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A Fog-Based DSS Model for Driving Rule Violation Monitoring Framework on the Internet of Things

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Abstract

In recent days for logistics as well as common peoples of developing and developed countries are in need of transportation policy including road safety, which can be achieved only when well-managed driving rule violation monitoring takes place to monitor the flow of increasing number of vehicles. Manual detection of driving rule breakers leads to overhead of today's traffic monitoring body. Switching to an automated decision support driving rule violation monitoring system based on sensor network is one of the paradigms to solve this issue. Upcoming cloud researchers have already felt the demand of designing such a sensor-based driver's driving rule violation monitoring cloud application that can release the overhead of the current traffic monitoring bodies. To accomplish the client's expectation researchers have realized such cloud application based on sensor network or Internet of Things (IoT) is not so satisfactory. To solve these bottleneck conditions of the cloud computing, researchers have introduced the future of cloud computing called fog computing in this aspect, where computing services reside at the network edge. This paper proposed novel fog-based intelligent decision support system (DSS) for driver safety and traffic violation monitoring based on the IoT. Our conceptual framework could easily be adapted in current scenario and can also become a de facto decision support system model for future hassle-free driving rule violation monitoring system.

Keywords: *Cloud computing, Fog computing, Decision support systems, Internet of Things*

1. Introduction

All developing and developed countries call for major improvements and innovations in conventional manual driving rule violation monitoring system in order to achieve road safety of growing vehicle population. Most of the traffic accidents are caused by driver inattention, distraction due to in-vehicle activities and fatigue. According to the Transport Research Wing's (TRW) report of 2011 the total number of person killed due to road accident are 1,42,485 and total number of road accident is 4,97,686 in India [1, 2]. The International Road Federation also estimated an annual monetary loss of $20 billion in India due to traffic collision [3]. Near about 1.34 lakhs out of 1.4 million people were died in India due to massive use of mobile while driving in 2010 [4]. World Health Organization (WHO) reported that India had reached 1st position for the total number of road accident due to use of hand-held mobile telephones [5, 6]. Majority of traffic violations are caused due to driver's lack of respect for traffic laws. Thus a driving assistant system is in demand to alert about their negligent behavior on the road and warning them to be more careful, leading towards a crucial safety solution. Therefore for the driver's safety and traffic rule violation monitoring of future, researchers faced many challenges for developing a cloud based traffic controlling system using wireless sensor network (WSN). For solving the on demand requirement for designing new traffic monitoring system, many of us has designed few decision support systems (DSS) service

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for the users as an open source on cloud. A Decision Support System (DSS) is a decision-making information system that can be either fully computerized, human or a combination of both. Handling user's demand many Cloud Service Providers (CSP) became interested for providing new software-as-a-service on cloud platform. CSP have also felt to develop new technology for meeting client's basic demand. Growing the vehicle population and huge in-vehicle smart processing units are communicated over the WSN. For the dense area the cloud based on demand information processing suffers for latency-sensitive applications. Therefore current Cloud Computing can hardly manage the involvement of IoT in normal people's life for mobility support and location aware application [7].

To address the above problem Cisco proposed a new concept of fog computing which enables location awareness mobility services to the end user [8, 9]. Our goal of this research is to design a fog-based DSS model for driving rule violation monitoring system, which can be adopted into the future driving rule monitoring service to prevent drivers from using hand-held devices during driving. This automated system prevents drivers from rule violations and infringements by instilling improved behavior. In this paper we have proposed a concept of simple three layer hierarchical fog-based traffic violation monitoring DSS model framework as in Figure 1, which would improve and enhance the traditional cloud-based DSS system or other intelligent DSS model for better location awareness, mobility support and low latency [9-14].

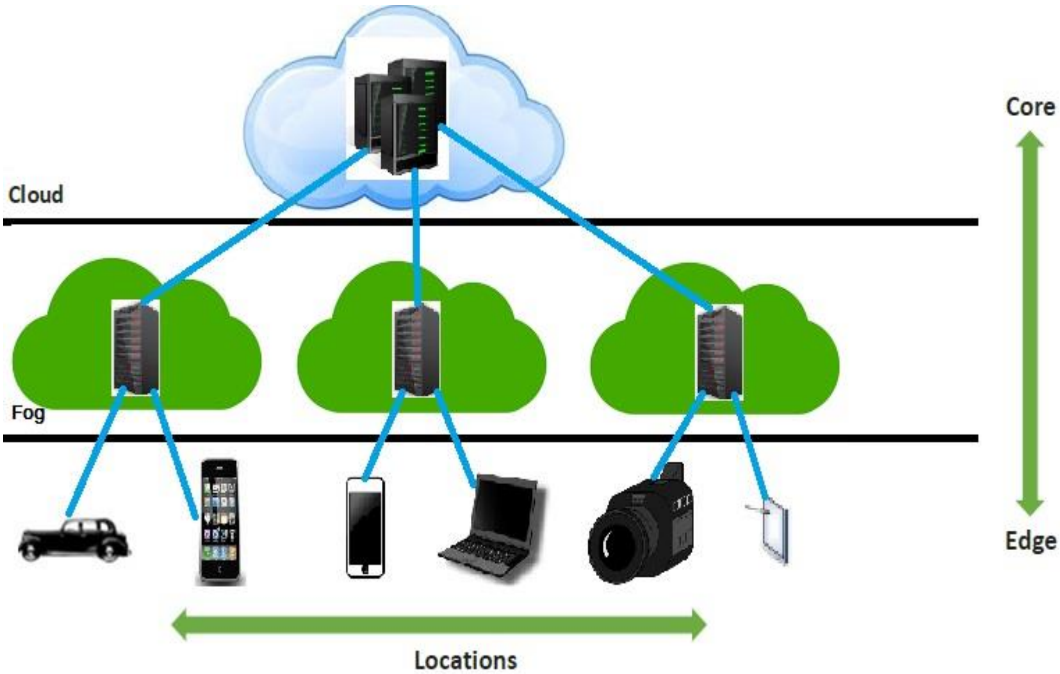


Figure 1. Fog between Edge and Cloud Computing

This paper is structured as follows: Section 2 discusses literature survey. Section 3 explains proposed traffic violation monitoring DSS concept on fog. Finally, Section 4 concludes our proposed framework.

2. Literature Survey

This section articulates the basic requirement and background study of designing our traffic violation monitoring DSS conceptual framework in fog computing environment. This model is not only capable of preventing drivers from using hand-held device while driving, but also helps designated authority for decision making while disobeying the rules related to hand-held devices while driving.

2.1. Focusing the Recent Risk Due to in-vehicle hand-held Portable Device

Recent literature and statistical study demonstrates the negative aspect of massive use of mobile phones and other hand-held portable devices in vehicle that could increases the road-crash [15-17]. Text messaging while driving causes road accidents 23 times higher than undistracted driving, reported by the United States Department of Transportation [18, 19]. The use of mobile phone while driving seems like as dangerous as drink driving [20]. Our research aims to address the requirement for inventing an automatic solution best suited for our near future that could identify the violation and offer a possible decision making policy for the relevant authority and could increase the road safety of drivers while driving.

2.2. Fog Computing Platform

Recently CISCO delivered a view of fog computing that can run applications directly on billions of connected devices at the network edge [8]. Users can develop, control and run their application on Cisco IOx framework to utilize edge of services. They provided an open source platform to encourage more developers for designing their applications based on edge of the network. Therefore so many applications have already proposed for fog environment to enhance the future of the mobile internet [21, 22]. As the massive use of mobile phone while driving could hamper the life of young generation, our main aim is to demotivate people from distracted driving and develop an automatic traffic violation monitoring decision support system for the relevant authority.

2.3. Previously Designed DSS Model for Driver Safety

A DSS is a computer-based information system that can facilitate an organization for decision making activity [23, 24]. DSSs serve the planning and operation level of an organization to make correct decision. There are many stand-alone and network-based DSS applications have been introduced and they are happily accepted into the market [14, 25, 26, 27, 28]. S. J. Miah and R. Ahamed introduced a cloud-based DSS model for traffic monitoring of Australian provisional license holding drivers [10]. They developed a smart processing system over the WSN which can automatically manage the driver safety and help decision making activity for the relevant authority. Communicating to the billions of smart devices with the cloud datacenter may fail to give best effort to the user. Cloud-based DSS systems suffer location awareness, mobility support and low latency. The advent of fog computing overcomes these shortcomings and improves the DSS systems with the concept of performing data processing at network end.

3. Proposed DSS concept in Fog Environment

Our manuscript enunciates the technical details of a fog-based DSS framework for driving rule violation monitoring system that can be adopted into the future driving rule violation monitoring service to prevent drivers from using hand-held devices during driving. The layered framework is pictorially depicted in Figure 1 [9]. In lower layer two types of smart processing devices Global Camera Sensor (GCS) and Local Camera Sensor (LCS) are required. LCS is deployed inside the vehicle, which is not only capable of sensing driver's activity and warn them accordingly. GCS is deployed at traffic signaling pole, which is capable of identifying vehicle number. Both GCS and LCS are capable of communicating to the fog servers of the middle layer for fast information processing. The middle layer consists of different fog servers capable of determining which vehicles are intentionally disobeying the traffic rules for hand-held devices and communicating to the designated cloud servers as per requirement to synchronize them with the recent updated information for decision making. The upper layer consists of the designated servers of concerned authority to synchronize themselves with the last updated information from fog servers and generate the decision based upon the violation rule book. Each of these three layers accomplishes different activities as follows.

Table 1. Activities of Different Layers

Layers	Activities
Lower Layer	i) Detecting vehicle number with the help of GCS ii) Detecting the usage of hand-held device by drivers while driving with the help of LCS iii) Warning drivers for a certain period with the help of LCS iv) GCS and LCS send vehicle number and vehicle identifier respectively to the fog servers
Middle Layer	i) Fog servers receive vehicle number and vehicle identifier from GCS and LCS respectively ii) Fog servers correctly identify the vehicle intentionally disobeying the traffic rules related to hand-held devices during driving iii) Send the accurate vehicle identifier information to the designated cloud server
Upper Layer	i) Cloud servers synchronizes themselves with last updated vehicle identifier information ii) Provides decision based on traffic violation rule book

The proposed framework comprises of layers and there corresponding activities are depicted clearly in Figure 2.

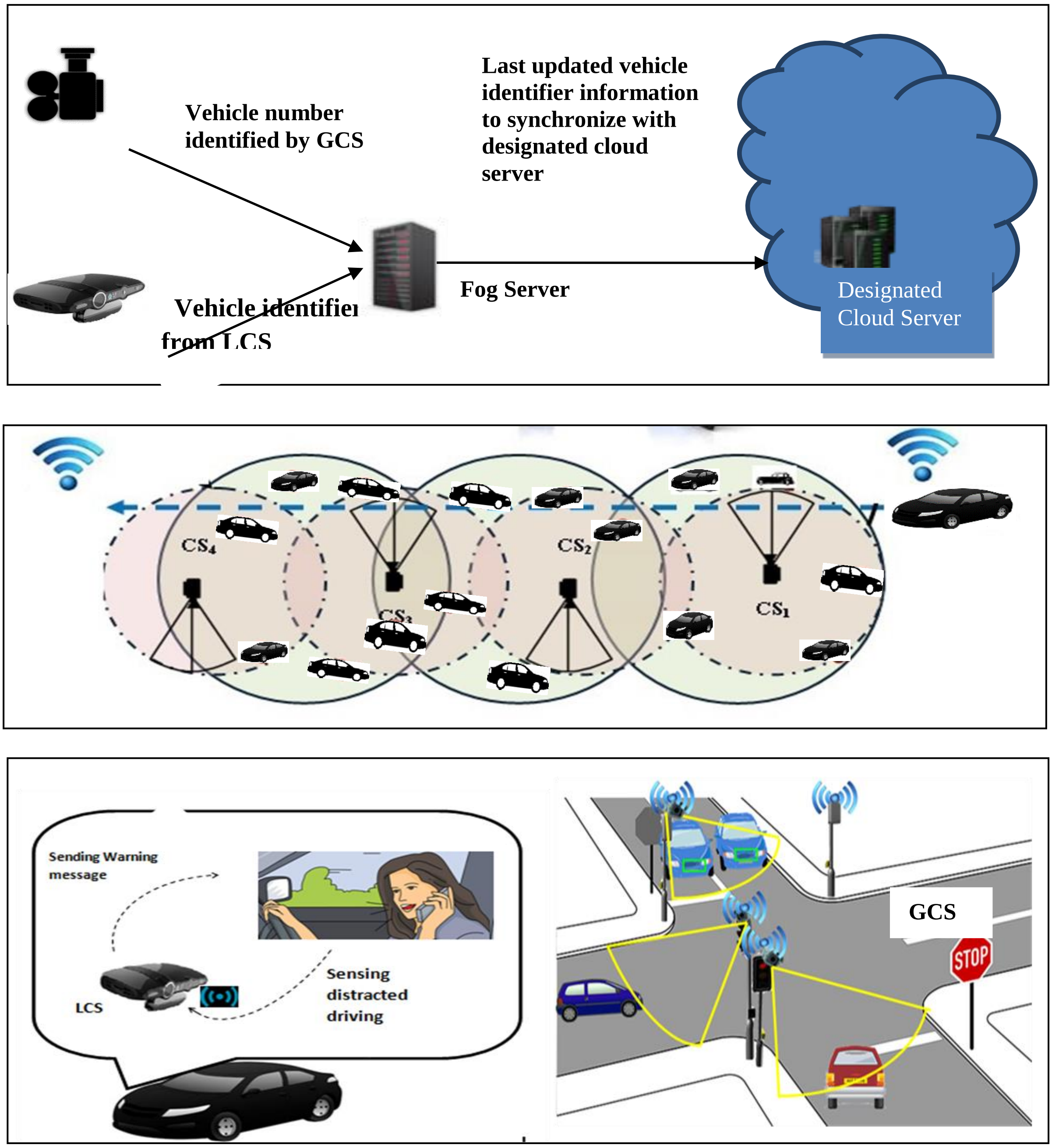
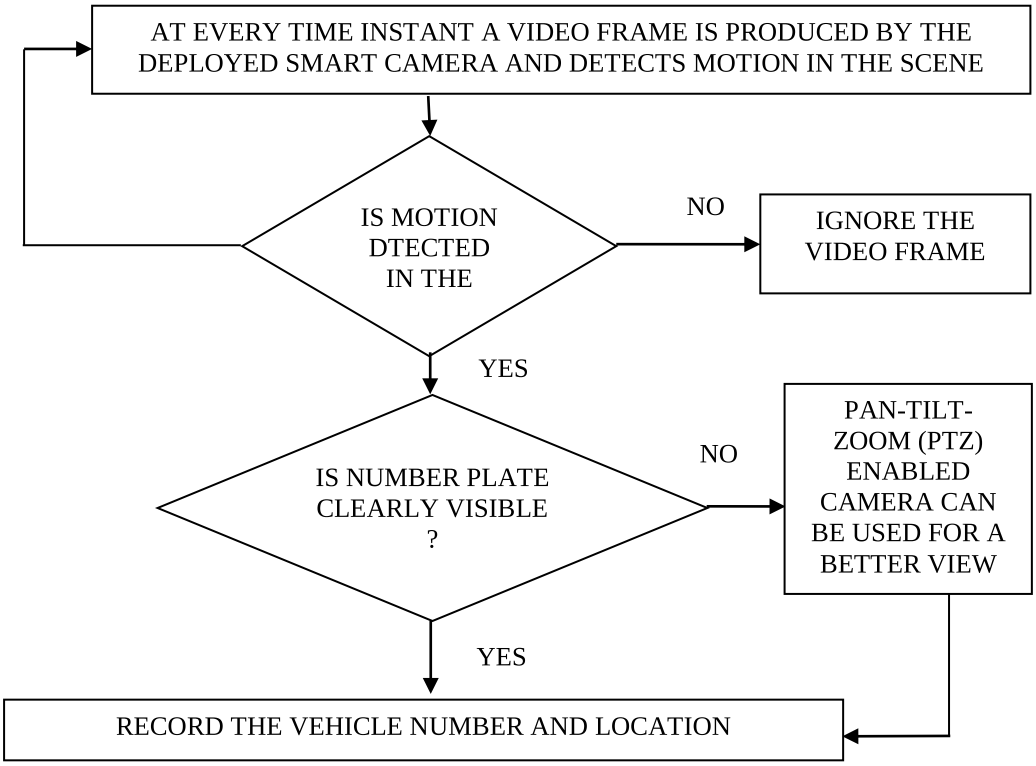


Figure 2. Three Layers and Corresponding Activities of Proposed Framework

3.1. Detecting Vehicle Number with the Help of GCS

The Global Camera Sensor (GCS) deployed on traffic control signal can detect a motion on the scene for detecting the vehicle’s number plate within the detection field area and record the current location along with the vehicle number [21, 30] to the local fog server. Flowchart 1 represents clearly represents this activity.



Flowchart 1. Detecting Plate Number of Vehicles using Cameras

3.2. Detecting the Usage of Hand-Held Device by Drivers while Driving with the Help of LCS

An in-vehicle smart Local Camera Sensor (LCS) is installed at the front side of the vehicle that can record the activity of drivers while driving. Driver's interaction with a handheld device can be detected using the Spatio-temporal video object segmentation technique [31]. This LCS is capable of providing warning message to the driver for this awful activity.

3.3. Warning Drivers for a Certain Period with the Help of LCS

Repeated warning message at the proper time can help to keep the driver safe at the time of driving [32]. The LCS unit needs to be capable of generating warning messages to the driver keeping away him/her from this awful activity [10]. After a certain amount of warning message LCS reports to the fog server for distracted activity with the vehicle identifier consists of distracted activity proof and vehicle number.

3.4. GCS and LCS Communicates to the Fog Servers

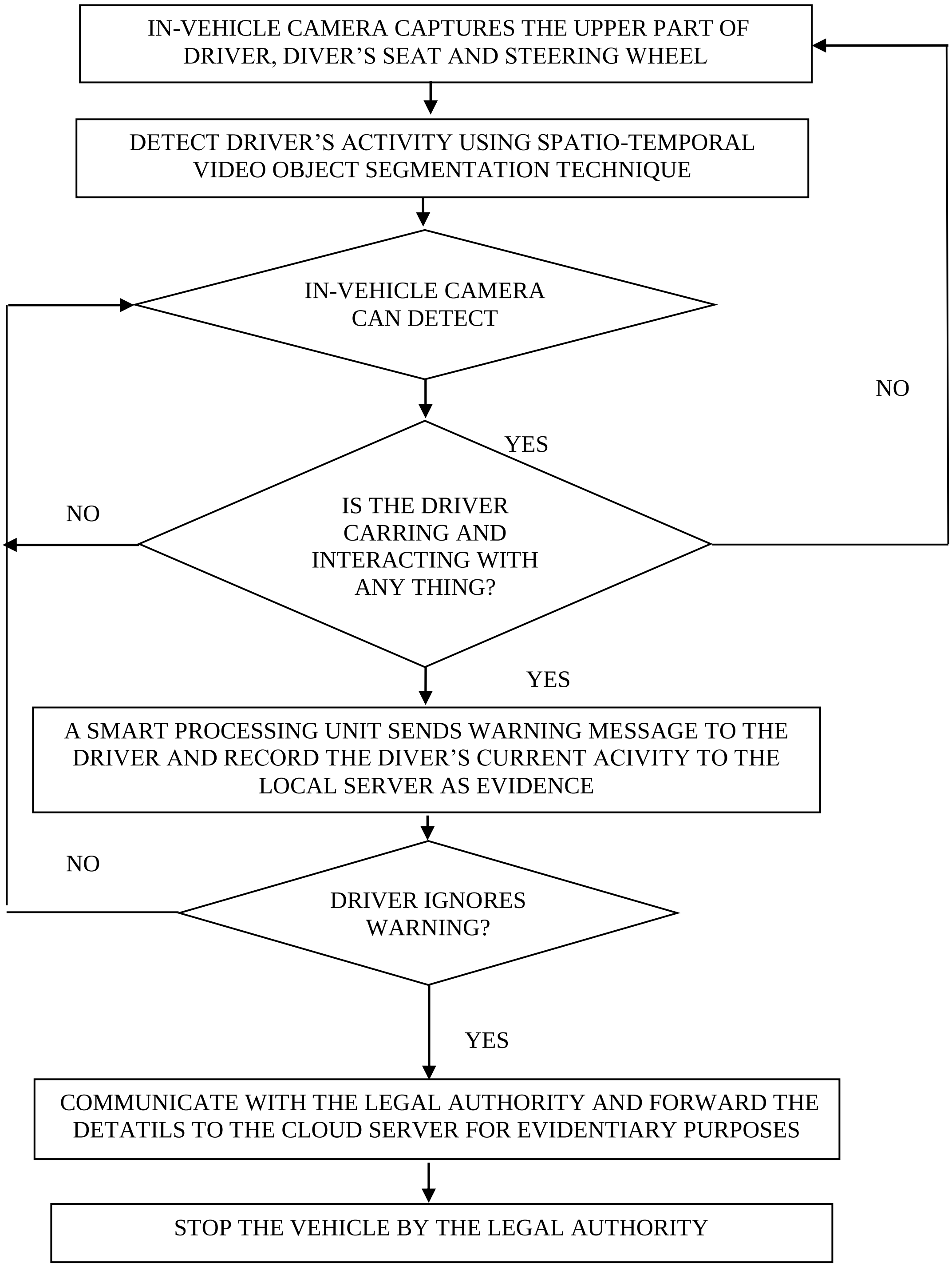
GCS detected vehicle number and LCS generated Vehicle Identifier are transmitted to the fog servers.

3.5. Correct Identification of Vehicles with distracted drivers

Vehicles with distracted drivers are identified from received vehicle number and vehicle identifier.

3.6. Communicating with a legal authority if driver disobey the alert

If the user disobeys the alert message the fog server unit communicates with the designated remote cloud server and last updated vehicle identifier is transferred from the fog server to the remote cloud server as evidence. Then designated authority takes the necessary action based on the traffic rule book. Our proposed DSS systems framework is explained in Flowchart 2.



Flowchart 2. Proposed Conceptual fog-based DSS model

4. Conclusion

This article presents fog-based DSS model, a novel frontier dedicated for serving the vital issue of on road driver's safety. Our proposed framework claims an automatic decision making system to prevent drivers from using hand-held devices during driving with the help of fog servers. Now placement of fog servers at network edge and fast communication establishment with them is the open challenge for the researchers. The massive use of mobile phone at the time of driving is a major cause of road accidents involving young generation. Our main aim to aware people about the proper traffic rule and also address those peoples used to violet the traffic rule intentionally. Our proposed system model can also help the legitimate authority to follow the act (like 'ROAD TRAFFIC ACT 2006, Section 3' and 'MOBILE VEHICLE ACT [RSBC 1996] CHAPTER 318, Part 3.1') properly using synchronized data from designated cloud servers.

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