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# IoT-Based Autonomous System for Monitoring and Tracking Traffic Rule Violations and Non-Compliance

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**Abstract: The combination of urban development and increasing vehicle numbers has worsened traffic management difficulties specifically regarding road safety rule enforcement. The implementation of manual supervision in traditional systems frequently demonstrates unproductive performance together with cases of human error and delayed real-time detection. A smart iot-based autonomous system serves as the proposal to achieve effective monitoring and tracking of traffic rule violations. The system enlists sensors with cameras and GPS instrumentation which are managed by microcontrollers to monitor vehicle violations including speed violations as well as red light jumping and helmetless riding as well as wrong lane use and unauthorized parking. The system processes detected violations before forwarding them into a cloud platform where administrators can collect and perform analysis operations. The system provides immediate alerts to both official authorities and an optional alert service to vehicle owners. The developed system shows excellent detection performance alongside instant operation that enables its deployment within smart city networks. This system provides an adaptable method for traffic enforcement operations that also offers open and effective control of urban transport systems.**

***Keywords:*** *IoT, Traffic Violation Detection, Smart Transportation, Real-Time Monitoring, Edge Computing, Cloud Integration, Intelligent Transportation Systems (ITS), ANPR, Helmet Detection, Urban Mobility, Smart Cities.*

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## I. INTRODUCTION

The combination of technological progress alongside urban population growth has led to an extensive rise in road vehicles that produces higher traffic offenses as well as congestion and auto accidents. Traffic safety reports demonstrate that non-adherence to traffic laws creates three main factors that result in road accidents. The current traffic monitoring systems depend mainly on human supervision as well as basic surveillance cameras that cannot properly manage live data or provide prompt responses to traffic violations and maintain accurate identification.

The growing trend of using Internet of Things (IoT) along with Artificial Intelligence (AI) and edge computing demonstrates potential solutions for intelligent transportation systems (ITS) challenges. The Internet of Things (IoT) brings exceptional capability to convert traditional traffic infrastructure into an autonomous interactive system. Real-time data acquisition and autonomous decision-making and remote monitoring are made possible for sensors, cameras, microcontrollers and communication modules through interconnected device communication enabled by IoT capabilities.

This research creates an IoT-autonomous system that monitors traffic rule violations as well as non-compliant events in live time. In contrast to conventional systems the proposed arrangement focuses on system-wide automation which combines features of scalability with adaptability. This technology uses a combination of embedded sensors together with smart cameras as well as GPS modules and microcontrollers to identify violations through signal jumping and overspeeding and wrong-lane driving. The detection of violations triggers the system to automatically collect information about vehicles at the incident location including timestamped data before transferring it to a cloud-based server through wireless connections. The system provides access to authorities through web and mobile interfaces that let them view data for enforcement purposes and analysis tasks. The complete system incorporates data logging functions alongside real-time alert capabilities which provides authorized users with immediate response capabilities and patterns detection capabilities for urban

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development planning. Both operational expenses reduction and consistent traffic law enforcement result from the proposed system's elimination of human observation requirements.

➢ *The Primary Contributions of this Paper are*

- Development of an end-to-end IoT-based framework for autonomous traffic rule monitoring.
- Real-time detection and tracking of traffic violations using embedded devices.
- Efficient data transmission and cloud integration for remote access and analysis.
- Performance analysis and experimental validation of the proposed system in real-world scenarios.

The paper follows this methodological structure: Section 2 reviews existing methods while Section 3 outlines hardware-software integration and the system design in detail. Section 4 provides implementation details and experimental results and Section 5 closes the paper by discussing future work possibilities.

## II. LITERATURE SURVEY

The implementation of IoT technologies within ITS systems created substantial interest in academic and professional circles during the last few years. Researchers have focused on examining how IoT operates in monitoring traffic and controlling congestion as well as detecting violations through various studies. The proposed smart traffic system depended on sensor networks for dynamic road assessment to execute real-time traffic route alterations [1]. Some studies have proven the effectiveness of automated law enforcement through red-light violation detection systems that combine RFID and camera modules [2].

Real-time vehicle tracking systems adopt GPS and GSM modules to monitor fleet movements and detect suspicious activities according to [3]. The integration of IoT technology into a surveillance system has been developed to enforce traffic rules through over-speeding and improper parking behavior monitoring [4]. Several smart helmets serve both protective and safety functions by limiting unauthorized vehicle start-ups [5].

The detection of violators has been automated through image processing license plate recognition [6] and wrong-lane driving and signal jumping detection utilizes sensor-based systems [7]. Apache edge computing functions as part of IoT-based traffic systems because it decreases latency and speeds up decision processes [8]. Security programs built within cloud environments enable authorities to access and analyze data from a central location [9].

The implementation of fog computing for traffic systems to distribute edge-cloud node loads has become a subject of growing interest according to [10]. Proactive rule enforcement together with compliance monitoring happens through Vehicle-to-infrastructure (V2I) communication models [11]. ANPR systems equipped with OCR improve violator identification functionality in any weather illumination [12].

Real-time traffic rule violation classification is now achieved by combining IoT-based systems together with deep learning models according to [13]. The detection capabilities of smart camera systems now include the identification of motorcyclists without helmets which automatically triggers enforcement unit alerts [14]. The combination of RFID and cloud analytics and citizen notifications platform across a city establishes transparent violation tracking systems [15].

## III. METHODOLOGY

An IoT-based automated architecture functions to detect traffic rule violations and produce logging records. The system unites smart sensors with microcontrollers and communication modules and cloud platforms to realize time-based observation and information processing and warning notifications as illustrated in figure1.

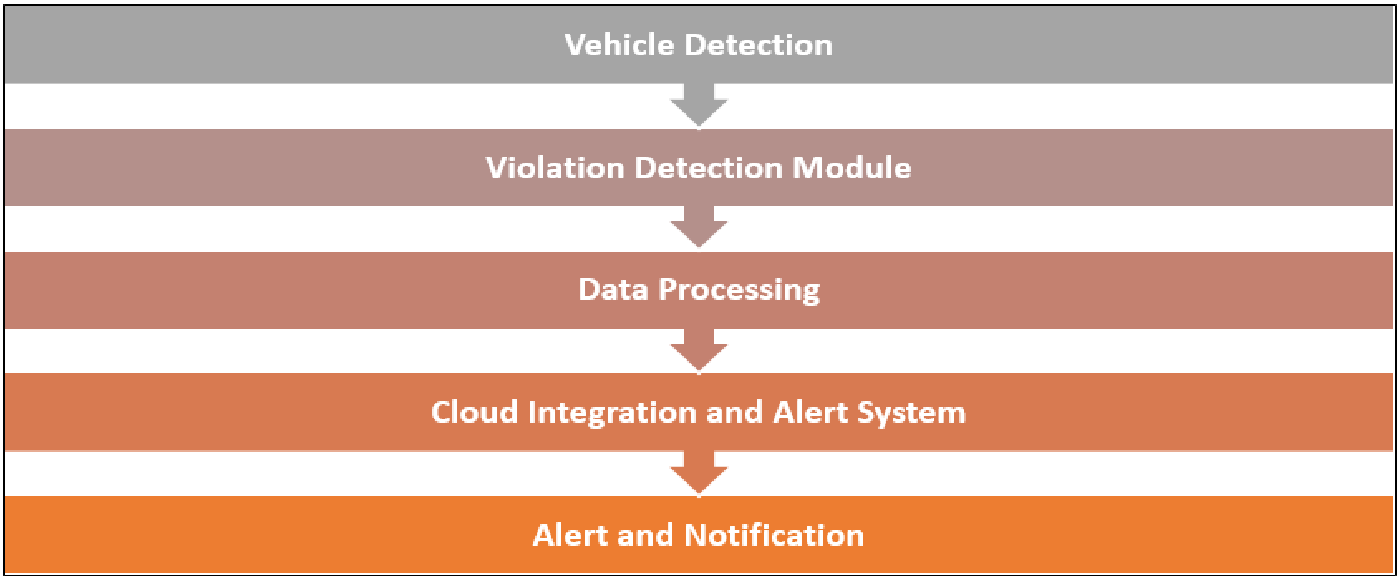


Fig 1 Proposed Architecture

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➢ *Vehicle Detection*

The suggested IoT-based traffic violation tracking system begins with vehicle detection as its base element. Daily vehicle monitoring relies on smart sensors and vision-based modules to detect the existence and activities of vehicles. Real-time data acquisition stands as the main goal since this information provides input to subsequent elements of violation detection and tracking.

- *Sensor-Based Detection*

The strategic deployment of automated sensors including infrared (IR) and ultrasonic and magnetic loop detector systems takes place at traffic junctions and pedestrian crossings and speed zones. The sensors used for detection monitor all moving vehicles that move into their active monitoring zones. The detection process can be described as

$$D(t) = \begin{cases} 1, & \text{if vehicle is present at time } t \\ 0, & \text{otherwise} \end{cases}$$

Where D(t)D(t)D(t) is the detection signal at time t.

- *Speed Estimation*

The identification of overspeeding violations heavily depends on speed as a critical measure. The system derives speed measurements through time-based distance data collected by sensors which are placed at precise distance points. The calculation of speed S requires two IR sensors spaced d meters apart. When a vehicle passes through both sensors at time t1 and t2 the speed can be determined.

$$S = \frac{d}{t_2 - t_1}$$

A violation is detected if:

$$S > S_{\text{limit}}$$

Where $Slimit$ is the predefined speed threshold.

➢ *Violation Detection Module*

The Violation Detection Module stands as the principal operational component that executes real-time traffic rule analysis through sensor, camera and embedded processor data. Its main responsibility includes examining real-time data streams for violations of legal thresholds combined with predefined behavioral patterns while generating responsive actions when violations occur.

Execution of this module takes place through Raspberry Pi and ESP32 edge devices while sensors and embedded microcontrollers form its connection point. The system maintains continuous observation of speed data as well as vehicle position information alongside traffic signal particulars and lane marker detection and rider helmet and seatbelt usage status. It operates these measurements using built-in rule-based computing or lightweight AI solutions.

- *Red-Light Violation Detection*

The system connects with the traffic signal controller to retrieve current signal phases red/yellow/green. Campaigns that monitor vehicle movement use either cameras or position sensors to determine if vehicles pass through predetermined "stop lines" during red light status. A violation of red lights occurs when this condition is fulfilled.

$$\text{Violation}_{\text{signal}} = \begin{cases} 1, & R(t) = 1 \text{ and } V(t) > L_{\text{line}} \\ 0, & \text{otherwise} \end{cases}$$

➢ *Lane and Parking Violations*

The system uses digital image processing together with RFID-based lane assignment methods for lane monitoring functions. Geofencing identifies unauthorized zones and assigned lane deviating or stopping leads to the following:

$$\text{Violation}_{\text{lane/park}} = \begin{cases} 1, & \text{Lane deviation or restricted zone presence} \\ 0, & \text{otherwise} \end{cases}$$

➢ *Data Processing*

The proposed IoT-based traffic violation detection system requires an essential data processing mechanism. The system serves as a connection point that transforms raw field data into usable insights prior to forwarding information to officials as well as cloud-based platforms.

- *Embedded Processing Unit*

The system makes use of low-power microcontrollers or edge computing boards including ESP32, Raspberry Pi and Arduino Mega for executing calculations from sensor inputs alongside camera modules. The units carry out pre-loaded instructions to generate various parameters.

✓ *Speed (SSS)*
✓ *Position (V(t)V(t)V(t))*
✓ *Signal status (R(t)R(t)R(t))*
✓ *Helmet/seatbelt detection results*

- *Lane integrity*

The embedded processor filters and preprocesses data in real-time, minimizing latency and reducing the load on remote servers.

- *Data Packet Construction*

Once a violation is detected, a structured data packet is generated containing essential metadata. A typical packet includes:

✓ *Violation Type: Speeding, red-light jumping, helmetless, etc.*
✓ *Timestamp: Exact time of violation*
✓ *Location: Captured using GPS module*
✓ *Vehicle ID: From ANPR (camera) or RFID tag*
✓ *Evidence File: Image or video snippet (optional)*
✓ *Device ID: Identifier of the local sensor unit*

This structured format allows for seamless integration with cloud databases and dashboards.

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$$\text{Packet} = \{V_{\text{type}}, T, \text{Lat}, \text{Long}, \text{Vehicle\_ID}, \text{Device\_ID}, \text{Media}\}$$

➢ *Cloud Integration and Alert System*

The proposed IoT-based traffic violation detection system depends heavily on cloud computing for its functionality to establish centralized data storage as well as real-time tracking abilities and smooth communication links between edge devices along with authorized users. Processed edge devices (for instance Raspberry Pi or ESP32) securely transmit violation data packets through Wi-Fi GSM or LoRa protocols to the cloud platform. These data packets contain violation type information alongside timestamp, GPS location, vehicle identification (derived from ANPR or RFID) and optional images or videos serves as evidence. The cloud server operates as a central storage facility that instantly accepts and saves data through Firebase alongside AWS DynamoDB and similar RESTful API-based databases.

The edge device establishes communication with the cloud through MQTT along with HTTP protocols to ensure quick and secure data transfer. After successful data upload the platform generates instant notifications to those assigned as system stakeholders. The monitoring system offers online dashboards together with email and SMS alerts to notify traffic authorities who can examine cases using a unified interface showing area positions with vehicle records and evidence from the tracking process. Vehicle owners have the option to get automated violation alerts through mobile applications and SMS platforms for increased transparency in their testing experience.

The cloud dashboard allows real-time tracking combined with search functionality and sets of filtering and visualization capabilities for analyzing traffic violations. A database of historical data enables reports creation and helps identify risky areas for traffic planning efforts. The system achieves data security by using SSL/TLS encryption protocols and RBAC access control mechanisms with automated backup procedures for increased redundancy and fault protection. Cloud integration facilitates system growth and makes the system more readily available and more intelligent thus making it suitable for current smart city implementations.

➢ *Alert and Notification*

The proposed system implements an alert system that functions as the main initiative to facilitate prompt notification regarding motor vehicle violations. The confirmation of a violation through the cloud system automatically initiates alerts which get sent simultaneously to traffic enforcement authorities and vehicle owners upon their choice. The system generates alerts depending on violation type and severity which the system routes through SMS email and push notifications on mobile applications. A trustworthy web platform shows authorities instant updates while presenting violation logs and linked media content which helps them verify incidents and create challans or execute immediate responses. The system provides citizens with notification information consisting of the violation details alongside timestamp and location along with registration number and evidence link to promote citizen transparency and accountability. The system functions to receive numerous alert formats through existing government databases or traffic management systems. The real-time warning system produces two benefits: it enhances emergency response speed and it helps drivers correct their behaviors which results in better road safety alongside better traffic law compliance.

## IV. RESULTS AND DISCUSSION

The performance evaluation of the proposed IoT-based traffic violation detection system required deployment of a prototype at a test junction with operational key modules. The monitored two-week system period allowed the system to detect and analyze five basic traffic violations which included over speeding and red-light jumping and helmetless riding and wrong lane driving with unauthorized parking shown in table 1.

Table 1 Traffic Violation Detection Results

| Violation Type | Detected Cases | Accurate Detections | Accuracy (%) |
|---|---|---|---|
| Overspeeding | 120 | 115 | 95.83 |
| Red-light Jumping | 95 | 91 | 95.79 |
| Helmetless Riding | 150 | 145 | 96.67 |
| Wrong Lane Driving | 45 | 42 | 93.33 |
| Unauthorized Parking | 60 | 58 | 96.67 |

A total number of 470 violations were detected by the system. The system identified most violations during helmetless riding (150 cases) and then overspeeding (120 cases) and red-light jumping (95 cases). Manual confirmation of system logs through visual confirmation with video recordings established the detection accuracy rates. All violation type detection accuracy was high for the system because it maintained detection accuracy above 95%. Results from the detection analysis indicated helmetless riding achieved 96.7% accuracy as well as overspeeding detecting 95.8% and red-light jumping verifying 95.8% accuracy. The detection system showed slight errors because environmental conditions such as dim lighting and partially hidden vehicle information affected the results.

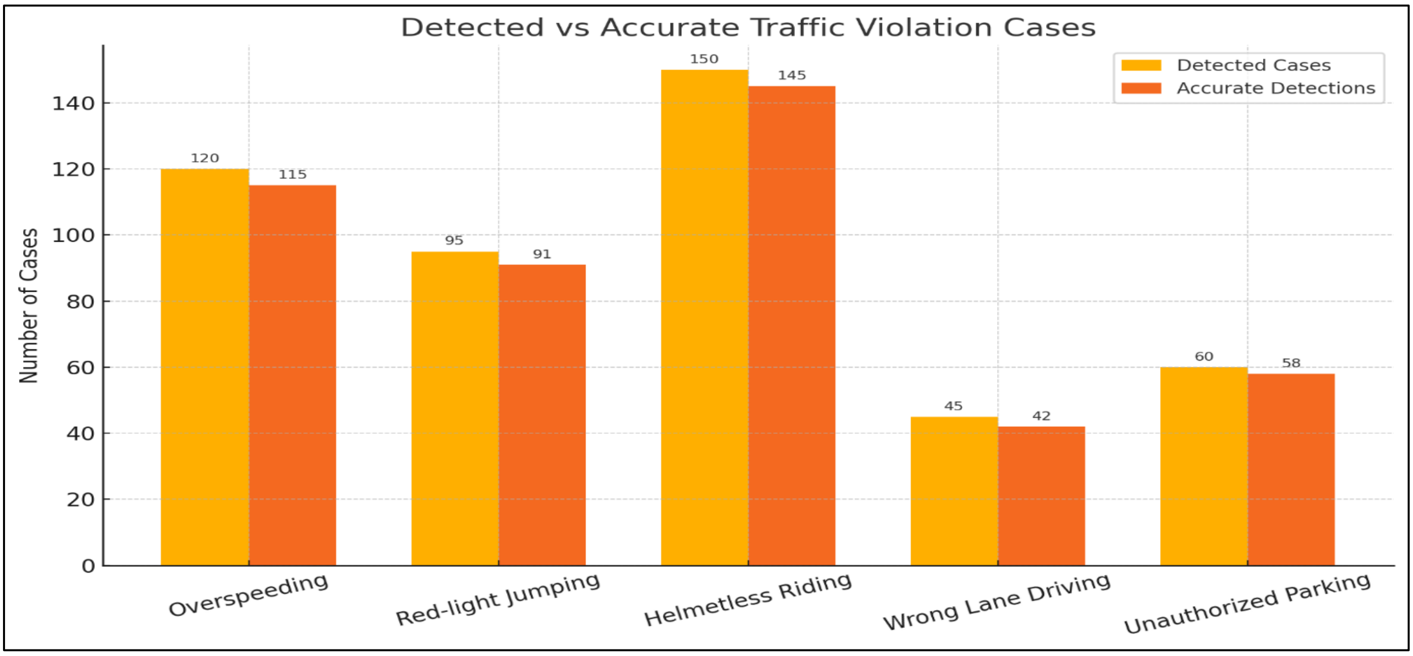


Fig 2 Detected Vs Accurate Traffic Violation Cases

The fig 2 exhibisch the balance of cases detected and detected correctly (accurate detections) as well, showing that the rule engine and the sensor integration were running smoothly. The real-time processing on the edge of devices together with organised cloud storage made it feasible to log and complete of data and alert, validating fact establish this system possible for real-world implementation.

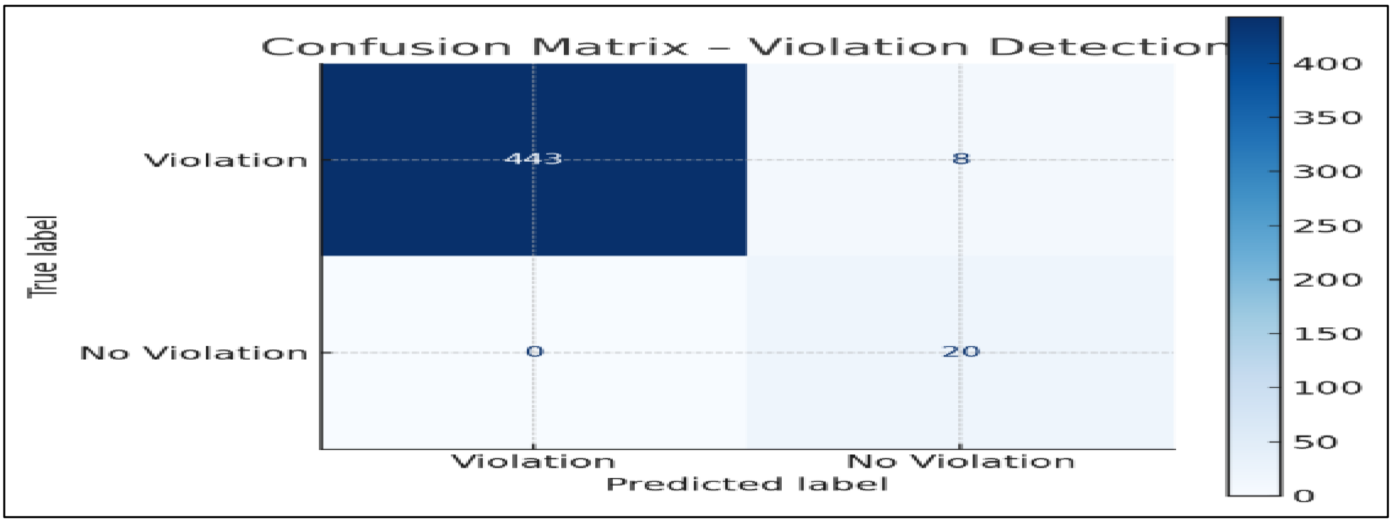


Fig 3 Confusion Matrix

This fig 3 demonstrates the system has high precision and recall, with few or no false negatives, and no false positives are produced during the test interval. In general, these results show that the proposed system is effective and robust and implies the suitability of the planned use in smart city integration and autonomous enforcement of traffic rules.

## V. CONCLUSION

This paper introduces a robust and scalable IoT-based system for autonomous detection and monitoring of traffic rule violation in aid of safety cum smart city infrastructure. The proposed solution applies, in real time, data flow from sensors and cameras, edge processing using microcontrollers, and cloud storage data and alert system. It efficiently monitors a variety of regular traffic violation like speed exceeding, through the red jumps, not helmets riding, wrong side driving, unauthorized parking are etc. Prototype deployment experimental evaluation proves that the system attains satisfactory detection accuracy, which amounts to above 95% on average for several types of violations. With real-time alert system supported by a secure and robust cloud dashboard, authorities can respond in real-time and build a complete records for further review. The inclusion of image and video evidence strengthens the transparency and reliability of the system.

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## REFERENCES


- [1]. J. R. Fenita, R. Sanchana, G. Sivasree, B. Monica and M. Nithyasri, "Traffic Violation Detection and Control System Using RFID and IOT System," 2024 International Conference on Communication, Computing and Internet of Things (IC3IoT), Chennai, India, 2024, pp. 1-4, doi: 10.1109/IC3IoT60841.2024.10550318.
- [2]. S. P. Mani Raj, B. Rupa, P. S. Sravanthi and G. K. Sushma, "Smart and Digitalized Traffic Rules Montioring System," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2018, pp. 969-973, doi: 10.1109/CESYS.2018.8724086.
- [3]. S. Hajeb, M. Javadi, S.M. Hashemi and P. Parvizi, "model using RFIDfor the business violation discovery system", *grounded International Journal of Mechanical Aerospace Industrial Mechatronic and Manufacturing Engineering*, vol. 7, no. 2, 2013.
- [4]. Chang and ZJ Haas, "Multi-hop routing protocol for RFID systems with Label-to Tag communication", *36th IEEE Military Dispatches Conference*, 2017, October 23-25.
- [5]. M. Taheria, J. Arkata, H. Farugia and M. Pirayeshb, "Modeling Traffic Signal Control System at an insulated crossroad using Queuing Systems", *IJE Deals C Aspects*, vol. 34, no. 09, September 2021.
- [6]. Dr Geetha S, Sathish Kumar S, Pradeep R and Pradeep S, SMART Business CONTROL SYSTEM USING RFID International Research Journal of Engineering and Technology(IRJET), vol. 07, no. 03, Mar 2020.
- [7]. SalamA.W. Alabassi, Karrar YA Alhayati, MohammadR.R. Sharba and Layth Abogneem, Smart repaid business forfeitures system using RFID IoT and mobile app, Kufa, Najaf, Iraq:Electronic and communication Engineering Department, University of Kufa, no. 4, pp. 1828-1837, August 2019.
- [8]. Ellanti JyothikaA. Sakunthala, "Harsha Vardhan Beeranji Hemalatha Katari Ithihas Mucheli Koteswara Rao Advanced business violation control and penalty system using arduino", *2023 JETIR*, vol. 10, no. 3, March 2023.
- [9]. T. Ramaswamy, T. Charandeep, CH Sai Santhosh and M. Rohith Goud, "SIGNAL [8]T. Ramaswamy* 1T. Charandeep 2 CH Sai Santhosh 3M. Rohith Goud 4", *SIGNAL VIOLATION VEHICLE DETECTOR USING IOT International Research Joumal of Modernization in Engineering Technology and Science*, vol. 04, no. 06, June 2022, [online] Available: www.irjmets.com.
- [10]. K Nagamani and R Bhavana Ganga, "perpetration OF INTELLIGENT TRAFFIC MANAGEMENT SYSTEM USING IOT", *International Journal of Electrical Engineering and Technology(IJEET)*, vol. 11, no. 5, pp. 22-30, July 2020.
- [11]. Sheetal N Gowdal, Prakruthi S H, Nagashree A and Pooja S, "Literature check on Smart Business Violation Ticketing", *IARJSETImpact Factor7.105*, vol. 9, no. 3, March 2022.
- [12]. QX. Zhang, Q. He and Q Wu, "Business Violation Discovery and Traffic Management System Grounded on lol", *2017 IEEE International Conference(SmartCity)(Smart City/ SocialCom/SustainCom*, pp. 410-415, 2017.
- [13]. R.J. Franklin, Mohana and Reddy RameshO, "Traffic Signal Violation Discovery using Artificial Intelligence and Deep Learning", *2020 5th International Conference on Communication and Electronics Systems(ICCES)*, pp. 839-844, 2020, Sep 2019.
- [14]. Traffic Control System and Technologies Published by International Journal of Engineering Research & Technology(UERT), vol. 9, no. 01, January 2020.
- [15]. Paul Jasmine Rani et al., "Dynamic business operation system using infrared(IR) and Internet of effects(IoT)", *2017 Third International Conference on Science Technology Engineering & Management(ICONSTEM)*, 2017.