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A Conceptual Model Simulation to Detect and Report City Traffic Violations using Distributed Intelligent Agents

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***Abstract*: Migration from village, semi urban to urban increased the population. There are many challenges due to migration, among those, usage of vehicles is the one. Due to large numbers of vehicles usage and lack of enough people to maintain traffic flow and capturing the traffic violation sometimes goes missing. Traffic violation management is a major concern in smart cities. The proposed system uses the Intelligent Agents (IA) which are distributed across the city so that it collects the violation by communicating with each other. The IA is an on-board built-in system inside the vehicle. The Agent receives committed traffic violations from the other vehicles along with vehicle information and Agents then set priority of violation then report it to the controller server for the collection of fines. The controller server communicates with external servers such as the Banking Regional Transport Office (RTO) to get details of the user and deduct fines from the user bank account directly. The usefulness of this proposal are: elimination detection of violations manually, corruption free agents, and builds a dataset which can be used for future prediction. Proposed system is validated by simulation by implementing the system using JAVA programming language.**

Keywords: Intelligent Agents, Sever, Smart City, Sensors, and JAVA

I. INTRODUCTION

In a wider perspective transportation is one of the necessities for people in life. Every so often humans are greedy and during urgency situation they violate rules and regulations. Most of the ignorance leads them to make mistakes, such violations are sometimes recorded by government authorities and sometimes violations are unnoticed. Even noticed/recorded violations may be considered as an excuse and relieved by receiving bribes. To overcome bribe incidents and recording violations without human intervention required. The traffic violation and recording system have been proposed, simulated and implemented.

India lives in villages but people of India die on roads. In India accidents [1] are skyrocketing, which is due to flood of cars, heavy vehicles, poor road planning, rules violations. Rules violations have been common nowadays. Several ways have been developed and deployed to tackle the rule violations such as installing surveillance at intersections. Cameras have deployed along the road side to highlight speed, wrong directions. Using police at different junction regions on a rotation basis. Installing surveillance will cost huge, installing cameras leads to poor processing. Deploying police every day is not feasible and viable. Smart vehicles are manufactured and available on road but the infrastructure for them to handle violation rules is yet to be provided by authorities.

Detecting violations through distributed intelligent agents does not let violators go unnoticed and a penalty is charged irrespective of the circumstances. It detects if the driver is wearing the seat belt or not, if the vehicle is moving in the wrong direction, if the insurance is valid or not, if the car is driving beyond the speed limit. It ensures if the violation has been rectified or not after an interval which eventually leads to a lesser number of accidents. Manpower expected is minimized. Corruption free system is established since human interaction is eliminated. Drivers are forced to obey the traffic rules because they cannot escape the consequences of violating the rules. It builds a dataset which can be used for future studies, surveys, predictions. It aids in maintaining the law and order.

Further, the rest of this paper is organized as follows: Section II presents the related work, and literature survey. The proposed model along with the features is defined in Section III. The implementation of the model is done and the results obtained are discussed in Section IV. Section V presents the conclusion and future scope of this project. References are listed in Section VI.

II. RELATED WORK

The system defined in paper [1] is as follows: a connection is established between the 2MP camera with integrated infrared system and Arduino for desktop, which will be placed at a zebra crossing. After this, the number plate of the vehicle is identified with the help of the image

processing algorithms mentioned. Depending on whether the violation occurred or not, an SMS alert is sent to the user as well as the RTO. The system works quite well however, there is still room for improvement. The camera used in the system for this project is sensitive to vibration and fast changing targets due to the long shutter time. The system speed can be increased with a high resolution camera. The character recognition method is sensitive to misalignment and to different sizes, so the affine transformation can be used to improve the character recognition from different sizes and angles. The statistical analysis can also be used to define the probability of detection and recognition of the vehicle number plate. At present there are certain limits on parameters like speed of the vehicle, script on the vehicle number plate, skew in the image which can be removed by enhancing the algorithms further.

The system described in the given paper [2] consists of a digital camera system deployed at a traffic location. The camera system is remotely coupled to a data processing system. The data processing system comprises an image processor for compiling vehicle and scene images produced by the digital camera system, a verification process for verifying the validity of the vehicle images, an image processing system for identifying driver information from the vehicle images, and a notification process for transmitting potential violation information to one or more law enforcement agencies. The system is efficient but there can be improvements. The system works well for traffic violations that can be captured or identified by the camera like skipping traffic signals, going in the wrong direction, etc. But it cannot be used for detection of violations like over speeding, insurance expiry, drink and drive; the violations that cannot be identified using cameras. Problems with the camera can pose as a difficulty to track the violations that might occur.

The methodology used in paper [3], relates to a method and system for automatically detecting traffic rule violations and applying the respective penal procedures. There have been several traffic monitoring systems in use with the main aim of detecting the violations correctly without any human interactions. Here the automation is done using digital maps, which contain the data of all the roads of a particular geographical area and the information on each roads of that particular region (GIS database) and available satellite-based communication systems and hardware (GPS and GSM). There will be a RAM unit in each vehicle to be traced, containing all the necessary information like traffic signal positioning, speed information about a particular road. Accordingly, a controller which will receive geographical data from the GPS. Data from the GPS and the data from the RAM unit will be compared continuously and if there is a violation, the GSM transmitter in the vehicle will report the violation to the required authorities and a notification in the form of an SMS or email will be sent to the driver by means of a cellular network.

The paper [4], implements an embedded system which is installed in each car can be integrated with the computer of the vehicle. It consists of several modules such as DGPS receiver; and database of the streets and roads (in the form of digital maps); the traffic rules information (e.g. speed limits and if the road is unidirectional or bidirectional); a wireless transceiver; VANET software stack; and the software programs to operate the system. Using the DGPS, the on-board unit can obtain in real time and with high accuracy the current position of the vehicle and hence it can calculate the vehicle's direction (displacement); its speed; and its acceleration or deceleration. As a result, using simple software, many kinds of traffic violations can be detected. The detected violations will be stored in the local memory of the on-board unit and will be used by the other systems.

The paper [5] discusses about developing an android application which maintains a database related to capture image through camera as proof and RFID Tag number such as name of owner, address of owner, license number, photo of vehicle user, mobile number, their bank account number and also the list of previous rules broken with image as proof, date and time and fine paid by vehicle owner. All the data about the vehicle will be displayed on a smart phone of traffic police. The rules violated are detected by means of sensor, RFID reader and RFID tag technology and capture image by means of camera. The system will control the traffic density of the specified location. The application automatically receives the fine from the owner's bank account and send the message to the user mobile application or about the number the rules and their fine. If the same vehicle is found to be flouting rules repeatedly then a specific action could be done.

III. PROPOSED MODEL

Figure 1 depicts the framework of the proposed model. Framework pertaining Agents, Agent monitoring system, User Application, RTO, Bank, Storage Server.

Agents: The agents have a receiver and a sender end. The receiver end is for receiving reports from agents who have violated rules. The sender end is to send a report consisting of violation ID and the agent ID who has violated a rule to the agent monitoring system. The agent has to have information about the violation that is under consideration and should be able to detect that in other vehicles.

Agent monitoring system: The agent monitoring system is responsible for receiving the report consisting of the agent ID and the rule the agent has violated in the form of a violation ID. It is also responsible for reporting the committed violation to the RTO. From this report sent the RTO will be able to take necessary actions for the committed violation.

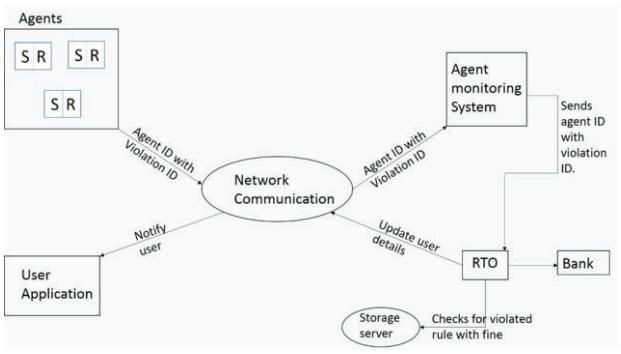

Fig. 1. Figure 1Framework of the proposed model

RTO: The RTO receives the violation ID and the agent ID who has committed the violation. The RTO matches the violation ID with the violation in their storage server with matching the agent ID with the owner of the vehicle. The RTO then updates the details of the fine that will be deducted from the owner's account to the user.

User application: The user application is responsible for notifying the user with the violation committed with the fine that is deducted from the user's account. The user application is only an interface that informs the user after the fine is deducted and nothing else. The application is installed initially only with basic credentials.

A database of streets and roads is primarily fed to the agents with information about the rules it has to detect and report. The information about the rules may be information about speed limits and if a particular road is unidirectional or bidirectional. If any of the rules is violated, it is reported to the agent monitoring system with the violation ID and gent ID.

*A. 3.1 **Working of overall system:***

The proposed framework is implemented via simulation. By assuming hardware parts and servers as object oriented classes, the framework is simulated. Four traffic rules: Seat Belt, wrong direction, over speeding and uninsured vehicles, from the website of the government of India were picked which were being violated frequently. Based on the design, how agents will detect each violation committed by some other agent which is installed in another car is made. A java program is written for performing simulation and predicting how many times which violation occurred by running the program for at least 1 hrs.

Based on the design there should be a server class and an agent class. Server class will act as RTO server which will have all the details of the registered agents. Agent's class will be superclass for all the violation classes and reporting agent's class will be subclass for all the violation classes which will send the violated agents' details to the server and also notify the user about the violation committed. For all the modules which we are using in our design, a separate class will be defined with their use for them from where we can fetch the details if needed to detect violations. In agent class, all the four violations will be called one by one to one and based on the algorithm, it will check whether the violation is committed or not. For simulation purposes we will run the program in a while loop for at least one hour. Simulation consists of Server.java, Agent.java, Seat_belt.java, and Wrongdirection.java.

*B. 3.2 **Algorithms for how each violation detection will work is as follows:***

1) Seat Belt Violation:

1. Start.
2. Define initial value of engine as 1 and then randomly generate value of seat as 1 or 0.
3. Then generate two random serial numbers and call reporting agent class by creating its object and send two randomly generated serial numbers to that class.
4. Call violated agent and reciever_agent function and get random violated and reporting agent id respectively.
5. Give a buffer time of 10 min and then start a while loop which will run till the engine is not equal to 0.
6. Check if the randomly generated value of the seat is 1 or 0. If it's 1 then go to step 6 or else go to step 10.
7. If the value of the seat is 1 then it means that the driver is wearing the seatbelt.
8. Give buffer time of 15min and randomly generate value for seat and engine.
9. If engine is 0 then terminate the loop and go to step 18.
10. If engine is 1 then repeat step 5 to 8.
11. If the value of the seat is 0 then it means that the driver is not wearing the seatbelt.
12. Give an alert of 5 beeps as warning to wear the seat belt and after warning provide a buffer time of 10min.
13. Again generate random value for engine and seat. If the value of the engine is 0 then it means the engine is stopped and thus terminates the loop and goes to step 18.
14. If engine ==1 then check if the seat is 1 or 0. If it is 1 then repeat step 6 to 9 else go to step 14.
15. If the value of the seat is still 0 even after giving warning then it means that seatbelt violation is committed by the driver. Send agent details to the server through reporting agent class.
16. Provide a buffer time of 10sec to let the server update the databases.
17. After updating databases send notification to the user.
18. Return seat, agent_id, reciever_agent_id and engine to the agent class.
19. In the main class print the messages according to the returned values.
20. End.

2) Wrong direction violation

1. Begin
2. Generate two random agent ids where one will be
3. Receiving/reporting agent and another will be the
4. Agent who will be checked for any committee violation.
5. To check if there is any agent present in the area, the coordinates of the violating agent and the reporting agent are checked if they are equal.
6. If true: A random direction for the agent is generated
7. Actual permitted direction for the area and the area in which the agent is present is fetched from the database using the GPS class. The generated random direction is compared to the actual permitted direction, if false then agent has to be reported by reporting agent by sending details of the violated agent to the server. A buffer is added here so as to provide time for the server to fetch

details from the database and update it accordingly.

8. If the condition is false, that means the agent is moving in the permitted direction.
9. After updating databases send notification to the user.
10. Return agent_id and reciever_agent_id to the agent class.
11. In the main class print the messages according to the returned values.
12. End

3) Overspeeding Violation:

1. Begin
2. Generate two random agent ids where one will be receiving/reporting agent and another will be the agent who will be checked for any committed violation.
3. To check if there is any agent present in the area, the coordinates of the violating agent and the reporting agent are checked
4. If true then, the current speed of the agent is fetched and the area in which the agent is present is also fetched using gps. For that area fetch the permitted speed. Compare the current speed with the permitted speed of the area, if the speed is within the speed limit, there is no violation, else a buffer of 20 seconds is given for the agent to slow down. After 20sec again the current speed is fetched from the speedometer. If the new current speed is within the speed limit then no violation, else the violation has been committed by the user.
5. Violated agent's details will be sent to the server by the reporting agent and then a buffer of 10sec will be given for the server to update the database.
6. After updating the database, send notification to the user.
7. Return agent_id and reciever_agent_id to the agent class.
8. In the main class print the messages according to the returned values.
9. End.

4) Uninsured Vehicle:

Figure 2 depicts flowchart for detection of uninsured vehicles. Generate a random AGENT ID. The agent itself will check on every 10th of the month and report by itself rather than sending it to any other agent. From the database, fetch the vehicle's insurance expiry date of the randomly generated agent then for current date, let date be 10 and month and year be random numbers. Months will be generated between 1 to 12 and years from 2018 to 2021. Compare Expiry date and current date if the current date is greater than expiry date then it means the insurance of the vehicle has expired already then give a warning to the user by sending notification to the user and provide a buffer of 3 days to let the user update insurance of the vehicle. Again fetch the insurance expiry date from the database and check it with the current date. If current date is still greater than expiry date then violation has been committed which will be reported to the server by sending his details to the server. After sending the details, give a buffer of 10 seconds to let the server update the database and then send notification to the user. If the current date is less than expiry date then the insurance is valid.

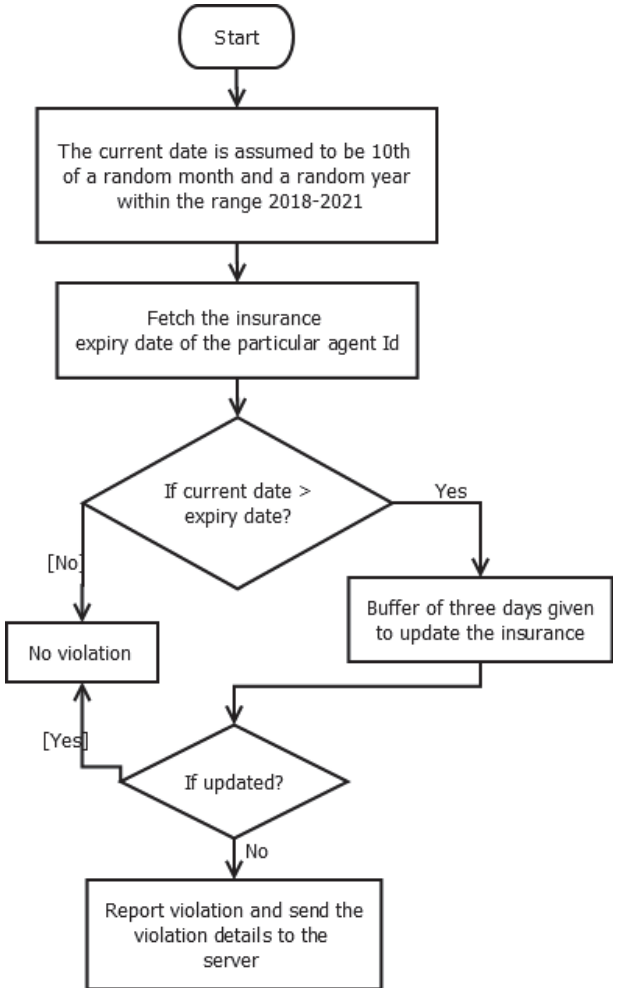

Fig. 2. Flowchart for detection of uninsured vehicles

IV. EXPERIMENTAL RESULTS

In this section, results obtained by this project are shown. Each and every outcomes of the project are explained with screenshots along with justification. Based on the design and algorithm, a java program was made for simulation. Random values were generated and based on the algorithm, it was simulated. Since it is a simulation, whatever results we got from this project are just predictions and not actual results. We simulated the program for approximately one hour and got the output with different results. 53 agents were reported for violations in 1 hour.

Case1: Insurance Violation committed: Figure 3 shows that an insurance violation is committed by the agent. Current date and expiry date is compared and found out that current date is greater than the expiry date and thus the user is sent a warning notification on mobile and given a 3 days buffer to get insurance renewed. After 3 days again the current and expiry date is checked and found that still it is not updated even after the warning and thus violation is committed by the user and reported to the server by sending the details to the server. After reporting, the user

receives a notification in her mobile for the violation she has committed, date and time at which this violation is reported and fine which has been deducted accordingly.

```
CHECKING INSURANCE OF THE VEHICLE....
Loading class `com.mysql.jdbc.Driver'. This is deprecated. The new driver class is `co
CURRENT DATE: Fri Jan 10 17:13:24 IST 2020
EXPIRY DATE: 2018-06-21
INSURANCE OF AGENT KA02011A IS EXPIRED!!
WARNING THE AGENT BY SENDING NOTIFICATION TO UPDATE THE INUSRANCE WITHIN 3 DAYS
SENDING NOTIFICATION TO THE AGENT....
NOTIFICATION SENT!!
CHECKING INSURANCE EXPIRY DATE AFTER GIVING THREE DAYS WARNING TO THE USER!!
INSURANCE IS STILL NOT UPDATED EVEN AFTER GIVING THREE DAYS WARNING TO THE USER!!
*********UNINSURED VEHICLE VIOLATION*********
SENDING AGENT ID AND VIOLATION TYPE TO THE SERVER
CONNECTING TO THE SERVER......
SERVER CONNECTED
REPORTING THE COMMITTED VIOLATION........
SENDING NOTIFICATION TO THE USER.......
NAME = Animesh Srivastava
ID = KA02011A
VIOLATION TYPE: Insurance violation
DATE: 2020-08-03
TIME: 17:13:38
FINE DEDUCTED: 2000
AGENT KA02011A HAS VIOLATED INSURANCE VIOLATION WHICH HAS BEEN REPORTED TO THE SERVER
```

Fig. 3. Insurance violation

```
CHECKING FOR SEAT BELT VIOLATION....
CHECKING AGENT KA04014F FOR SEAT BELT VIOLATION
BUFFER OF 10 MIN IS GIVEN FROM THE TIME ENGINE IS SWITCHED ON
DRIVER IS NOT WEARING A SEAT BELT
AN ALERT OF 5 BEEPS IS GIVEN TO THE DRIVER TO WEAR THE SEAT BELT
BUFFER OF 15 MIN IS GIVEN AFTER WARNING THE DRIVER
DRIVER DIDN'T WEAR THE SEAT BELT EVEN AFTER THE WARNING
*******SEAT BELT VIOLATION*******
SEARCHING FOR NEARBY AGENTS.....
FOUND AN AGENT KA04090N
SENDING AGENT ID AND VIOLATION TYPE TO NEARBY AGENT i.e. KA04090N THROUGH WIFI MODULE
CONNECTING TO THE SERVER......
SERVER CONNECTED
REPORTING THE COMMITTED VIOLATION........
SENDING NOTIFICATION TO THE USER.......
NAME = Aditi Sharma
ID = KA04014F
VIOLATION TYPE: SeatBelt violation
DATE: 2020-08-03
TIME: 17:02:35
FINE DEDUCTED: 1000
AGENT KA04014F HAS VIOLATED SEAT BELT RULE AND AND IT HAS BEEN REPORTED BY AGENT KA04090N
```

Fig. 4. Seat belt Violation

Case 2: Seat Belt Violation: Figure 4 shows that seatbelt violation is committed by the user. Based on the algorithm, the first 10min is given after the engine has started. Even after the 10 min buffer driver was not wearing the seatbelt and thus the warning was given to the user with an alert of 5 beeps. And after a buffer time of 15min, again he was checked but still he wasn't wearing the seatbelt thus seat belt violation is committed. Then a nearby agent is searched and to that agent, details of the violated agent are sent and through that agent, details have been sent to the server and the database is updated. After that user is sent a notification for the committed violation with all the details.

```
CHECKING FOR OVERSPEEDING VIOLATION....
KA04090N AGENT SEARCHING FOR AGENTS NEARBY......
FOUND AN AGENT KA04014F
FETCHING ITS CURRENT SPEED....
CHECKING AGENT'S SPEED WITH PERMITTED SPEED....
CAR'S CURRENT SPEED IS MORE THAN THE SPEED LIMIT!!
GIVING BUFFER TIME OF 10SEC TO DRIVER TO MAINTAIN THE SPEED LIMIT
CAR WITH AGENT ID KA04014F IS STILL GOING MORE THAN THE SPEED LIMIT
*********OVERSPEEDING VIOLATION*********
CONNECTING TO THE SERVER......
SERVER CONNECTED
REPORTING THE COMMITTED VIOLATION........
SENDING NOTIFICATION TO THE USER.......
NAME = Aditi Sharma
ID = KA04014F
VIOLATION TYPE: Speed limit violation
DATE: 2020-08-03
TIME: 16:57:51
FINE DEDUCTED: 1000
AGENT KA04014F HAS VIOLATED OVERSPEEDING RULE
THIS VIOLATION HAS BEEN REPORTED BY AGENT KA04090N IN  4th main road RAJAJINAGAR
```

Fig. 5. Figure 2 over speed violation

Case 3: Over-speed violation committed: Figure 5 shows that over speeding violation is committed by the user. First an agent searches for nearby agents in the vicinity and when found fetches its current speed. From the database, permitted speed is fetched and both permitted and current speed is checked and found that the user is going above speed limit and thus user is given a 10sec buffer time to maintain his speed according to the speed limit. After 10sec again speed is fetched and found that the speed is still more than the speed limit and thus violation has been committed by the user. Receiving agent will then send the details of the violated agent to the server and the database gets updated. After that user is sent a notification about the violation committed with all the details of the violation.

Case 4: Wrong direction committed: Figure 6 shows that an agent searches for any nearby agents and finds an agent. Then it fetches his current direction in which the car is going. Then from the database, permitted direction is fetched and compared with the current direction and found that the agent is going in the wrong direction thus the wrong direction violation is committed by the user. Agent's details are sent to the server by the receiving agent and the database is updated and after that a notification is sent to the user with all the details of the violation committed.

```
CHECKING FOR WRONG DIRECTION VIOLATION....
KA02049C AGENT SEARCHING FOR AGENTS NEARBY......
FOUND AN AGENT KA04014F
FETCHING ITS DIRECTION....
CHECKING AGENT'S DIRECTION WITH PERMITTED DIRECTION....
CAR WITH AGENT ID KA04014F IS GOING IN WRONG DIRECTION
*********WRONG DIRECTION VIOLATION*********
CONNECTING TO THE SERVER......
SERVER CONNECTED
REPORTING THE COMMITTED VIOLATION........
SENDING NOTIFICATION TO THE USER.......
NAME = Aditi Sharma
ID = KA04014F
VIOLATION TYPE: Wrong direction
DATE: 2020-08-03
TIME: 16:58:36
FINE DEDUCTED: 500
AGENT KA04014F HAS VIOLATED WRONG DIRECTION RULE
THIS VIOLATION HAS BEEN REPORTED BY AGENT KA02049C IN Chord road RAJAJINAGAR
```

Fig. 6. Wrong direction violation

V. CONCLUSION

Numerous solutions have been available to detect traffic violations using camera. Using image processing and video processing to identify traffic violation and violator, these solutions are expensive and time consuming. Information about the existing government rules and regulations for traffic rules violations was collected. The proposed model consists of devices installed inside the vehicle and each device acts an Agent. Agent inform and collects violation rules and reported to central server. And also the reported violators pays fine from their respective bank account which is linked with RTO. The proposed model was simulated using JAVA programming by creating Classes by designating particle work to each classes which resembles hardware part required to create a device. Intelligent agents to understand traffic violations were successfully modelled and simulated. The intelligent agents were successfully implemented in java. The simulated agents were deployed/distributed to detect traffic violations made and report them respectively.

In future, simulated version is converted as hardware parts and software parts. Hardware such as sensors,

transmitters, receivers made as an Agent by installing rules in this unit. GPS module is connected with an Agent unit to provide geographical information and SMS and report generation to vehicles owners via Banking system, RTO server, Cloud storage which consists of user vehicle profile database, rules and regulation information database. SMS alert consists of violation type, fine collected and timestamp. We can add more traffic violation rules in addition to the four violations. We can install these agents in 2 wheelers as well. These agents can be installed to the newly manufactured cars as of now, a way to install these agents to existing cars should be found. We can extend this project's implementation from an area to city or country as well.

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