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Web Application for Traffic Monitoring and Guidance

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Abstract. Nowadays, it is becoming challenging in populated cities like Bangalore, India, to control the Traffic or divert the Traffic. The Traffic authority cannot control Traffic all at a time and cannot collect fines or penalties from people since everything is moving digital. There are many problems like traffic congestions, surveillance. So, we want to help the traffic authority with our Stand-Alone Web Application, which helps them get insights into Traffic, control traffic, do the surveillance, and all other features. It can be used in situations where real-time surveillance is required to get the traffic insights, trends in traffic flow in a particular location are needed. With the help of those insights, the vehicles can be diverted, or any other solutions can be implemented. Since many machine learning models are created but not implemented, we decided to create an Application with our model. Herewith this application, we want to help the Govt. or Traffic Authority get Traffic's insights. Predict the future Vehicle flows from the prediction module implemented with LSTM neural network and have metrics values, i.e., Mean Squared Error MSE = 95.328306. Root Mean Squared error RMSE=9.763622. They can also use this application for all the real-time surveillance with Vehicle Plate Recognition. It also has the feature like Penalty for traffic violations which can be directly notified to the user through the mail after the Admin approval.

Keywords: Long short-term memory (LSTM), root mean squared error (RMSE), mean squared error (MSE), advanced traveller information systems (ATIS), deep neural network (DNN), tensor flow (TF).

1. Introduction

It is challenging to control the flow of vehicles in cities and crowded areas. Many vehicles are jumping the traffic signals and are violating the laws. As students, we want to contribute to the traffic police so that their difficult task of controlling vehicle traffic can be reduced. We want to do some experiments on this scenario. Many Traffic Guidance systems are present in the real world, which implements the vehicle images' use and visualizing. Their metrics are present, but the main problem of signal jumping, which leads to accidents, are not present. We want to focus more on this problem where the vehicles are stopped or fined, or any other actions are taken. Sometimes it's challenging to get vehicle types like ambulances and make way for them, so there are some smart emergency services and identifying vehicles to develop an advanced transportation system. With the traffic guidance system's help, it reduces running distance and average waiting time for vehicles. So, traffic analysis can be done, and we may even get some insights about vehicle flow peak times, etc. After analyzing the Traffic and its flow, a route guidance system can be implemented and used to intercommunicate on a real-time basis without human intervention. The traffic signal controllers can find the optimal routes from themselves to all other intersections by Dijkstra's shortest path algorithm. An intelligent parking guidance system with laser sensors can be implemented, determining whether the Vehicle overrun and the specific location.

Some of our objectives are Analyzing the traffic flow at a particular location and getting insights over the traffic flow to make our model work at peak times or any other likely situations. We also want to build an Application with beneficial features that help the traffic Authority and are available all in one place. So, we have decided to build an application that the traffic Authority can use to control the Traffic and contains some useful features like surveillance, no. of vehicles going at a particular location, and a vehicle fining and penalty collection.

Traffic flow analysis can be done to know when the Traffic is enormous in the area so that the laser system can be switched on or off. This makes it easy to control traffic signals and avoid congestion at peak times. We also want to include all those features and create a Model that the Traffic Police can directly use. The main stakeholders for this system are the Traffic Authority or Government. Vehicle Users are also involved in penalty collection where the vehicle number is associated with users. The State Government can implement it for the Urban and Rural areas. The Central government can implement this system for the National Highways, State Highways.

This paper has gone through some articles and papers, researched the existing system, and explained them in the literature review with specifying some advantages and disadvantages of various implementations. Then, we pointed out problems in the current systems and fixed the objective. All the modules' descriptions and functionalities with usages and the flow of events can be found in

the proposed methodology section. Then, explained the framework, tools, and dataset that we have used, and their information is available in the experimental setup section. Challenges and the methods to overcome these challenges are pointed out in the results, and the discussion section, including how the system works and their performance, are compared. A conclusion and what we want to update in the future are explained in the conclusion and future work section.

2. Literature Review

The authors in developed a smart traffic monitoring system utilizing diagram hypothesis and formal techniques (Latif et al., 2018), activities remembering finding the briefest way for terms of time and distance, discovering specific areas inside the city, and discovering the most secure and low rush ways the objective. The diagram-based model is changed into a proper model utilizing Vienna Development Method-Specification Language. Two scheme differential and Categorization algorithms are explained in with Aerial Surveillance (Karaki et al., 2019). The problems with the non-stationary camera is identified. Metrics like Distance calculations based on the sensors' location and Signal status of the Traffic signals are used for the smart emergency services to identify vehicles in (Abbas et al., 2016). They said that smart algorithms could be implemented for controlling signal timing on specific thresholds for making the roads free of Traffic. (Wu et al., 2018) proposed a prediction model with reliable accuracy and analyses the internal mechanism of DNN with RMSE and MRE as their metrics. The majority of the prediction model is done using visualization, and implementation can be made, and understanding work will be easy as it is done in visual tasks. The guidance system's use can reduce the need for the labor associated with forming endpoint to endpoint layout markings and provide reliable guidance that straighter lines than would be achieved using conventional technologies, as stated in (Vanneman et al., 2017). Explained the essential functions that can be implemented for the city traffic guidance (Wang, 2017); it includes other functions like real-time monitoring, intelligent control, and accurate prediction. They want to construct a big data model of city traffic guidance, which provides insights and information to the research works. Proposed a system that performs big data analysis based on real-time traffic information and historical traffic data (Lim et al., 2019). It indicates the user to change the route by showing warning messages. Implemented a productive travel route using keyword structures that use the knowledge acquired from the customer's historical facts and social collaborations (Danish et al., 2018). Proposed a smart road traffic congestion control using backpropagation neural networks that predicts the congestion (Impedovo et al., 2019). It provides solutions to increase the comfort level of travelers for better transport decisions. Proposed a system that uses different deep learning algorithms that automates the Traffic monitoring-based models(Mandal et al., 2020). They also implemented different object detection

algorithms to track the vehicles and also count the number of vehicles. Proposed a Machine learning approach which takes the GPS collected vehicle data and uses the Gaussian process to predict the real-time (Kamble et al., 2020), short term traffic. In (Zeng, 2015), a Laser is utilized to get information, and Big Data Algorithms are applied to comprehend traffic difficulties. Handling huge information in ongoing years, we need to have new ventures and remodel of the old framework. Used a gadget that might be a segment of a more robust framework joined into a vehicle or an independent device (Cheok et al., 2011). The gadget might be versatile, briefly, or for all time introduced on the Vehicle. The activity of the skyline gadget might be physically or consequently controlled. Proposed a route guidance system based on the shortest path algorithm regulating traffic flow of every crossroads intersection and reducing the average running distance and waiting time (Qiao et al., 2011). Gave a pipeline to develop a traffic classification system from videos (Wang et al., 2013). The pipeline is made up of three main steps: vehicle detection, feature extraction, and classification. Table 1 presents various existing works with its advantages & disadvantages.

3. Proposed Methodology

We came with creating a full ecosystem for the Traffic Authority in a Web Application form. We can add features like Real-Time Surveillance, Automatic fining systems. Predicting the traffic flow and finding out traffic flow trends, and displaying it to the Authority is possible. This idea of a Complete Ecosystem for the Traffic can be beneficial for the Traffic Authority in massive traffic places. Since they can get some insights into how the traffic flow will be in each location, it will be easy for them to control the Traffic and reduce the waiting time of people in Traffic. The modules which we have developed for the system and description are available in this section. Each module has its advantages and can be implemented to gain insights and collect fines from the vehicles. Our proposed system mainly consists of Admin and Users, where users are the vehicle owner and admins the traffic authorities. Our web application consists of a database where the information about the vehicles and their owners are stored. The application uses real-time data from the CCTV for the surveillance. Fig.1. presents the proposed system architecture.

Table 1: Comparative Analysis

Reference No.	Advantages	Disadvantages
Al-Sakran (2015)	Used RFID and IoT based model which tracks vehicles	Every Vehicle should be attached with tags, and it may give some cost implications, and any damage to RFID may lead to false predictions.
Cucchiara et al. (2000)	It uses rule-based reasoning on visual information.	Any event outside the rule can make the system give false information.
Nadeem et al. (2004, January)	Gather the information in real-time using their E-road equipment.	It depicts the traffic information around a particular vehicle but cannot be used for traffic control.
Xiao and Wang (2011)	Used RFID to perform vehicle prediction to overcome the problem of weather changes.	When a lot of Vehicle traffic is present at a particular location, it can increase the network traffic, and the system may not work as it uses GPRS to send data to the server.
Zhu et al. (2007)	Proposed an intersection-centric routing algorithm of a traffic simulation system to increase the efficiency of guidance.	This system cannot work when there is no intersection between the vehicles.
Kitani et al. (2008)	They proposed a system on the traffic simulator and compared information propagation efficiency between inter-vehicle communication	The inter-vehicle communication can be unreliable since it sometimes produces false-positive data
Yogheshwaran et al. (2020)	Proposed an IoT based application where the vehicles are stopped or speed are controlled based on traffic information.	Every Vehicle needs to be implemented or attached to that device to reduce accidents. But it can cause problems when any natural calamities happen.
Shi et al. (2009)	Peripheral detection is used to evaluate vehicle information.	Combining each Vehicle's data and forming a complete data of vehicle flow is a big task.
Jahn et al. (2005)	Proposed Advanced Traveler Information system to give insights to the travelers using the traffic information	They have used a Fuzzy set approach, which cannot be reliable in some situations.

3.1 Module in the Proposed System

- **Realtime Surveillance:** If we consider a particular location or area, all the CCTV's would be connected to the proposed system so that the traffic authority can monitor easily in their locations and easily guide other teams to control Traffic, or it can be used in other scenarios. An admin can view all the CCTV's which are connected to our system.
- **Violations:** If any vehicle violates the traffic rules like signal jumping. Parking in no Parking areas can be fined or penalized using these violation modules. Since Automatic Fining may cause issues to Authorities, we made another

module for approvals. In real-time, this module can be enabled at particular locations, and it will detect the vehicles which violated the traffic rules, and those details will be saved in the database for future use. Here for demonstration purposes, we have used images uploading. After uploading an image of a Vehicle, our system detects the vehicle number from it and gives its number stored in our database. This module uses OpenCV, a python library, to detect the vehicle numbers in real-time.

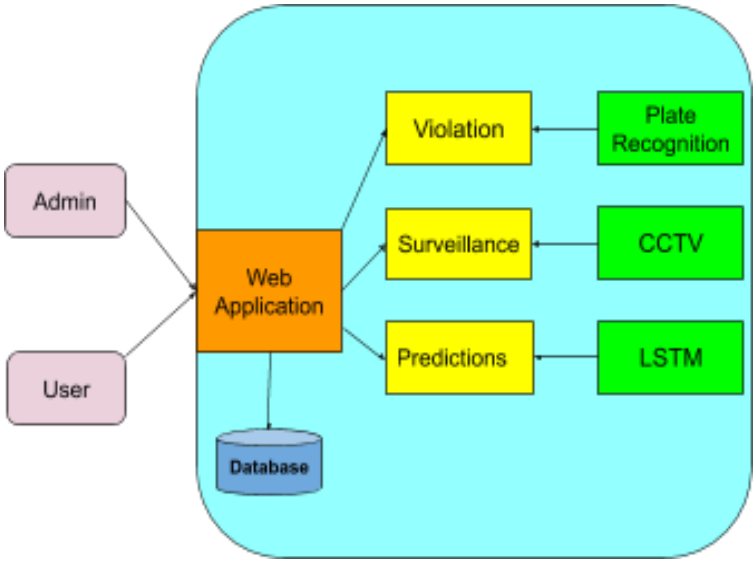

Fig. 1: System Architecture

- **Dashboard**: Here, the real-time traffic trends and insights can be viewed by the traffic authorities, which helps them to control Traffic and divert vehicles to other routes and can be used for other scenarios also.
- **Approval for Penalties:** Automatic fining systems can sometimes make false decisions and cause revolts from the people. This can occur due to poor image quality or weather due to which the numbers cannot be detected easily. So, it needs admin approvals. Here in this module, the admin will verify the details of the penalties and approve it. After the approval, a mail will be sent to the user with all the details of the violation, and he will be prompted to visit the website and make them pay the penalty amount.
- **Traffic Flow Predictions:** Here in this module, we have used a pre-trained machine learning model that takes current traffic flow input and predicts future traffic flows. It will give the output as the number of vehicles that pass through at a particular location every five minutes. In this way, traffic authorities can use these predictions to get real-time information, understand traffic congestions, etc. For demonstration purposes, we have used an upload box

where the admin can upload the dataset and get the predictions that can be used for future insights.

Here we want to analyze the Traffic and get insights into all the parameters, so we need a data set. We have found a dataset capture from tesla sensors in real-time from individual detectors spanning the freeway system across California's major metropolitan areas.

- **Training:** After comparing with various models in deep learning LSTM network can effectively preserve the long-term effect of the data for time series data. Therefore, the LSTM network is an up-and-coming model for time series data. We have trained the LSTM network with the dataset for up to 600 epochs and saved the model into a file.
- **Send mails:** Instead of using a separate application for communicating with other authorities in the traffic board, we have done this module to send emails to people and other authorities.

3.2 LSTM Model Architecture

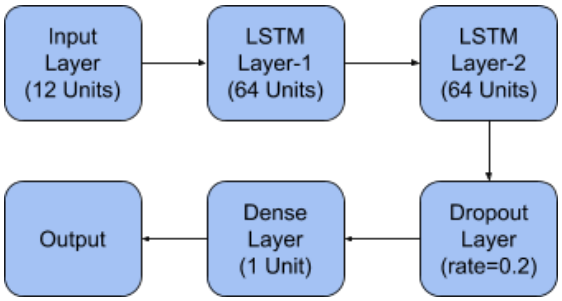

Fig. 2: LSTM Model Architecture

Figure 2 shows the various layers in LSTM architecture. First, it contains the 12 input units where the data gave is transformed and transferred. Then the input layer is connected to the first LSTM layer of 64 units, and data from this layer is propagated to the second LSTM layer of 64 units and then transferred to the dropout layer of rate=0.2, which reduces the overfitting of data by dropping some of the nodes in the neural network based on the given rate. The last layer, which is the Dense layer of 1 unit with sigmoid activation function, has only one node, which gives the output or prediction of the flow.

3.3 Prediction Module Flow Diagram

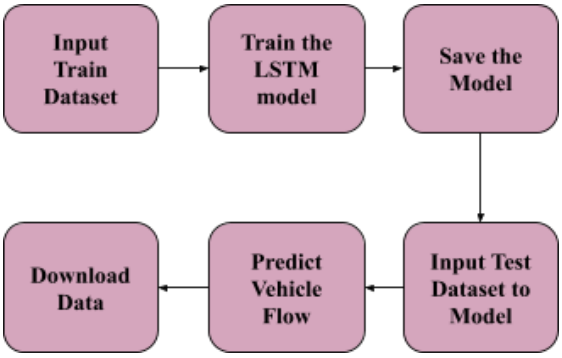

Fig. 3: Flow of Events in Prediction Module

Fig. 3 explains abstractly the flow events are happening in the Prediction module. Here the model is first trained with the training dataset, and then the model is saved to use for real-time prediction where it predicts the vehicle flow and can be downloaded.

3.4 Violations Module Flow Diagram

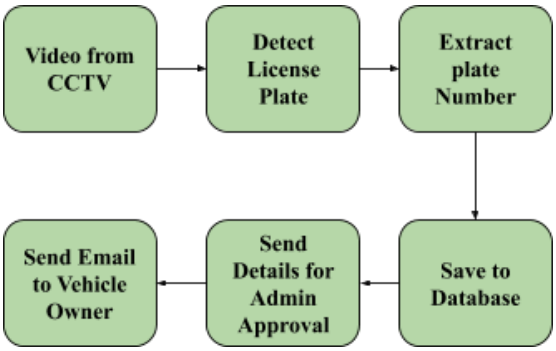

Fig. 4. The Flow of Events in Violations Module

Fig. 4 explains abstractly the flow events are happening in the Violation module. Here CCTV's can be connected to the server. It automatically detects the license plate and extracts the plate number that will be saved to the database, including the location timestamp, etc. Since we cannot rely completely on automation for penalizing the owner, we made a module called approval. The admin can see the violation and confirm the fining process to the Vehicle owner, which can be sent through email.

4. Experimental Setup and Dataset Details

The tools that we have used for this work is Visual Studio Code, XAMPP, MySQL, GIT, Laravel 7, PHP 7.2, Python 3.7, Tensor flow, Scikit Learn, Keras. We have

used Laravel Framework, which is based on PHP language, for the proposed system. It is based on the Model View Controller (MVC) architecture. Some of the features of Laravel are a modular packaging system with a dedicated dependency manager, different ways for accessing relational databases, utilities that aid in application deployment and maintenance. It uses Eloquent ORM (Object Relations Mapper) for the database, easy to implement, and use. Since Laravel uses Eloquent ORM, which is a fluent query builder, it helps from SQL Injections. Cookie class uses the Application key to generate secure encrypted strings and hashes; it protects cookies by using a hash. It also protects an app from a CSRF attack by using the CSRF token. The data set consists of attributes like time with five minutes difference and the flow in specific lanes i.e., several vehicles capture for every 5 minutes and the lane points and the observed percentage. Fig. 5 presents the dataset visualization.

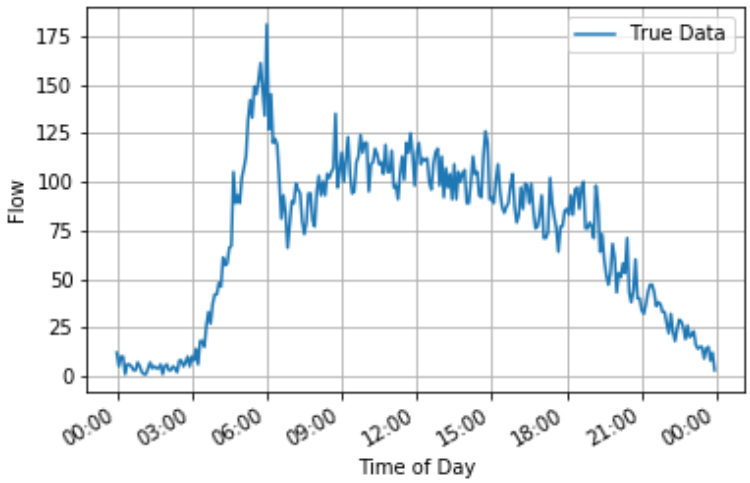

Fig. 5: Visualization of Dataset Showing the Vehicle Flow over a Day

5. Results & Discussions

5.1 Testing

The saved LSTM model is then inherited and used to find all the metrics like Mean Absolute Percentage Error, mean squared error, and Root Mean Squared Error, as presented in table 2. Fig. 6 presents the graph plot between LSTM and actual data for the time & flow of the Vehicle.

From the above analysis of data using the LSTM neural networks, we can get a good result of the model with good accuracy and fewer errors. We can see from the metrics that the model is quite good enough to implement real-time traffic analysis. Here from the graphs, we can easily know the peak times when vehicles travel on the road. So now, the Traffic guidance system can use this model to control the Traffic in real-time and guide vehicles to make decisions based on the flow of the vehicles.

Table 2: Experimental Results

Epochs Metrics	**200**	**300**	**400**	**500**	**600**
MAE	7.28491	7.29695	7.01127	7.05965	7.10634
MSE	98.8941	95.5507	91.0906	94.2933	95.3283
RMSE	9.94455	9.77500	9.54414	9.71047	9.76362

After having a brief insight into the predictions, we want to use the trained model in an application where all the details regarding the predictions and real-time predictions can be made. So, we got an idea of making a website where the traffic authority can use those features for other scenarios like Penalties.

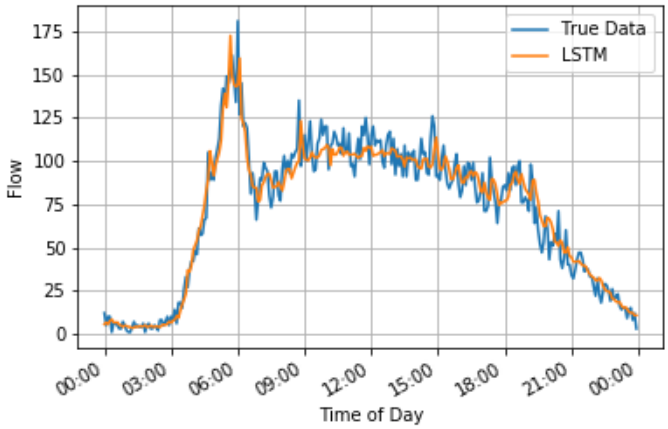

Fig. 6: Graph Plot between Time and flow of Vehicle and are compared with LSTM output and Actual Data

Finally, we have built the system with all the modules described above and each with its advantage. Here from the surveillance modules helps for real-time surveillance. The Violations module built with OpenCV detects the plate and extracts the plate. It sometimes fails as a result of various types of plates used for various types of vehicles. Since Automatic acceptable approvals can lead to unwanted results, we have included the approval module so that the admins can approve for penalty collection. The prediction module that works based on LSTM has its advantages like continuous traffic flow can be predicted from that and gives some insights to the traffic Authority. The model has its metrics values, i.e., Mean Squared Error MSE = 95.328306, RMSE=9.763622. In the future, we will continuously train the model based on holidays and locations to be used anywhere, which helps in diverting the Traffic and reducing the congestion.

5.2 Challenges Faced while implementing the system

- Calling or starting the Python Modules from Laravel.
- Interaction between the Python Modules and PHP modules
- Managing Python Packages was difficult since each package has different dependencies.

5.3 Methods used to overcome Challenges:

- After some research in PHP documentations, we have found the function named system () it can execute the CLI commands, which solved calling the python modules.
- ()PHP (calls using system () function) --->Python]
- Since these two languages are different, we were not able to make connections. So, we have used separate files for interaction. For example, python will save the detected license plate in a text file and php will read the text file and save the text into the database.
- ()Python(saves)-->Intermediate File<--(uses) PHP]
- We have used "VENV," a python library that creates or isolates the python project dependencies from system python's dependencies to manage and use packages.

6. Conclusion and Future work

In this paper, we have created the Traffic Monitoring and Guidance ecosystem with all the modules like surveillance, traffic flow insights, Fining system, which can be used by the traffic Authorities in real-time to control Traffic and get future updates can communicate with other Authorities also. We also made the website easy to use and mobile-friendly to have a good experience using it. We think the Traffic Authority will use our application because of its features like traffic flow predictions and detection of traffic violations that are not implemented before. We also tried to make the application mobile friendly to use it from mobile phones and pay the penalties. In the future, we want to integrate the system with vehicle registrations and add modules like Vehicle Registrations, Users License Issues, Blogs for Traffic Rules, Realtime traffic congestions, Video Conference within the application for traffic Authorities. Also, improve the current modules with training the traffic prediction model based on the Holidays and days of a week and other attributes and make the application user-friendly and mobile-friendly.

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