Experimental validation of an accident detection and management application in vehicular environment

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ABSTRACT

Traffic congestion is a common transportation problem around the globe, especially in populated cities, which leads to the issues of traffic safety and its management. A major cause of accidental deaths on the road is due to either the traffic-mismanagement or the absence of quick medical assistance. This work presents a TestBed that is designed and implemented along with the prototype application to provide a solution of traffic safety-and-management using Vehicular Ad hoc Network and Internet-of-Things. The application detects and assesses the severity of accidents with the help of an on-board unit, deployed inside the vehicle. When accident happens, it sends a message to control-room, where a server determines the position of an incident and the nearest hospital to request a quick medical assistance. In order to clear the route to the incident-location, the application in the ambulance generates alert/emergency messages. We analyze the implemented Testbed and evaluate the application for different accident scenarios and conclude that the application detects accidents and assesses the situation correctly to avoid false alarms.

1. Introduction

World Health Organization (WHO) has reported the statistics of global road-safety in [1]. According to this report, over 3400 people die everyday and tens of millions injure or become disable every year, around the globe [1,2]. Fig. 1 presents the fatality rates in different regions of the world. It shows that the maximum deaths are in middle-income regions and the risk of fatalities in road-accidents is seven times greater in middle-income regions than high-income — despite the fact that the population is approximately four times greater in high-income region. The efforts of WHO [1] along with its collaborative partners, either at governmental or nongovernmental level, are remarkable. These organizations are working on the prevention of road traffic injuries and promoting awareness of best practices to address the key behavioral risk factors to the community, such as high speed, drunk-driving, riding motorcycle without helmets, driving cars without seat-belts, and booster seats. Half of the death rate is due to the absence of quick medical service to affectees at accident location. In this regard, post-crash care management should ensure safety, accident alerts and
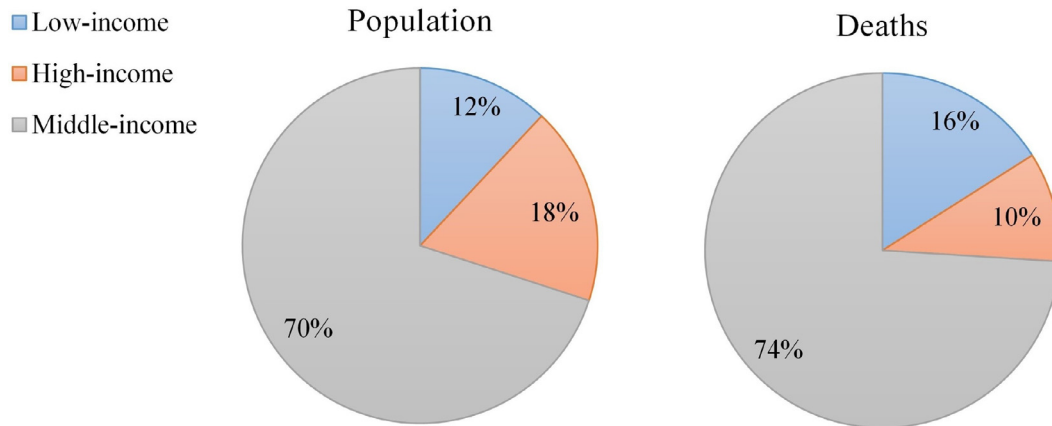
Fig. 1. Population and road traffic deaths based on income-wise regions [1].

medical aid at the incident location. WHO [1,2] is one of the organizations that is working on the project where the priority is given to safety, and it incorporates emergency services such as injury surveillance systems, extremity help access, and medicine tutelage. Additionally, automobile industries are working on innovative solutions to introduce advanced technology in vehicles by considering the safety, tranquility and reassurance to both passengers and drivers [3].

In order to avoid accidental deaths, the above mentioned problem is divided into two parts. The first part is safety-and-management that is used to avoid accidents, and the second part works for the post-accident care. With regards to safety-and-management, communication and collaboration are interesting concepts to implement. Since 1980s, research communities and industries have considered the use of wireless communication technologies within the vehicles to cope with aforementioned issues by enabling the communication among vehicles [4]. In contrast to this, since last two decades, the traffic safety-and-management applications are being developed using Vehicular Ad hoc Networks (VANETs) with the combination of other technologies e.g., Wireless Sensor Networks (WSNs), Wireless Personal Area Networks (WPANs), Cloud computing and Internet of Things (IoT). The synergies of these technologies have been used to launch research- and development- based projects. Apart from efficient traffic management, road safety also aims at information and resource sharing along with security, navigation, and comfort, cf, e.g., [5,6]. The increase in the development of such types of projects is due to the availability of low-cost, standardized components, attractive features, and the potential synergies which are emerging from applications embedded in the vehicles by the vehicle manufacture companies [5,6]. Cellular networks, on the other hand, also provide several multimedia and lookup services for entertainment and information to facilitate their customers during on-road travel. In emergency situations, however, the direct communication in Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2I) settings is preferable to ensure low latency. Although, this is provided by VANET [4], however, cellular/mobile communication networks may induce high latency, hence may not be well suited for the safety applications [7].

In order to reduce the fatality rate, research communities and industries are working on joint projects to prevent accidents on the road and to provide post-accident care, cf., e.g., [8,9]. One of the main reasons of high death rate is the lack of post-accident medical care. To cope with this issue, the development of supporting applications is required, cf., [10,11] for post-accident care management. In this work, we develop a TestBed and an application prototype that can discern and assess accidents on-road by using smart sensors embedded in vehicles, which can automatically contact emergency services. Another major contribution of this work is the hardware implementation for collision detection among vehicles or objects based on four different modules that work independently and are synchronized with each other. We analyzed the proposed application within the implemented TestBed, where each of the embedded vehicles operate as either IoT- or VANET- based device. The objective of implemented TestBed and proposed prototype application is to provide quick medical assistance at the accident location.

The remainder of the article is organized as follows: Section 2 argues the state-of-the-art literature related to road-safety, accident prevention/ detection applications, and requirement of immediate post-accident medical care. We also assess the solutions proposed in the literature and their short-comings. In Section 3, we present the proposed design of the TestBed, the developed application prototype, details about smart devices used in the TestBed, accident detection mechanism, level of accidents, and immediate medical help management at the incident location. We also provide details regarding the software level implementation. Then, in Section 4, we present test results of the accident with different scenarios. In the end, Section 5 concludes the research work and provides an outlook.

2. Literature review

The accident detection and its management is well investigated, and a number of researchers has carried out the studies to make accident detection more reliable and efficient. Various solutions are proposed in the literature which use the combination of different types of mechanical sensors with the intelligent-hand devices or android-based applications to call emergency medical services using