# Traffic Lights Analysis and Manipulation for Emergency Vehicles Using Deep Learning Algorithm

**S. Sobitha Ahila , D.Sivakumar M.Naveen Nanda , Nivedita, Suresh Kumar Nair, Sruthi Kannan**

***Abstract:*** ***The traffic light control performs a fundamental role in any intelligent traffic management system. The light sequence and duration are the two key angles to be considered in traffic light control. In numerous nations, most traffic lights include settled sequences and light length span. Fixed control strategies are anyway reasonable for steady and ordinary traffic, however not for dynamic traffic circumstances. Taking a gander at the current situation of practice, the light sequence is resolved without considering the conceivable presence of emergency vehicles. Vehicular traffic is perpetually expanding everywhere in the world and can cause awful traffic clog. In this way, emergency vehicles, for example, ambulances, police cars, fire engines and so forth, stuck in a traffic stick experience delays in achieving their goal which thus can prompt loss of property and lives. The proposed system introduces a concept to schedule emergency vehicles in traffic. The goal of the proposed software item is to perform traffic analysis, particularly amid pinnacle hours, and to utilize Deep Learning so as to perform traffic manipulation of signs by means of relay transmission utilizing Raspberry Pi Microcontroller, to make a Smart Traffic Light System , so as to control the first and succeeding traffic motions by means of a dynamic variant of the shortest path algorithm so as to decrease the quantity of deaths hugely occurring as a direct result of the delay in the patient transit.***

***Index Terms: ITMS, Microcontroller, Deep Learning, Relay Transmission***

## I.INTRODUCTION

Statistically speaking, the main problem faced by ambulances is wading through traffic, especially through rush hour. As of now, there is no monitoring system in India, except for that of CCTV footage. It is alarming to note that more than 56% of the accidents occur during patient's transit .ie.the time taken to transport the patient from point A to the hospital/clinic. The requirement is to significantly reduce the death toll by creating a smart system using unconventional technologies at a low cost. The system is built, keeping in mind ambulances, firefighters and for policing purposes.

The system's growth. important concept is to create a smart traffic light system, which is capable of communicating with each other by means of relay signals via the microcontroller. The communication is also maintained despite weather complications, as the signal for communications among traffic signals is less, also that each microcontroller used will relay the signals from one point to another.

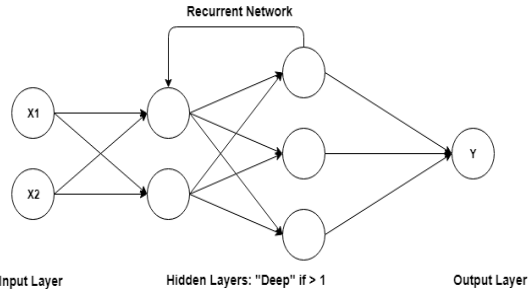


FIGURE 1 RNN FEED FORWARD

The smart traffic light system is built based on an algorithm known as Compact Prediction Tree, which uses concepts and computation methodologies similar to that of existing Recurrent Neural Network algorithms. RNN feed forward (figure 1.1) is a branch of Deep Learning algorithms which have an internal state memory which is used to process the sequence of inputs. RNN algorithms such as LSTM,GRU etc are being widely used for various domains ranging from finance to medicine.

The specific algorithm to be used here is Compact prediction Tree, which is a derivative of Deep Neural Network, which is capable of performing computations at the same rate as that of regular deep learning algorithms. CPT is a recurrent neural network algorithm. Compact prediction tree is an algorithm which supports lossless

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compression of the training data with respect to all relevant information which is made available for each prediction.
The objective of the proposed software product is to perform traffic analysis, especially during peak hours, and to use Deep Learning in order to perform traffic manipulation of signals by means of relay transmission using Raspberry Pi Microcontroller, to create a 'Smart Traffic Light System' , in order to manipulate the preceding and succeeding traffic signals by means of a dynamic version of the shortest path algorithm in order to reduce the number of death's massively occurring because of the delay in the patient's transit.

## II.LITERATURE SURVEY

**[5]** through their paper, "Employing Cyber-Physical Systems: Dynamic Traffic Light Control at Road Intersections", IEEE Internet of Things Journal put forth the objective to establish a dynamic traffic light control system using RSU (road safety units). This is done using VITCO and RITCO protocols. The result obtained is that it can handle two lanes with car capacity equal to 100 where the estimated vehicle arrival rate is 90 per lane. The red and green interval is 20 sacs. The drawback for this model is that it has a high dependency on hardware therefore it is expensive to implement.

[9] through their paper, "Real-time Traffic Light Recognition Based on Smart Phone Platforms", IEEE Transactions on Circuits and Systems for Video Technology propounded the objective to establish a Real time traffic light recognition based on smart phone platforms. This is done at first by utilizing an ellipsoid geometry limit show in HSL shading space worked to extricate fascinating shading districts. These areas are additionally screened with a post-handling venture to acquire applicant districts which fulfill both shading and splendor conditions. Second, another bit capacity is proposed to viably join two heterogeneous highlights, HOG and LBP, which is utilized to depict the applicant districts of traffic light. A Kernel Extreme Learning Machine (K-ELM) is intended to approve these hopeful areas and at the same time perceive the stage and kind of traffic lights. The outcome got was a perception as for a Finite Traffic framework which diminishes GPU reliance of highlight vector from 512 to 256 was established. The disadvantage for this model is the part that it can deal with just single edge for HSV as it were.
[7] through their paper, "Intelligent Traffic Light Controlling Algorithms Using Vehicular Networks", IEEE Transactions on vehicular technology, implemented the objective to establish Intelligent Traffic Light controlling algorithms using vehicular traffic. A one of a kind shrewd traffic light controlling (ITLC) calculation is proposed. ITLC is proposed to plan the periods of each segregated traffic light proficiently. This calculation considers the continuous traffic attributes of the contending traffic streams at the signalized street crossing point. The outcome got is a 10% abatement in rush hour gridlock blockage amid travel. The disadvantage for this model is the way that the proposed calculation is not plausible to be tried for huge scale execution.
[5] through their paper, "Saliency Map Generation by the Convolutional Neural Network for Real-time Traffic Light Detection using Template Matching",IEEE Transactions on computational imaging, suggested the following objective to generate saliency map by the convolutional neural network for real-time traffic light detection using template matching. To perform vigorous traffic light recognition in changing conditions with couple of false positives, the proposed calculation comprises of a disconnected saliency map age and an ongoing traffic light location. In the disconnected advance, a convolutional neural system distinguishes and perceives the traffic lights in the picture utilizing locale of-intrigue data given by an installed GPS sensor. The identified traffic light data is then used to produce the saliency maps with a changed multi-dimensional thickness based spatial grouping of utilizations with clamor (M-DBSCAN) calculation. The outcome acquired is a high identification exactness with irrelevant false positives under changed light conditions. All the more essentially, a normal computational time of 10 milliseconds for every casing is achieved. The disadvantage for this model is that the principle use lays on its help includes and can't be utilized as an independent framework.

[4], through their paper, "Adaptive Quasi-Dynamic Traffic Light Control", IEEE Transactions on control systems technology carried forth the objective to generate a Adaptive quasi-dynamic traffic light control system. Utilizing minuscule bother examination, they infer online inclination estimators of a cost measurement concerning the controllable light cycles and limit parameters and utilize these estimators to iteratively change all the controllable parameters through an online angle based calculation in order to improve the general framework execution under different traffic conditions. The outcome acquired is the foundation of a dynamic framework equipped for working in different rush hour gridlock conditions notwithstanding blockage. The disadvantage is that there is thought just for a solitary path/crossing point and is in this way deficient.

[6] through their paper, "Emergency Traffic-Light Control System Design for Intersections Subject to Accidents", IEEE Transactions on intelligent transportation systems, carried forth the objective to establish a emergency traffic light control system for intersections that are subjected to accidents. The given paper utilizes deterministic and stochastic Petri nets(PNs) to structure a crisis traffic-light control framework for convergences furnishing crisis reaction to manage mishaps. The outcome got was an improvement in the best in class ongoing auto collision the executives and traffic security at crossing points, with help for halt and live lock situations. The disadvantage is that mishap aversion progressively isn't demonstrated

[5] through their paper, "Real-Time Traffic Light Detection With Adaptive Background Suppression Filter", IEEE Transactions on Intelligent Systems, carried forth the objective to recognize the various car makes and models from a single traffic camera image. The proposition depends on a novel vision-based traffic light identification strategy

for driving vehicles. The proposed technique contains two phases: the hopeful extraction arrange and the acknowledgment stage. The result acquired can accomplish an ideal location result with high caliber and vigor; at the same time, the entire discovery framework can meet the continuous preparing necessity of around 15 fps on video groupings. The downside is that the attention on applicant extraction is high and more straightforward techniques for performing highlight extraction could be utilized.

[8] "Traffic Light Recognition for Complex Scene With Fusion Detections", IEEE Transactions on intelligent transportation systems, carried forth the objective to bring about traffic light recognition for complex scenes with fusion detections. This specific strategy acquires a powerful traffic light acknowledgments demonstrate dependent on vision data is presented for on-vehicle camera applications. Three viewpoints are involved. First, the perspective proportion, zone, area, and setting of traffic lights are used as earlier data, which builds up an errand display for traffic light acknowledgment. Second, we propose a progression of improved techniques dependent on a total channel highlight strategy, including changing the channel include for every sort of traffic light and building up a structure of combination locators. Third, we present a strategy for between edge data examination, using discovery data of past edge to change unique proposition locales. The outcome acquired when contrasted with other traffic light discovery calculations, our model accomplishes aggressive outcomes on the mind boggling scene VIVA informational index. The disadvantages watched are high blunder rate because of the attention on independent nature.

[10] through their paper," Road Traffic Anomaly Detection based on Fuzzy Theory", IEEE ACCESS, carried forth the objective to propose a traffic anomaly detection algorithm for straight roads based on fuzzy theory. The accompanying hypotheses are proposed therefore, The fluffy traffic stream, Traffic stream mirrors the present traffic conditions and can be utilized to recognize traffic peculiarities. The fluffy traffic thickness is proposed. Traffic thickness mirrors the present traffic force, which is extremely useful for traffic irregularity identification. The objective's fluffy movement state is proposed, since our objective is identifying traffic oddities, the objective's fluffy movement state is essential. The traffic abnormality discovery calculation is proposed. The proposed calculation identifies traffic inconsistencies by utilizing the previously mentioned fluffy traffic parameters and some structured fluffy control rules. The outcome got is that the normal precision rate is 93.4% at stable situation and amid substantial clogs it is 72.2%, with a mistake rate under 3%. The disadvantage is that is does not utilize constant information to check the exactness.

[2] through their paper," Recognition of Car Makes and Models From a Single Traffic-Camera Image", IEEE Transactions on intelligent transportation systems, carried forth objective to recognize the car make and model using neural network ensemble, linear binary patterns histogram and Histogram of Gradient classifiers. The outcome acquired is that 100% accuracy was gotten with highlight standardization and a precision of 99.82% was gotten without highlight standardization. The significant disadvantage is that the framework is not fit for dealing with a city wide usage.

## III. SYSTEM DESIGN

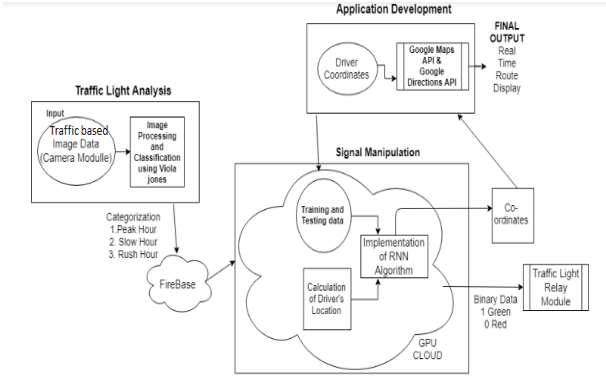


FIGURE 2 FUNCTIONAL ARCHITECTURE

The functional diagram mentioned in Figure 3.1 is split into 3 sub sections, namely:

*Application Development:*

From the user endpoint, an application is developed using Google Maps API and Google Directions API to serve as GUI for the output endpoint. This application is built, keeping in mind a hybrid platform so that it is capable of operating in an OS independent environment.

*Traffic Light Analysis:*

During normal conditions, analysis using the microcontroller is performed to understand and classify road congestion based on three categories, namely peak, slow and rush hour. This data is the crux for understanding how the system will and should respond based on certain traffic situations.

*Signal Manipulation:*

The cloud server will relay the instructions in the form of a binary message in order to change the signals based on system stimulus. The manipulation is traversed by using signal relays which is part of the microcontroller module as hardware.

The hardware and software components used are as follows:

*Hardware:*

### A. ARM Processor

The aim is to create a mechanism to enable communication between signals so as to relay the binary values from the main server to the devices in order to manipulate the signals. This is performed using Raspberry Pi 3 Model B. This operation is performed headless in order to enable wireless communication. The microcontroller is fitted with a PI camera in order to perform Vehicle Detection for the analysis phase.

The hardware in question is essentially a camera, designed to act as an image processing sensor for producing real time data. The image processing is performed using FireBase MLKit, and open source API provided by the firebase team. The model is already pre built using Tensor Flow, the open source Machine Learning Library maintained by Google Inc.

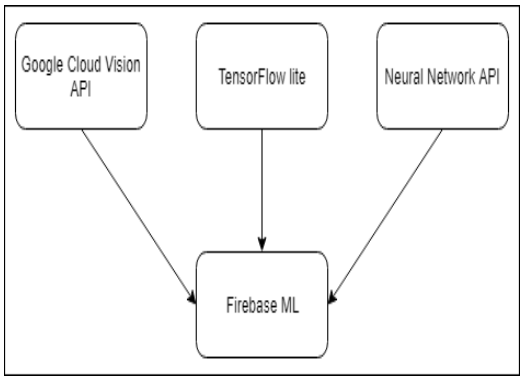


FIGURE 3 FIREBASE ML KIT

Relay transmission of signals among traffic lights is done using the raspberry pi microcontroller. The Firebase MLKit represented in Figure 3.2 is also run via the microcontroller using VMware to facilitate android operations.

*Software - Deep Learning:*

For performing traffic signal manipulation, the relay signals offer commands so as to alter the traffic lights. The algorithmic principle used to perform computations for the task is RNN(Recurrent Neural Networks), a class of counterfeit neural system where associations between hubs structure a coordinated chart on a succession. this grants it to show dynamic fleeting conduct for a period grouping. as opposed to feed forward neural systems, RNNs will utilize their interior state (memory) to process groupings of sources of info. This makes them appropriate to undertakings like no segmental, associated penmanship acknowledgment or discourse acknowledgment. In the particular case, we tend to utilize it to perform mammoth scale Sequence Prediction. Grouping forecast, to put it in simple terms, is required at whatever point one will anticipate that a particular occasion is most likely going to be trailed by another occasion and one must foresee that. The inward recursive logical control used to help the RNN is the Compact Prediction Tree algorithmic program. The CPT algorithmic program is utilized to foresee the succession dependent on logical control, and is more precise than conventional Machine Learning Models

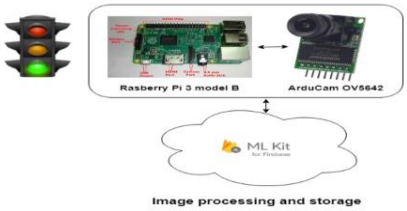


FIGURE 4 TRAFFIC LIGHTS ANALYSIS(TLA)

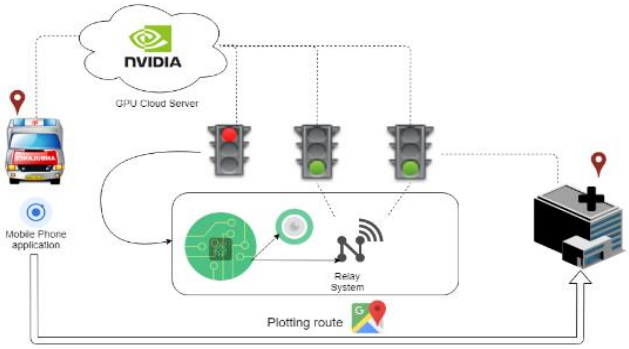


FIGURE 5 TRAFFIC LIGHTMANIPULATION(TLM)

As illustrated in Figure 3.3, the hardware portion consists of the raspberry pi, the relay module attached to the traffic light system via jumper cables. The raspberry pi is connected to the traffic network server which is possible through the cloud support available in the Rasping OS.

As illustrated in Figure 3.4, the cloud server acts as a central communication mechanism in order to communicate signals from one traffic light signal to another. The coordinates sent by the driver is stored in the cloud as a starting point in order to understand the position of traffic lights from point A to B. The path taken into consideration is taken from the shortest path as suggested by google maps API.

## IV. SYSTEM IMPLEMENTATION AND PERFORMANCE ANALYSIS

A camera, fitted with a microcontroller, is positioned at each traffic light. During regular rush hour, the camera performs data analytics by means of image processing to understand the traffic patterns at a given moment. This is also done to exactly identify which time is considered as ‘rush hour’. This analytics is performed at regular intervals and the data is stored in MongoDB, a nosql database used to handle big data. The RNN model is trained based on the analytics performed by the image processing algorithm. The flow can be comprehended as shown in Figure 4.1:

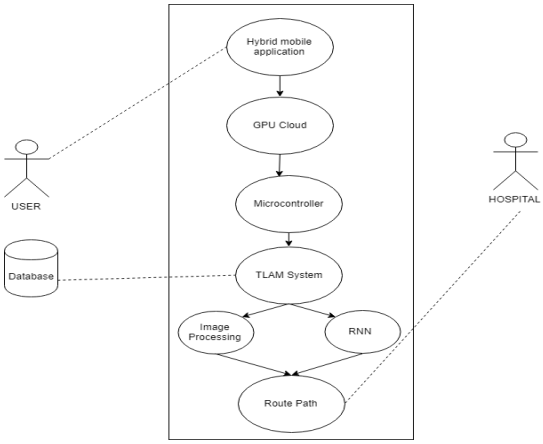


FIGURE 6 USE CASE DIAGRAM

The RNN algorithmic program is then deployed over a GPU targeted cloud,.ie. NVIDIA cloud, to perform coaching and testing operations using GRIDCV and SCIKIT LEARN. GridCV is employed to perform hashing victimization to extend the potency of the method. From the user point of view, a hybrid application is constructed which performs basic operations to tell the live location of the emergency vehicle. The app is constructed using Ionic, an application development toolkit used to build application where the code is written once but will run in android and iOS stack.

The live location is fed to the system by means of latitude and longitude coordinates, which is easily understood by the microcontroller as raspberry pi has an in-built GPS navigation mechanism. The android application enabled with the API is part of a HTTP request and response which allows for calculating the coordinates of the user and the XML format of the same is shown in Figure 4.2

HTTP request

```
http://maps.googleapis.com/maps/api/directions/xml?
origin=44.94033,-93.22294&destination=44.94198,-93.23722
mode=driving
```

XML response

```
<step>
   <start_location>
      <lat>44.9403300</lat> <lng>-93.2229400</lng>
   </start_location>
   <end_location>
      <lat>44.9395900</lat> <lng>-93.2229500</lng>
   </end_location>
   <duration> <value>8</value> </duration>
</step>
      ..... remaining steps .....
```

FIGURE 7 REQUEST AND RESPONSE XML

Using the sequence prediction Algorithm, we determine which preceding and succeeding traffic lights are to be manipulated in the route of the emergency vehicle. The algorithm is as follows:

There are two steps to perform sequence prediction. First, one must train a prediction model to be able to perform sequence based prediction attributed to a similarity in both training and testing datasets as shown in Figure 4.3

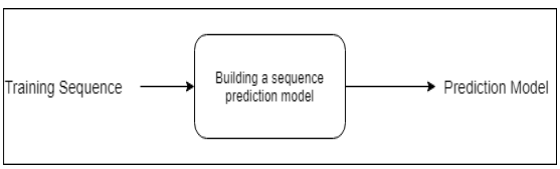


FIGURE 8 ROLE OF TRAINING SEQUENCE

The second step is to use a trained sequence prediction model to perform prediction for new sequences (i.e. predict the next symbol of a new sequence), as shown in Figure 4.4

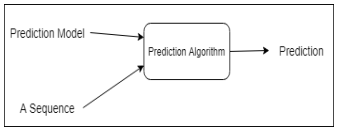


FIGURE 9 PREDICTION PHASE

The output is processed as binary inputs, which is easy to transmit from signal to signal. Since every traffic light signal responds to binary output, a link is established and maintained. The algorithm for generic recurrent neural network adapted for this purpose is as follows:

**Data**: a set of sequences with their corresponding context.
**Result**: RNN optimized for generation.
Initialize RNN at random and set $N^{XENT}$, $N^{XE+R}$ and Δ;
**for** s = T, 1, -Δ do
    **If** s == T **then**
        Train RNN for $N^{XENT}$ epochs using XENT only;
    **else**
        Train RNN for $N^{XE+R}$ epochs. Use XENT loss in the first s steps, and REINFORCE (sampling from the model) in the remaining T - s steps;
    **end**
**End**

### A. Internal state memory

The Data Structure used here is called as a tri structure. It is an ordered tree based data structure used to store a dynamic set of values which are usually string in nature. The types of tries used here are dynamic based on requirement. They are as follows;

1. Bitwise Tries
2. Compressing Tries
3. External Memory Tries

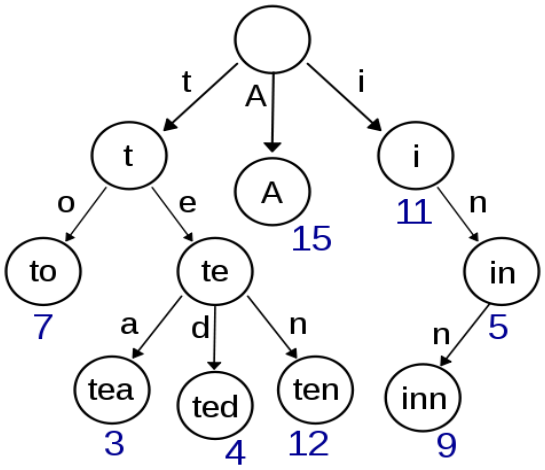


FIGURE 10 TRIE STRUCTURE

As shown in Figure 4.5, the specialty of the tri structure is in the way it is able to manage large amount of data and maintain the relation between individual bytes of data related by the sequence in which it is to be analyzed or processed.

**1:** for i∈{1..N} **do**
**2:** $S_i$←bootstrap_sample(L)
**3:** $m_i$← train_model($S_i$)
**4: repeat**
**5:** **for** i∈{1..N} **do**

**6:** $L_i \leftarrow \emptyset$
**7:** for $x \in U$ **do**
**8:** **if** $p_j(x) = p_k(x)(j,k \neq i)$ **then**
**9:** $L_i \leftarrow L_i \cup \{x, p_j(x)\}$
**10:** $m_i \leftarrow$ train_model$(L \cup L_i)$
**11:** until none of $m_i$ changes
**12:** apply majority vote over $m_i$

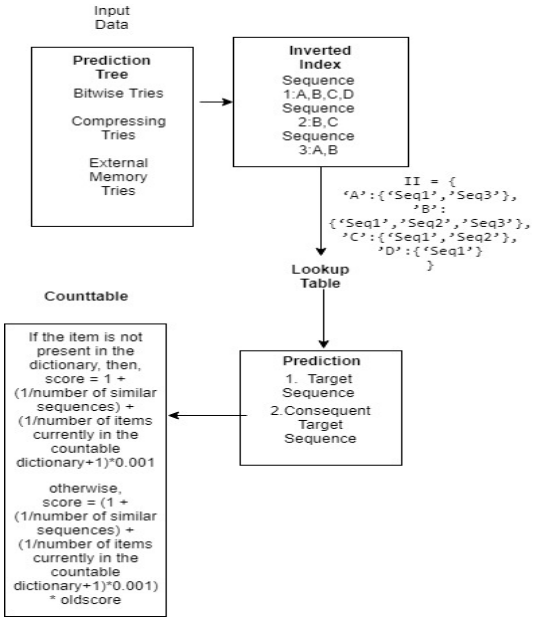


FIGURE 11 CPT WORKFLOW

### B. Performance analysis:

The performance analysis is based on a comparison between existing systems and the proposed system. The comparison takes two metrics into consideration, namely

- Prediction rate- The rate at which the algorithmic program is in a position to perform consecutive predictions

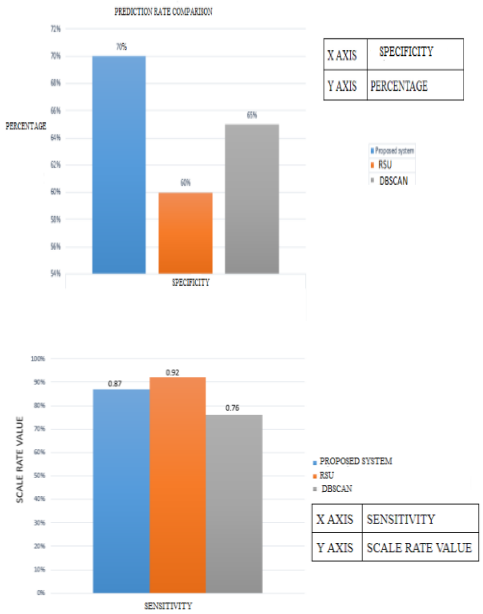


FIGURE 12 PREDICTION RATE COMPARISON

Sensitivity is a measure of the proportion of actual positive cases that got foretold as positive (or true positive). Sensitivity is additionally termed as Recall. This means that there will be another proportion of actual positive cases, which might get predicted incorrectly as negative (and, thus, might even be termed as the false negative). This may even be delineated in the form of a false negative rate. The formula for determining sensitivity is as follows:

$$SN = \frac{TP}{TP + FN} = \frac{TP}{P}$$

Where TP is Total number of correct positive predictions
P is the total number of positives

Specificity is outlined as the proportion of actual negatives that got foretold as the negative (or true negative). This suggests that there will be another proportion of actual negative that got predicted as positive and will be termed as false positives. This proportion could even be referred to as a false positive rate. The total of specificity and false positive rate would invariably be one. The formula to define specificity is as follows:

$$SP = \frac{TN}{TN + FP} = \frac{TN}{N}$$

Where TP is Total number of negative predictions
P is the total number of negatives

FIGURE 13 FPS COMPARISON

- FPS-Frames per second- Frame rate is the recurrence at which sequential pictures known as casings show up on a showcase. The term applies similarly to film and camcorders, embellishments, and movement catch frameworks.

The comparison is taken between three systems. System 1 is by Ossama You is[6] which proposes a cyber physical system placed in traffic intersections. It uses the VITCO and RITCO protocol approach to enable Road Safety Units.

System 2[5] uses Conventional Neural Network clubbed with DB Scan algorithm to create saliency maps with high efficiency. It takes into account false positives to generate the maps and perform traffic light detection.

## V. CONCLUSION AND FUTURE WORK

The proposed work guarantees that it gives an efficient development of traffic and furthermore expands the traffic-dealing with limit in the convergences. Legitimate physical formats and the executives estimates region unit utilized, and thusly the flag operational parameters zone unit looked into and

refreshed on a regular premise to expand the adaptability of the control flag to fulfill current traffic request. This conjointly decreases the recurrence and seriousness of beyond any doubt sorts of accidents, especially right-point impacts. They are facilitated to supply for persistent or about consistent development of traffic at a careful speed on a given course underneath good conditions. This also drastically reduces the transit delay that seems to prevail enormously in our society. By doing so, a lot of lives can be saved and a lot of thefts can be stopped. The main concern is, coaching the RNN model; it's going to take a major quantity of procedure resources, that ought to be overcome by finding a technique to coach the information. The future work focuses on improving efficiency and reach of the algorithm within the system. The first proposed future work is to improve efficiency of algorithm from 0.9 to 12. GHZ, by performing parameter tuning in a stable version of CUDA. It is also important to perform the manipulation at real time as the emergency vehicle crosses each traffic light. A support to change destination mid way is also essential to the

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