobile communication). Such message will hold the exactly location and occurring time of accident. The accident location will be identified by using Global Positioning System (GPS). On the other side, an agents system will be used to analyse the collected messages then Inform the ambulance services, fire fighter and police station about the location of the accident. As a result of the possibility of delaying of the ambulance to arrive to accident location, the multi-agents system will scan the area of the accident location and then search for the residents of that area. In addition, it will navigate the contact information of the nearest neighbour to accident location then call them for help until the ambulance services arrive. Such approach would help the injured passengers' for receiving first aid faster and thus saving their lives.

The proposed system is implemented and prototyped to solve the above problems. The main contribution of the proposed system is the ability of early detection and notification of car accident in real time to reduce the risk of injuries. The multi-agents system will play a vital role in finding the closet person to the accident location then inform hem/her about the accident. In addition, new idea has been added to such system compared with previous proposed systems.

KEYWORDS: Car Accident Detection, GPS, GSM, Multi-Agents, accident notification

I.INTRODUCTION

In Saudi Arabia and according to statistical studies, 526,000 accidents annually recording with up to 17 deaths daily [1]. In addition, Saudi Arabia is ranked 23rd on the list of countries witnessing the highest death rates in road accidents in the world [1]. Furthermore, the World Health Organization (WHO) reported that 1.24 million people were killed on the road, and up to 50 million people were injured worldwide, and the number of road traffic deaths is expected to increase further by 2020 [2]-[3].

The clearest reason for a person's death during accidents is the delay of the first aid provision, which is due to the delay in the information of the accident being reached to the ambulance or to the hospital. Another study illustrate that most of the people involving in accidents are dying due to lack of medical attention within time [4].

Therefore, in case of incidents relating to car accidents, rescue time is critical for the timely delivery of emergency medical services to accident injured and is expected to have an impact on fatalities. Moreover, each minute is passed while an injured passengers do not receive emergency medical care can make a large difference in their survival rate, for example, analysis shows that decreasing rescue time by 1 minute correlates to a six percent difference in the number of lives saved [5]. Another study illustrate that a 10 min reduction of the medical response time can be statistically associated with an average decrease of the probability of death by one third [6].

To cope with such growing problems, the researcher proposed an advanced solution for detecting and notification of accident occurring in real time. Such system will play a vital role in saving the injured passengers life by decreasing the rescue time. In addition, the proposed system illustrates a new method to improve the emergency services depending on community assistance in providing first aid to the injured until the ambulance arrives.

Multi-Agent System (MAS) or Smart Agent Group is a system which divides rules between agents for fast execution and treatment of more tasks in one time (Parallelism) [7]. An agent is simply another kind of software abstraction, an abstraction in the same way that methods, functions, and objects are software abstractions. An object is a high-level abstraction that describes methods and attributes of a software component. An agent, however, is an extremely high-level software abstraction which provides a convenient and powerful way to describe a complex software entity. Rather than being defined in terms of methods and attributes, an agent is defined in terms of its behaviour [8]. This is important because programming an agent-based system is primarily a matter of specifying agent behaviour instead of identifying classes, methods and attributes. It is much easier and more natural to specify behaviour than to write code [8].

Agents are now widely discussed by researchers in mainstream computer science, as well as those working in data communication and user interface design. A multi agent system is a system that consists of a number of agents, which is tract with each other, typically by exchanging messages through system or between different systems. In addition, agents are capable of sensing their environment (via sensors), and have a repertoire of possible actions that they can perform (via effectors or actuators) in order to modify their environment. In addition, a multi agent system is a dynamic society made up of a number of intelligent agents, so it is an intelligent society [8].

In this paper, multi-agents system for intelligent early car accident detection and notification   has been created and designed. Such system mainly consists of six agents cooperate and communicate together to manage such intelligent application. The proposed multi-agents system will support many beneficial functions i.e. find out the accident address by converting the location coordinates (latitude, longitude) into address, search for the nearby population of the accident site, search for contact information for nearby residents of the accident site, communicate with ambulance services to provide them for accident address as well as communicate with police station. Furthermore, early car accident detection and notification prototype has been designed and implemented based on accident detection sensor and arduino controller. Such system will be used as sensory input to multi-agents system. Finally, an integrating Multi-agent System with sensory input for intelligent early car accident detection and notification has been proposed.

II. RELATED WORKS

Some works of other researchers in the area of detection and notification of car accident location were explored in the following sections.
 M. Raghavendra and V.Sharath Chaitanya have done a study to locate the exact position of a collided vehicle using GPS and sending the information about collision to the prescribed numbers using GSM module. GPS system is provided to a car and a transceiver for the respective GPS modem is placed by the front window, continuous coordinates will be taken by the transceiver from the geostationary satellites in the terms of latitude and longitude [4].

Hamid M. Ali and Zainab S. Alwan have done a study for detection and notification of car accident using smartphone in case of low speed car accident. Their proposed system consists of two phases; the detection phase which was used to detect car accident in low and high speeds. The notification phase, and immediately after an accident is indicated, was used to send detailed information such as images, video, accident location, etc. to the emergency responder for fast recovery. Their system was practically tested in real simulated environment and achieved quite very good performance results [9].

C.Prabha et al have done project for vehicle accident detection and alert system with SMS to the user defined mobile numbers. The GPS tracking and GSM alert based algorithm was designed and implemented with LPC2148 MCU in embedded system domain. The proposed Vehicle accident detection system can track geographical information automatically and sends an alert SMS regarding accident. The result shows that higher sensitivity and accuracy was indeed achieved using this project. EEPROM was interfaced to store the mobile numbers permanently [10].

Many other studies have been done in such area and all of them focused only on hardware. The new ideas in the proposed approach are as follow.
   i. To make the system more accurate, the accident occurring will be detected directly from airbag crash sensor.
   ii. To decrease the rescue time, the proposed method depends on the mechanism of autonomously self searching on specific governmental database using specific agent for the nearest neighbours to accident location then contact them to help the injured passengers as can as possible until the ambulance arrives.
   iii. Intelligent software (MAS) will be used to navigate the accident address by converting the location coordinates then inform the ambulance fire fighter and police about the accident occurring as well as its location.

III. PROPOSED METHOD

In this paper, the design of a multi-agent system for early detection and notification of car accident is proposed. An intelligent concept for agents is proposed that would deal with any accident occur in an independent and efficient way, with different agents cooperating and communicating through message exchange, each agent is specialised in specific tasks of the system functions. Seven types of agents have been identified to be concerned with these services in hierarchical way. In addition, one of the most promising methods for dynamically searching for the nearby population of the accident site based on a novel multi-agents approach was proposed and discussed. The proposed system mainly consists of three phases; the early detection phase which is used to detect car accident in real time using airbag crash sensor. The notification phase will immediately start after an accident is indicated and its responsibility is to send detailed information about the accident location to the emergency services as well as to the police for fast recovery. In phase three, the system will autonomously search for nearby population of the accident site then find their contact information to inform them about the accident and asking for their help. The intelligent early detection and notification of car accident system would mainly consist of both hard and soft parts. The overall system is composed of two subsystems (platforms), namely the car-based side system and emergency–based side system.

A. Multi Agents System

In software part, multi-agents intelligent software is proposed to reflect the intelligent specialty of such system. The selected architecture for the multi-agent system in this paper is the Belief, Desire and Intention (BDI) architecture in which decision making depends upon the manipulation of data structures representing the beliefs, desires, and intentions of the agent. The Prometheus methodology [11] was used to develop the multi-agent system of the early accident detection and notification system. As a result of this detailed process, five agents were developed; located on the emergency side; Accident Detection agent, Decision maker agent, Emergency agent, Nearest-Neighbours-finding agent and Database agent. These agents are selected according an iterative process where data coupling diagrams and agent acquaintance diagrams were used. Based on the proposed design, the agents within the platform would communicate through messages while such agents would communicate with hardware system through mobile network. The agents' interaction diagram with sensory input for the proposed system is presented in Figure 1.
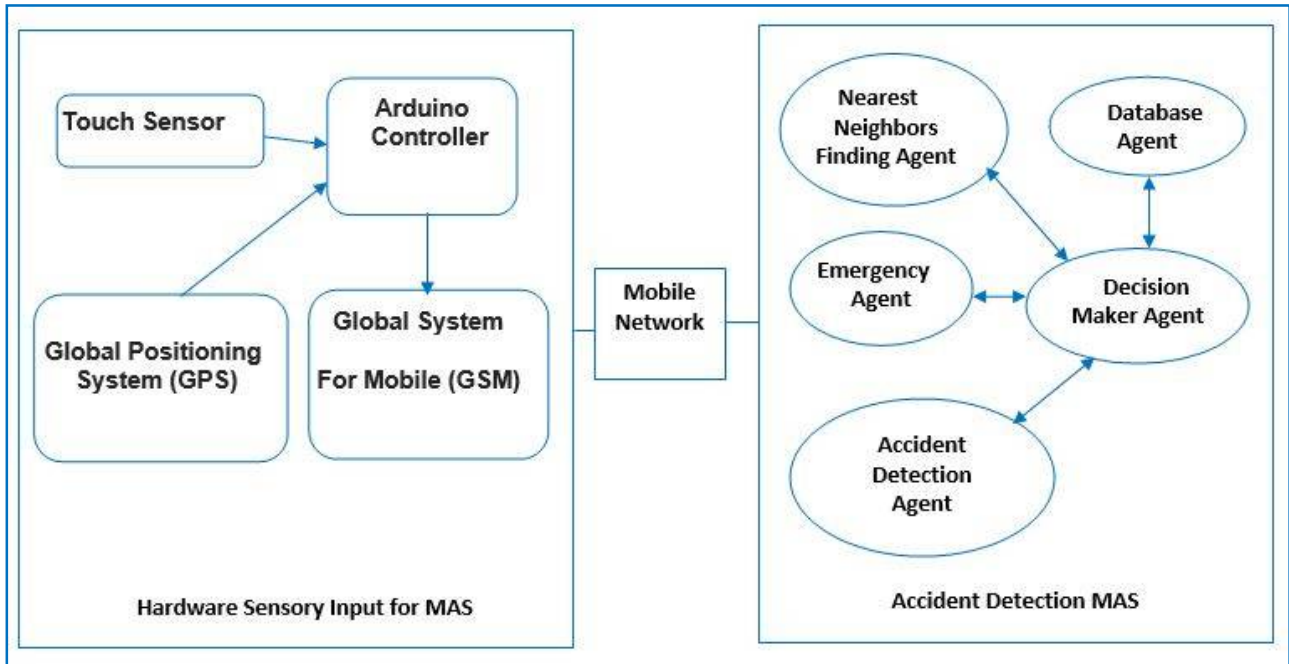
Fig. 1 Agents' Interaction Diagram with Sensory Input for the Proposed System

The selected agents and their roles are defined as follows.
- Accident Detection Agent.

The accident detection agent will detect the accident occurring then determine the exactly location and occurring time of such accident as follow.
    i. Receive the sending message from accident detection device which contains location coordinates (latitude, longitude) and accident occurring time.
    ii. Convert the received location coordinates (latitude, longitude) into address using specific free online application i.e. LatLong.net [12].
    iii. Notify the Decision maker agent about the accident information via message passing.

- Decision Maker Agent.

  The decision maker agent intelligently analyses the output of accident Detection agent for the following purposes.
    i. Reach a decision regarding accident occurring.
    ii. Request the exactly accident location from accident location agent.
    iii. Request information regarding to the closest neighbors to the accident location from Nearest-Neighbors-finding agent.
    iv. Contact and inform the nearest neighbor about the accident location then request for their relief efforts.
    v. Send a guidance message about how to deal with injuries due to accident.
    vi. Contact the nearest emergency center, police station and firefighters to report the location of the accident.

- Nearest-Neighbors-finding Agent

The main duty of this agent is to find out the nearest neighbors to the accident based on the following scenario.
    i. Receive the accident location from decision maker agent.

ii. Search in some private or government databases which is available in most countries to find out the contact information by giving home address and getting back   such information.

iii. Notify the Decision maker agent about the contact information of the nearest neighbor to the accident location via message passing.

- Emergency Agent.

The main task of this agent is to support the emergency services i.e. ambulance, police and firefighters by needed information regarding to the accident such as accident location, best path to reach the accident and accident occurring time as follow.

i. Receive the accident location from accident detection agent.

ii. Receive the accident occurring time from accident detection agent.

iii. Find the best path and the expected time to reach the accident location by using specific path finder algorithm i.e. Dijkstra algorithm, Astar algorithm.

iv. Prepare a message holding all previous information then send it through decision maker agent to emergency services via message passing.

- Database Agent

The database agent is also initiated for collecting all important information from other agent's i.e. occurring time, location, best path, expected time as well as all generated data and decisions occurred during system phases. Such data will be used for statistical study.

B. Design and implementation

As a result of comparing many methodologies [13]-[14], it has been noticed that Prometheus methodology is an appropriate methodology to design and implement the proposed system.

In this research, the Prometheus methodology which is supported within specific tool (PDT) is used in determining the specifications of the proposed system. The Prometheus Design Tool (PDT) has been selected to design and implement the proposed MAS. PDT is a graphical editor which supports the design tasks specified within the Prometheus methodology for designing agent system [15].

Three design phases in Prometheus are selected and implemented. In system specification phase, the actors (human or software) are identified to interact with the system in terms of actions and percepts. In addition, goals of the system are presented in details as well as system scenarios in terms of sequences of steps are described. Furthermore, roles which include small system functionality (identified by goals, percepts and actions) are described and captured.

In   High-level (architectural) design phase, the agent types that will exist in the proposed system are illustrated by joining roles, the overall structure of the system is described using a system overview diagram. An interaction protocols are added to capture the dynamics of the system in terms of legal message sequences.

In last phase (detailed design), the internals of each agent are developed in terms of capabilities, events, plans and data. The selected methodology is used to design and implement the proposed system as follow.

B.1 System Specification

In system specification, system description must be elaborated and explored, to provide a sound basis for system design and development. In the proposed system, the agents system is described as shown above with seven distinct phases in which the system must operate: sensor collect data in real time, Arduino received and analaysed the collected data, determine accident status (occurring or not), determining the accident location, inform emergency side about the accident status, finding the nearest neighbors to the accident location, then contact both nearest neighbor as well as the emergency services.

Typically, using Prometheus, the development of the system specification begins with identifying the external entities (referred to as actors) that will use or interact in some way with the system, and the key scenarios around which interaction will occur. In addition, the goals of the system are selected, the agents interfacing with their environment is captured in terms of actions and percepts and system functions are defined. In the proposed system, three actors have been selected (Accident detection device, Nearest Neighbors and Emergency services). This is done by utilising Prometheus Design Tool (PDT) using the analysis overview diagram as shown in Figure   2.
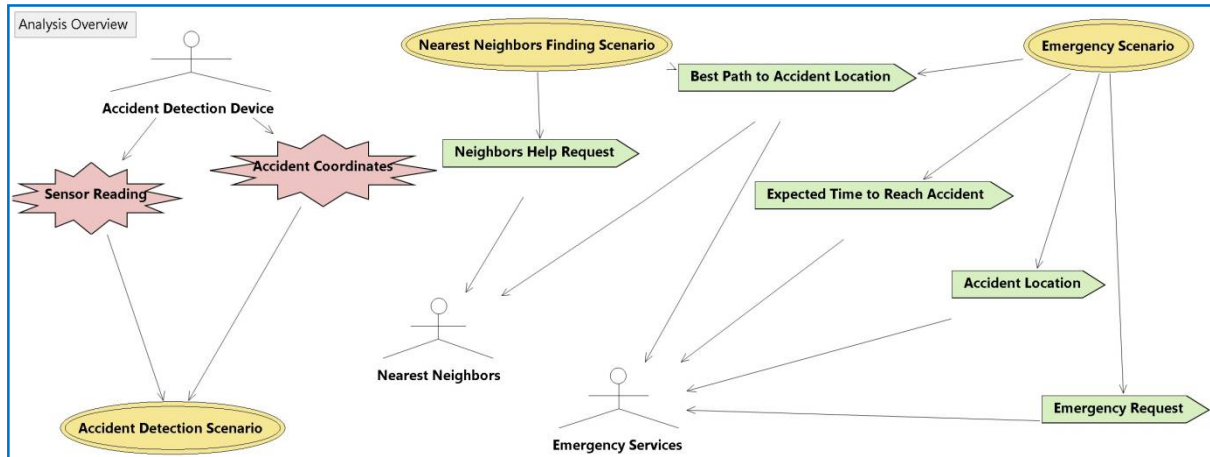
Fig. 2 Analysis Overview Diagram

B.2 Scenario Development

At this point in the design process, it is necessary to identify the role that the step is associated with. In addition, any data which will be read or written by the step must be added to the scenario descriptors. Developing scenarios is one of the convenient ways that show the sequence of steps that take place within the system. Scenarios become even more important in the case of community-managed resources that are shared among many agents. They are used primarily to illustrate the normal running of the system and it also can be useful when used to indicate what is expected to happen when something goes wrong. Three scenarios were developed; Accident Detection Scenario, Emergency Scenarios and Nearest Neighbours Finding scenario. The steps and sequences of these scenarios are configured. All the previous scenarios have been developed using PDT tool. In addition, the initial set of goals for the proposed system is configured and implemented using such tool.

B.3 Detailed Design

The main purpose of this phase is to group configured roles into agents (using the Agent Role Grouping diagram), introduce and develop agent interactions (using system overview diagram) and specify the details of the data stores in data descriptors. In detailed design phase, the agents interact to achieve the goals associated via their roles and associated goals. A generic detailed design describes agents in terms of capabilities, or modules. These capabilities finally specified in terms of plans and events, which are of necessity more specific to the implementation paradigm or platform, than the preceding steps. At this point the abstract design of the system was completed, since the structure, the functions and the internal design had been reached. The final system overview and system role overview are illustrated in Figures 3 and 4.
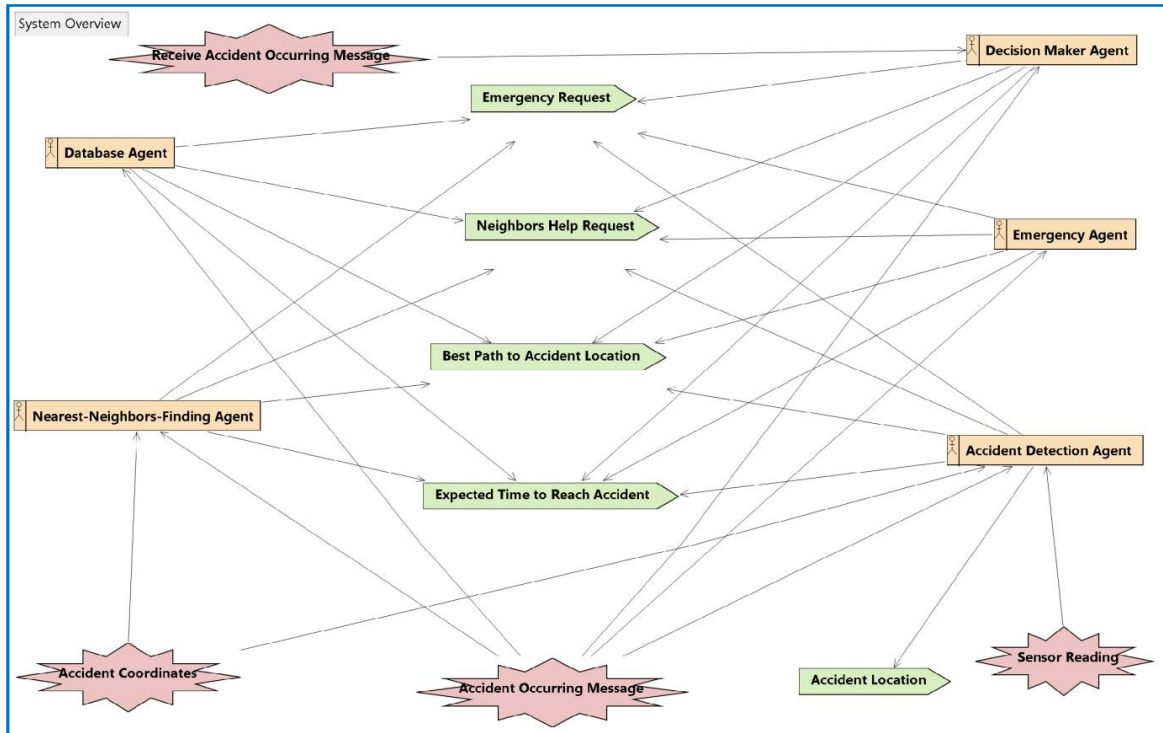
Fig. 3 System Overview Diagram
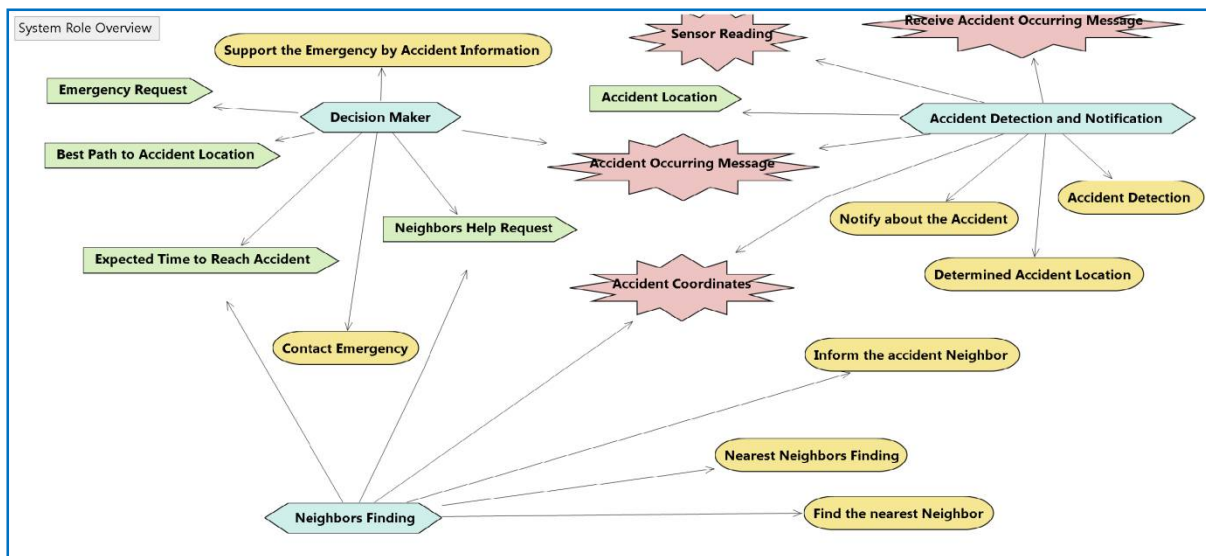
Fig. 4 System Role Overview Diagram

Finally, the roles have been grouped with identified agents to carry out these roles in the system. This step of detailed design has been done as shown in figure 5.
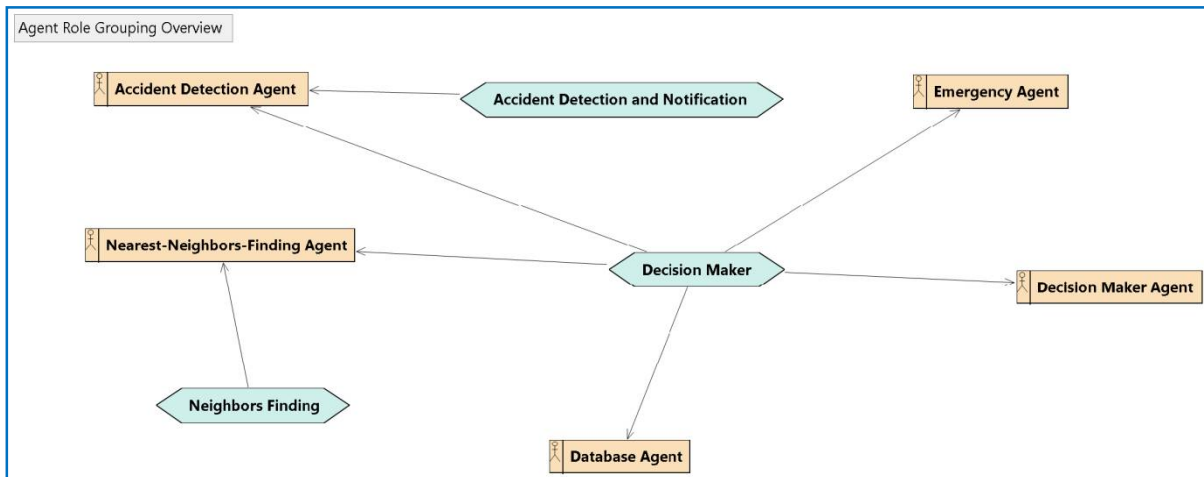

Fig. 5 Agent Role Grouping Overview Diagram

At the end of the design process, the system is ready for implementation and it will be reached using agent speak Language (JASON) software.

C.   Hardware Sensory Input

The car accident detection prototype is simulated and implemented where its hardware components would consist of Arduino system, GSM module, GPS module and touch sensor. Such system would be installed in car side and it will be useful for most of current used cars in Saudi Arabia. Figure 6 shows the simulation result of proposed prototype using Proteus simulation software.
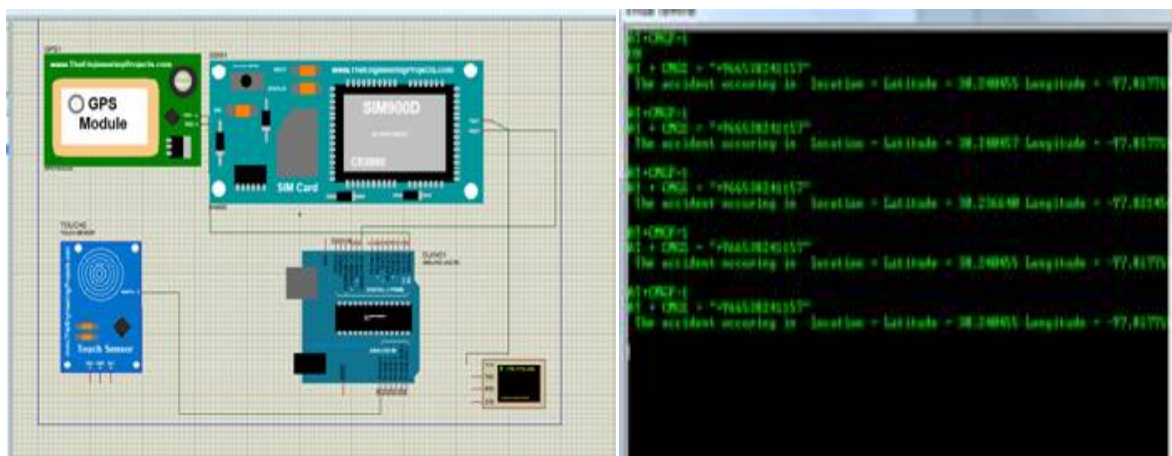

Fig. 6 The Simulation result of Proposed Prototype

The hardware components were selected based on system analysis and requirements as follow.

- Arduino Mega.

The Arduino Mega is a microcontroller board based on the ATmega1280 with 16 MHz crystal oscillator, 54 digital input/output pins and 16 analog inputs. It contains everything needed to support the microcontroller as well as compatible with most shields designed for the Arduino [16].

- GSM Module.

The GSM 900 module has been selected in the implemented prototype to connect the car with internet using mobile network by plug in any SIM card.

- Airbag Touch Sensor.

It is used to Sense a crash occurring in car based on changing in electrical capacitance respecting to acceleration.

- GPS Module.

GY-GPS6MV2 is WAAS (Wide Area Augmentation System) which is compatible with Arduino mega. It was selected due to its high features i.e. heading accuracy: 0.5 degrees while moving, velocity accuracy: 0.1 m/s, maximum velocity: 500 m/s and position accuracy: 2 m.

The touch sensor is already installed in most current used cars and its reading will be connected to Arduino. Due to difficulty of using real airbag touch sensor, a switch was used to represent such sensor by giving high signal in case of accident occurring. In addition, the GPS module was connected with arduino to determine the location coordinates (latitude, longitude). Furthermore, The GSM module was interfaced and connected with Arduino board to wirelessly send the sensor reading via message through mobile networks. The implemented device was programmed using arduino IDE software in C-code. Finally, accident detection device responsibilities are collecting sensor reading; processing data gathered from the sensor and pass it through GSM to mobile device. Figure 6 below shows selected components of the prototype. Flowchart shown in figure 4 illustrates the sequence of programming accident detection device.

V. RESULT AND DISCUSSION

Now days, Multi agents system becomes powerful tool in industrial applications. As a computational paradigm, multi-agent systems (MASs) provide a suitable solution for autonomous monitoring and controlling system in real time. In addition, Multi-Agent System (MAS) approach provides a powerful platform for modelling and solving real world problems such as easily identifying accident location detection and notification. The objective of this research is to propose, design and development innovative solution to offer a more proactive and reliable system to easily identify accident location and to request the required support. A framework methodology was selected to deal with such problem in an effective and smart way. In addition, the specific agent architecture along with the internal work of each agent has been discussed and commented as well as the method of communication between the agents. In the proposed system, negotiations between different presented agents help the system to improve current methods by reducing the needed time to access the accident location and giving an efficient decision. Real-time sensor reading seem to be the most promising way to inform about the accident occurring. In addition, GPS technology is the best way to identify the exactly accident location. Furthermore, GSM technology is one of current used technology to wirelessly contact with ambulance services for any help request in case of accident occurring. All these technologies were used to implement the proposed accident detection prototype as shown in figure 7 which is done and tested with high accuracy and in efficient way. Such prototype will be used as sensory input to the proposed multi agents system. Finally, multi-agents system is proposed and designed to deal with accident occurring in real time by identifying the accident location, determining the time of accident occurring, finding the nearest neighbour to accident location and finally requesting the needed help.
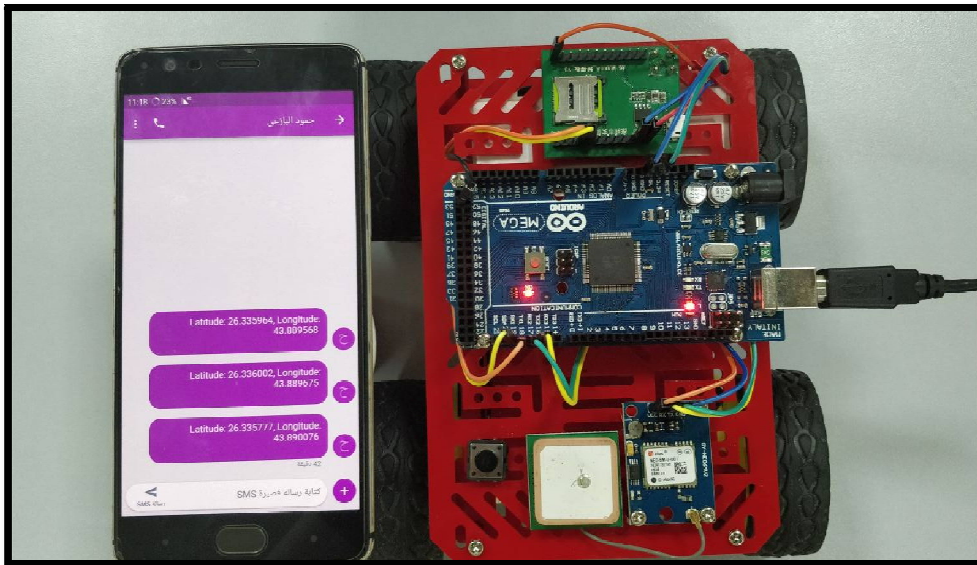
Fig. 7 Implementation of Accident Detection Prototype

VI.CONCLUSION

In Saudi Arabia, road accidents are one of the most important problems that need urgent solutions. As a result of wide geographical area as well as the high percentage of accidents occurring outside cities, road accidents are one of the leading causes of death. One of the most difficult current challenges for car accidents is how to early detect the accident occurring as well as reduce the time needed to identify the accident location then reduce the needed time to reach such location. Such challenge will lead to many problems and causing troubles for the accident victims. In   this paper, the researcher proposed an   intelligent method based on agents system that would use the agent's features to maximize the potential quality of save accident Victims life by reducing the time needed to identify accident location. An intelligent early accident detection and notification system using multi-agents approach is proposed and designed. A new dynamic method for finding the nearest neighbours of accidents location that would help to dynamically contact the accidents neighbours for requesting their support is presented. A prototype of agents sensory input is implemented and tested. To be concluded, a new method for early accident detection and identify it's exactly accident location was investigated. The main objective of such method is reduction of the time interval between the accident occurring and the arrival of the emergency services to the accident location which is lead to a lower probability of death. Depending on this method, the rate of rescue of the accident victims is expected to rise significantly and thus the lives of the injured will be safer.

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BIOGRAPHY

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