Traffic Management and Violation Detection Systems: An Open Challenge

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Abstract – The motivation for understanding the traffic management system comes from the observation that with the increase in the number of vehicles are increasing violation of traffic rules. One of the prominent factors responsible for violation rules is distracted minds from driving and negligent behaviors. In addition, violator's vehicle is not tracked by human eyes and also makes drivers irresponsible about the traffic rules. Many automated traffic management systems which usually consist of computer vision and data recorder have been designed to capture such violations. However, owing to a report published in, the rate of traffic rule violation reflects that the existing automated systems are not fool proof. This paper reviews existing traffic violation detection and management systems and a comparative analysis of existing systems have been presented with the aim to improve the existing structure in future.

Index Terms – Automated Traffic Management System, Radio Frequency and Identification, Intelligent Traffic Management System, General Packet Radio Service.

1. INTRODUCTION

Nowadays in cities, traffic management poses challenges like traffic congestion, traffic violation because of that road safety has become necessary otherwise it will cause many accidents. The majority of traffic accidents are caused by driver's carelessness, distraction due to in-vehicle activities and fatigue. Sometimes the majority of the traffic violations such as over-speeding and ignoring stop signs are unintentional, they occur due to the lack of concentration. So, the driver should become more aware of their driving behavior. Thus, a driving assistance system is a must for alerting about their negligent behavior on the road and warning them to be more careful about their mistakes to prevent traffic. There is a lack of proper public transport infrastructure which leads to shifting of people from public transport to personal vehicles. There is more congestion due to more cars on the road. As the population increases the chase of owning personal vehicles also increases making traffic management a necessity as more are the number of cars more is the congestion on road. A careful investigation of existing mechanisms indicates that there exist many rules and automated systems to regulate traffic and catch hold of traffic violators but the need for a more intelligent system which is smart enough to automatically catch traffic violators is highly apparent. But before working on a new system, it is strongly desired to explore and understand the prevailing mechanisms and hence the motivation for this work.

The paper has been structured into five sections: Section 1 justifies the need of current survey. Section 2 presents the work of eminent researchers and compares the existing mechanisms. On the basis of comparison, it is concluded that SACAT is the most popular traffic management and hence a brief overview of the same is being presented in Section 3. Section 4 concludes highlighting the future scope.

2. RELATED WORK

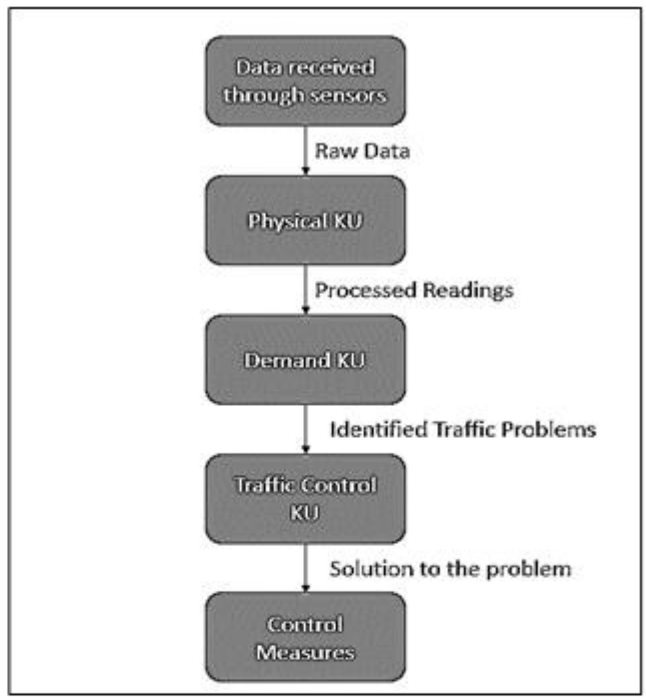

Figure 1: Flowchart of a TRYS system.

The section summarizes the existing research by comparing the different available systems presently running in some areas and features they contribute to managing road safety and traffic. The role of knowledge-based architecture appears to be quite important in intelligent traffic management systems. In the year 2002 Barcelona freeway system used agent-based environment called TRYS (Trippery Regional Youth Service) for building an ITMS (Intelligent Traffic Management System) in two different ways: InTRYS [5] and TRYSA2 [5]. Both TRYS and TRYSA2 are knowledge-based applications for real-time traffic management. Different real-time problems and solutions are fed into different agents with their solutions. This knowledge is based upon the topology of the area. Some general traffic problems that occur very often with their solutions are summarized in the software agents. As shown in figure 1, the software agents are organized in so called knowledge units (KU's) and a collection of KU's is a knowledge model. Basically, these KUs are divided into 2 categories: Behavior KU and Traffic Problem KU.

The Behavior KU contains information related to traffic behavior. This information is organized in 2 other KUs: physical structure KU and the demand knowledge. The physical structure KU perceives the scenario data from loop detectors etc., records and analyses the data to deduce signal information, basic traffic qualitative magnitudes (i.e. speed, occupancy, flows) and certain aggregated measures.

The demand KU contains historical information of traffic flow distribution. This detects different traffic situations based on the readings received by the physical KU. In general, these agents understand the traffic problem that impedes traffic flow.

Once a traffic problem is detected the traffic control KU selects a VMS (Variable Message Sign) panel to display control measures which help drivers to take a diverted path so as to avoid the congested area. A local control station that is capable of receiving all the information coming from either the infrastructure or the vehicles has to be capable of intelligently managing the traffic to avoid collisions. A station can be setup that receives and analyzes the information coming from the vehicles to send each driver information about how they are driving and an alert and recommended action to avoid any critical situation.

A fuzzy traffic management system [6] was developed to evaluate the traffic situation. Fuzzy logic is considered a good control technique when dealing with systems whose definition is imprecise. Implementation of fuzzy logics led to the creation of an intelligent traffic management system. With implementations of hardware and software, it was shown that how artificial intelligence can be useful in handling real life problems. AS shown in figure 2, the system consists of a passive tag RFID reader, microcontroller, GPRS module, high-speed server, with the database system and user module.

A dynamic system is required to solve the problem of traffic congestion. We must have a mechanism to collect road informatics in real timing in a city and provide to the user using a dynamic shortcut path guide system. RFID tag and reader provide dynamic data to the computer server. Passive RFID tags placed on the vehicle using a unique Electronic Product Code(EPC) are detected by readers through antennas. The EPC's retrieved are transferred to the microcontroller which calculates the speed of the vehicle. Microcontroller forwards it

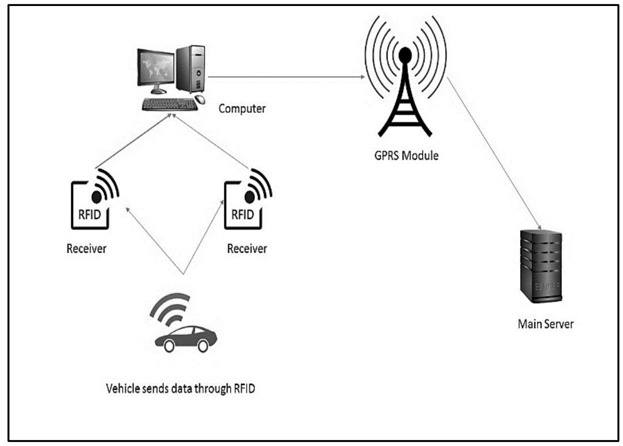

Figure 2 ITMS through RFID

to the GPRS module and then to a central computer which then calculates average speed and facilitates route. To calculate faster route a blueprint of the city roadways is pre-loaded at the central server along with average values using Dijkstra's Algorithm. A user feeds in his source and destination through an interface fitted in his vehicle which would enable him in finding the fastest way. In this system lack of concentration of driver while driving is considered as a cause of traffic violation.

A vision-based traffic monitoring system using cameras uses non-invasive visual sensing based on computer vision techniques has been listed in [9]. An IRV technology using cameras along with RFID technology, database server, and GSM technology can be used to reduce violation and road accidents [10]. A machine vision algorithm to detect traffic violations of vehicles blocking the pedestrian lane can be used [11].

A network of Xbees can get data from other vehicles which also contains Xbees that send data to master Xbees [12]. Embedded microcontroller and sensors can also be used in the vehicle which can connect to each other through Wi-Fi using software framework for evaluation, planning and future improvement in transportation system [13].

A cognitive traffic management system (CTMS) based on the Internet of Things approach and Smart traffic light integration is described in [14]. A predictive road traffic management system (PRTMS) based on the Vehicular Ad-hoc Network (VANET) architecture is described in [15]. Work in [16] describes a real-time monitoring system for traffic event detection from Twitter stream analysis. Use real-time Floating Car Data (FCD), based on traces of GPS positions to gather accurate traffic flow information in a road network is described in [17]. For automatic traffic sign detection and classification an image analysis technique is proposed in [18] which detects, recognizes and classifies vertical sign, cameras equipped with vehicles as well as to identify positioning and visibility with respect to road sign regulations. Another image processing technology is described in [19] which detecting, recognizing and classifying vertical sign, cameras equipped with vehicles as well as to identify positioning and visibility with respect to road sign regulations.

Highway Intelligent Space System (HISS)[20] uses space sensors system and communication technology which provides vehicles with the surrounding road information to study vehicle environment It can provide advance road information far from the vehicles, which provides vehicles with warning information about the road situation ahead. Another popular system is SACAT is not autonomous but it supports additional features like vehicle identification, violation management, warning before the violation. SACAT also contains hardware interfaces and GPS maps. The comparative analysis suggested that SACAT is better than any other existing mechanism. However; it also has some limitations. Due to the absence of software agents, it is not autonomous. It doesn't provide a check over traffic congestion. Physical conflict may occur as cameras may fail during shape analysis.

A critical look at the above literature depicts that prominent features of InTRYS include being autonomous as well as supported human guidance whereas TRYSA2 supported only human guidance. Both works on software agents and on real time environments. They have data storage capacity with dedicated data servers. Although it lacked grousome features like it is unable to manage any violation occurred. Also, they have some physical conflict. On the other hand SACAT supports much of the listed features even on being real time like vehicle identification, violation management, and warning before violations. It is preloaded with maps, cameras, S modules along with microcontrollers to assist drivers. Although it has many capabilities, it works only on the users' personal level i.e. it can't be connected with the main traffic control of the city. Also, it is not autonomous. It also gives acoustical warnings to drivers.

ADAS feature almost like SACAT but it has more cameras one for the day and another for the night. It also has microcontrollers and GPS maps but unlike SACAT it lacks violation management and detections. It also gives acoustical warnings to the driver. In addition, AUTOPIA is still an underdeveloped application for traffic management which is autonomous. Like SACAT it has a capability of violation management and detection. On the basis of above, a comparative analysis of few popular traffic management systems is being presented in table 1 (given at the end of paper) and the comparison thus presented concludes that SACAT is better than other listed applications. The detailed work SACAT is being presented in the next section.

3. SACAT

SACAT primarily has two components: Computer vision and Data recorder. The purpose of SACAT is Traffic Violation Alert Management which is further divided as Traffic Sign Detection and Recognition (TSRD) and Traffic Violation Management (TVM). For this, a video camera, two color cameras, and a smart card are used. The smart card is used for three user profiles: user (end user), Transport company agent (system administrator), Traffic enforcement agency. A camera is used to detect traffic signals along the road. Then a series of objects are subjected to shape analysis and if the shape matches to traffic signs driver is sent an acoustical message via loudspeakers.

Another system checks for stop sign (checked whether the speed of vehicle is zero or not), speed limit (vehicle speed is matched with stored limit and alert message is active before the time traffic violation is recorded), forbidden turn (checked on the basis of steering wheel angle and vehicle's speed) etc. It is based on advanced driver assistance system which provides feedback to drivers about their driving behavior. The system detects traffic violation fault in a local database and visualizes it using geographical map. Driver assistance system informs the driver about their mistakes they did while driving. Event Data Recorder (EDR) is used to provide drivers with feedback about their traffic violation records, it can be used for recognition of mistakes and give training and prevention for that. When a traffic violation is committed, its corresponding scenario is then recorded. This scenario is a set of data composed mainly of the type of the detected traffic sign, its GPS location, a picture of the surroundings, the vehicle speed etc. In the case of a traffic violation, a warning is emitted in the form of acoustical messages through the vehicle loudspeakers. These warnings are issued with sufficient time to provide the driver with enough notice to react to the oncoming traffic situation.

As shown in figure 3, SACAT needs various hardware components to operate on different functionalities. The interoperability of these components is illustrated in figure 4. For the main processing unit, it uses a Mini-ITX Board. All data from different sources are sent to the board for processing. Cameras are fitted on the rooftop to capture images which are further sent to an image processing unit. The image processing unit identifies the image and sends details to the Mini-ITX board which then decides which step is to be taken next. The calculated suggestions are displayed on the screen which is enabled with a touchpad. Touchpad enables a driver to interact with the system. GPS is also attached to the board which keeps track of the location of the vehicle along with the other details like speed and position of vehicle, angle of the steering wheel, status of the brake systems and much other information which comes from the CAN-Bus. All these data is stored in the flash memory or external memory via a card reader. With data storing capability driver can also check his previous records if needed. Although SACAT offers an efficient solution for traffic management system, however, same is not autonomous and it appears that use of RFID tag would improve the efficiency of existing architecture.

Table 1: The Comparative Analysis of Popular Traffic Management Systems

Properties / Technologies	**InTRYS**	**TRYSA2**	**SACAT**	**ADAS**	**AUTO-PIA**
Autonomous	√				√
Human Guidance	√	√	√	√	
Software Agents	√	√			
Using VMS	√	√			
Real-time	√	√	√	√	√
Congestion Warning	√	√			
Vehicle Identification			√		√
Violation Management			√		√
Information Of Violation			√		√
Warning Before Violation			√		√
Physical Conflicts	√	√			
Microcontroller			√	√	
Data Server	√	√			√
Normal Cameras			√	√	
Day Night Cameras				√	
Data Storage Capability	√	√			
GPS MAPS			√	√	
RFID					
GPRS Module			√	√	
Shortest Route Map	√	√	√	√	
Blue Print Of City Map			√	√	
Acoustical Warning			√	√	

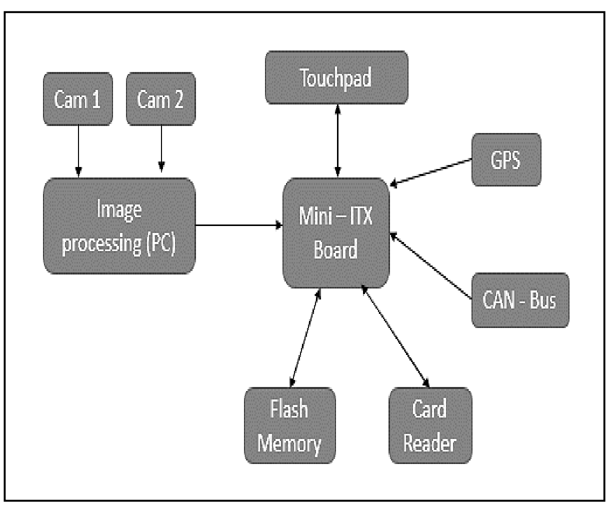

Figure 3 Hardware components of SACAT

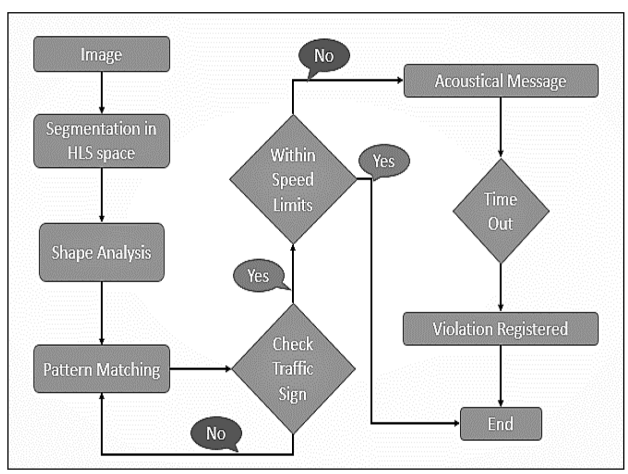

Figure 4 Flow chart of SACAT system

4. CONCLUSION

This paper analyzed existing Traffic Management and Violation Detection Systems. Although SACAT is better than any other, it was discovered that the same was not autonomous. Making SACAT autonomous would make it more effective and further it is understood that implementing RFID tags in the main vehicle shall add to the better and efficient Traffic Management System which is the need of the hour.

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