A review of traffic violation detection technology in reporting mechanism

A Alaydrus1, W K Putra2, Y Nugroho3, Muhammad4, and N Surantha5*

Computer Science Department, BINUS Graduate Program-Master of Computer Science, Bina Nusantara University, Jakarta, Indonesia, 11480

Email: nico.surantha@binus.ac.id

Abstract. Traffic Violation Detection system using radio frequency identification (RFID) has been applied to detect vehicles with limited power sources through RFID Tag. Camera sensors are also applied to identify a vehicle and its plate number through image and video processing known as computer vision. On the other hand, vehicular ad hoc network (VANET) to gain information about location, speed, and so on through the vehicle-to-vehicle (V2V) connection. Lastly, the internet-of-things that is backed-up by cloud computing helps to store various information from each of these technologies and process them to get results. Many researchers have proposed and developed algorithms or technology with astonishing experimental results of them. However, there has been no review of the integration and reporting mechanism that correlates them. There has also been no review about how to connect the information to the authority and violator. Therefore, the review was made to explain each technology’s method with their experiment’s results and issues. Moreover, the future challenge also had been given to further research.

Keywords: traffic violation, traffic violation detection, traffic detection technology, reporting mechanism

1. Introduction

The world’s population is gradually increasing, comparable to the vehicle’s production. This phenomenon leads to traffic congestion, violations, and traffic-related accidents [1,2,3]. These matters cannot be handled by the police alone due to the limit of personnel [4,5]. Thus, numerous technologies have been developed and applied to certain countries that have been able to organize and monitor the system even though that is not the case with the developing countries. The majority and current technologies that have been applied so far are Vehicular Ad Hoc Network (VANET)[6,7,8,9], Computer Vision[3,10,11,12,], Radio Frequency Identification (RFID)[13,14,15] and other supporting methods that are worth mentioning[9,16].

The mutual problems that all the technology mentioned previously are the integration between them and the processing data through real-time connection [2,17,18,19,5]. VANET has an issue detecting other objects on the road to collect data [23] as well as computer vision when detecting the exact kind of violation that has been captured through camera sensors [7]. As for RFID, it has an issue when controlling the signal to detect the tag and dealing with the range of all vehicles at a time [14].

The review analyzes more about the most targeted technology to be implemented. We will map which technologies are most suitable for each situation, at many points, and the current infrastructure
that supports the delivery of information and data most quickly and accurately. The review presents methodology, in-depth analysis, future challenge for research in this topic, and the conclusion.

2. Review methodology

The literature are collected through an online search engine on academic libraries such as Google Scholar, IEEE (Institute of Electrical and Electronics Engineers), and Science Direct. The keywords are "traffic violation detection", "vehicular ad-hoc Network", "computer vision", "radio frequency identification" and pairing the first keyword with every other keyword.

Figure 1. The Number of Literature Used, Based on the Published Year.

As shown in Figure 1, most of our literature are collected in 2017-2019. It means the interest of the research in this field has been increasing recently. From all found references, the reviewed reference are selected based on some criteria, e.g., the specific research problem, the proposed method, and the comprehensive evaluation of the proposed method. Based on these criteria, there is 33 chosen literature refined and reviewed by the paper following these criteria.
3. Traffic violation detection system

Several different technologies can be applied to a traffic violation detection system (see Figure 2). In the review, several existing technologies will be classified based on their objectives, which are technologies that are suitable to be applied in the scope of the Jakarta Province. The technology to be classified among others is sensor-based supported by IoT, Computer Vision, and Wireless Networks such as VANET and RFID. The combination of different classifications of existing technologies may also be the best performance in its application. All technologies used in this section are reviewed in Table 1.

Table 1. Overview of the Different Technologies Used in a Traffic Violation

| Classification       | Technology                  | Advantages                                                                 | Disadvantages                                                                 |
|----------------------|-----------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Sensor               | Infrared Sensor [5,20]      | Simple and cheaper tools to detect violation systems.                        | A limited number of violators from one incident                               |
|                      | RFID [1,13]                 | Simple and can save data                                                    | Just can save limitation data                                                 |
| Wireless Network     | VANET [10]                  | New technology for violation detection system based on a combination vehicle | Vehicle must have technology VANET for used this method                       |
|                      | Wireless Frequency (Bluetooth, Wifi, ZigBee) [1,2] | Has several protocol variants for data communication and have more coverage area | Can interference with the same protocol                                       |

Figure 2. The Infrastructure of the Vehicle Violation Detection System
Computer Vision Camera (CCTV) [3,4,11,18] Can capture images and videos to process violation data more effectively More costly and needs processing form computer or cloud computing

3.1. VANET
It is included in the wireless communication network where communication occurs via the wireless link installed on each node. Each node on VANET acts as either participant or router on the network. It also works either for the main node or neighbourhood node communicating within a transmission radius from the VANET [7,8]. The main purpose of this VANET is later can be used to create and provide transportation applications to support safety and comfort for the driver. VANET surely requires the implementation of the routing protocol that follows the characteristics of VANET. The vehicles are incidentally having a high dynamic movement within the node of a network. The routing protocol on this wireless network itself is divided into three, namely proactive, reactive, and hybrid [2,17]. It is known that reactive routing protocols have a better performance than proactive on a network with high mobility. One reactive routing protocol that has been tested in VANET is the ad-hoc on-demand routing protocol distance vector (AODV) [9]. Furthermore, another research discusses about performance analysis of the ad-hoc on-demand routing protocol the distance vector (AODV) with the parameter 802.11p in the VANET environment [18,19,5].

3.2. Computer vision
Most of the papers that use computer vision technology [23,24,16] are based on convolution neural network (CNN) method. The first step of computer vision to work is to extract the video frames from the side of the highway daily time driving [25]. A pre-trained four multi-layer CNN model is used to transform features to predict driver's illegal activities during highway driving [23,26]. Those frames are extracted from a video in every 0.3 seconds. Afterward, a deep belief network (DBN) model is applied to predict the final decision of the activity class of driver's illegal driving [24]. The DBN model is trying to help the pre-trained CNN model to pool layer for defining an effective features map [21]. In the proposed system, a single feature map is utilized that is extracted from a single video frame [27]. A group of frames is used for recognition to perform the final prediction about the driver's illegal activities. From the video frames, fifteen feature maps are stored to generate by the pre-trained CNN model for prediction, the equivalent of three seconds of video. Afterward, this group of feature maps is concentrated into a single pattern, which will be the input of our proposed DBN model, to obtain the final classification of the traffic violation system [28,24]. The computer vision workflow is presented in Figure 3.

![Figure 3. Computer Vision WorkFlow](image-url)
3.3. **RFID**

There is only few research about the use of RFID as a vehicle identity. There is a research on the identity of vehicles that use smart cards, namely by replacing a Driving License (SIM) with a smart card. If there is a violation, then the violation data will be stored in the SIM [13]. Utilization of RFID as an identity attached to the vehicle has been done for the parking system [14] by placing a tag on the vehicle. If the vehicle enters the parking lot, the tag will read the reader. If the identity is registered, then the vehicle is welcome to enter. Also, the use of RFID as a vehicle identity attached to the vehicle is used for tollgate payments [15]. This tollgate payment system is done by installing tags on the vehicle and reader above the toll gate. If the vehicle passes the toll gate, then the vehicle's identity is read then this identity is calculated to deduct the balance on the registered account. It occurs because RFID has the ability for long-distance wireless communication so it can be used to monitor traffic violations, especially traffic light.

4. **Future challenge**

By analysing the current research, authors have collected several topics about the detection of traffic violations that may be relevant in the near future. Some of the common topics in other transmitters, such as VANET for reporting, are relatively new technologies. There is still plenty of room for improvement to show potential reporting on traffic violations.

Cloud computing plays a significant role in storing and processing inputs of data in real-time. We suggest making a reporting mechanism no longer than a few hours to reach the authority and violator. Also, this process can potentially get a delay depending on the capacity of data that can be stored, handling process, maintaining inputs. Most of the paper is about computer vision referring to the plate number registration detection. In some cases, there can be a driver who is not the owner of the vehicle made a violation. Thus, developing face detection to the driver is needed to help identify the violator more accurately. Regulations and rules need to be applied in cloud computing to help to do documenting various detection with an appropriate fine. Automation of documentation and a digital report will be useful to propose a quick decision for ticketing and avoid some possible case about lost documents or cheating.

Having a sensor to work non-stop can cost electricity. The solution can be done by minimizing the trigger development to start the sensor to work. Developing VANET in gathering information from RFID and Camera about a violation is made and sent to the cloud to process for better accuracy. And, developing RFID to apply in all signs and driving licenses to improve the tracking the violation.

Another challenge for identifying traffic violations in the future is the application of the device in a number of circumstances, such as various weather conditions and light conditions. As we know, current image-based detection is very sensitive to the nature of the image used as input. The image that is too dark or too bright may reduce the accuracy of the detection system. Further work is therefore required to improve the reliability of image-based traffic violation detection.

5. **Conclusion**

The paper has reviewed the state-of-the-art detection of traffic breaches in recent years. Specifically, convergence of RFID, computer vision, mobile, camera, cloud computing and VANET to detect traffic violations. Although issues that limit during implementation could not be denied because the environment is not weather-friendly and the cost of applying all of the technology referred to is quite costly. Further research is needed to explore the best possible implementation of these technologies under different weather and light conditions.

**Acknowledgements**

This research publication is fully supported by Bina Nusantara University.
References

[1] Firouzabadi M H H and Azizi R. 2019. Automatic identification of personal automobiles plates of Iran using genetic algorithm. Computer Engineering and Intelligent Systems.

[2] Hirawan D, Hadiana A, Abdurakhim A 2019. The prototype of traffic violation detection system based on internet of things.” IOP Conf. Series: Materials Science and Engineering, 2019.

[3] Agarwal Y, Jain K, Karabasoglu O. 2018. Smart vehicle monitoring and assistance using cloud computing in vehicular ad hoc network. International Journal of Transportation Science and Technology.

[4] Aydin M M, Koffee S, Agkog K, Yildirim M S. 2017. Utilization of a new methodology on performance measurements of redlight violations detection systems. International Journal of Engineering & Applied Sciences (IJIAS).

[5] Krishna, Madhav P, Giridhar M K and Amit S P. 2016. Automated traffic monitoring system using computer vision. IEEE.

[6] Nahri M, Boumalakoul A, Karim L and Lbath A.2018. LoV distributed architecture for real-time traffic data analytics. Elsevier Procedia Computer Science.

[7] Ardakani S P. 2018. ACR: A cluster-based routing protocol for VANET. International Journal of Wireless & Mobile Networks (IJWMN).

[8] Feng S, Joon W C and Dempster A G. 2017. A DSRC Doppler/IMU/GNSS Tightly-coupled Cooperative Positioning method for relative positioning in VANETs. The Journal of Navigation.

[9] Hanana A H A, Idrisa M Y, Kawaiartaya O, Prasad M and Shahe R R. 2017. Real traffic-data based evaluation of vehicular traffic environment and state-of-the-art with future issues in location-centric data dissemination for VANETs. ELSEVIER Digital Communications and Networks 3.

[10] Nejati O and Suraki M Y. 2012. NFC: Smart recording of traffic violation system. ResearchGate.

[11] Kumar T and Kushwaha D S. 2017. Traffic surveillance and speed limit violation detection system. IOS Press.

[12] Dandala T T, Krishnamurthy V and Alwan R. 2017. Internet of Vehicles (IoV) for traffic management. IEEE.

[13] Chang L and Haas Z J. 2017. Multi-hop routing protocol for RFID systems with Tag-to-Tag communication. 36th IEEE Military Communications Conference, Baltimore, MD, October 23-25.

[14] Ahmed S H, Yaqub M A, Bouk S H and Kim D. 2016. SMARTCOP: ENABLING SMART TRAFFIC VIOLATIONS TICKETING IN VERNACULAR NAMED DATA NETWORKS. Hindawi Publishing Corporation.

[15] Wong S F, Mak H C, Ku C H and Ho W L.2017. Developing advanced traffic violation detection system with RFID technology for smart city. IEEE.

[16] Ibadov S R, Kalmykov B Y, Ibadov R R and Sizyakin R A. 2019. Method of automated detection of traffic violation with a convolutional neural network. EDP Sciences.

[17] Navaneethan,C, Meenatchi,S, Mutyala V.S.Rathnakumari,and Thamaraiselvi.V.2015. An optimistic approach for data retrieval in vehicular adhoc networks. Elsevier Procedia Computer Science.

[18] Singh S, Negi S, Verma S K and Panwar N.2017. Comparative study of existing data scheduling approaches and role of cloud in Vanet environment. Elsevier Procedia Computer Science.

[19] Abbas Q.2019. V-ITS: Video-based Intelligent Transportation System for monitoring vehicle illegal activities. (IJACSA) International Journal of Advanced Computer Science and Applications.

[20] Aaron C P U, Ana R F Q, Rhen A B, Abad A, Bandala A, Sybingco E and Dadios E P.2016. Automated traffic violation apprehension system using genetic algorithm and artificial neural network. IEEE.

[21] Chaudhari P, Yawle R and Chaudhari P.2017. Traffic Violation detection and penalty.

[22] Özkul M and Çapuni I.2017. Police-less multi-party traffic violation detection and reporting system with privacy preservation. IET Journals.

[23] Roy S, Bose R and Sarddar D.2015. A Fog-Based DSS model for driving rule violation monitoring framework on the internet of things. International Journal of Advanced Science and Technology.

[24] Trepicaćová M, R’ezácˇ P, Kurecˇová V, Zámeˇc’nik P, R’ezác J and Kopeˇc ková J.2019. Differences in facial affect recognition between non-offending and offending drivers. Esevier Transportation Research.

[25] Lu J, Han J, Lv H and Li B. 2015. An ultrasonic sensor system based on a two-dimensional state method for highway vehicle violation detection applications sensors.

[26] Arora M, Jain A, Rustagi S and Yadav T.2019. Automatic number plate recognition system using optical character recognition. IJSRCESEIT.

[27] Firouzabadi M H H and Reza Azizi R. 2019. Automatic identification of personal automobiles plates of
Iran using genetic algorithm. *IISTE.*