Smart Traffic System-based on Object Detection using Machine Learning

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Abstract

Most of the traffic system is manually operated and hence prone to human error. Malfunctioning at traffic management leads to rule violation so either violation or the malfunctioning of traffic lights should not happen. Operating a better road network for free traffic flow has a direct impact on the productivity of the economy. The policy of congestion detection plays a vital role in this project. The adaptive control technique is reducing the waiting time. Geospatial traffic guidance for emergency vehicles is included in this project. Routing is implemented so that ambulances waiting with critical patients with heavy traffic need not worry about waiting and stopping at every traffic signal. With this, a smart traffic system is created which helps in making road transportation easier, convenient, faster, and efficient.

Keywords: *Traffic forecasting, Geospatial traffic guidance, Intelligent Transportation System, Non max suppression filters, Max pooling, Same padding, Valid padding, Spatial and Temporal dependencies.*

I. Introduction

Traffic forecasting [1] is the blooming technique to solve congestion issues. From the traditional transportation system to the newly developing smart traffic systems the development technology has given a greater chance to overcome all the hardships faced. Starting from the car parking system till the dedicated short-range communication the department of transportation has developed a lot. Intelligent Transportation System (ITS) [2] is utilized to manage all the traffic and locomotion problems in India. Only a few metropolitan cities have a very good public transport infrastructure and organized public transportation so handling the traffic congestion caused by the increase in private transportation is very important. To prevent traffic congestion and to manage the waiting time in the signal is the main objective of this project. The development of intelligent transport management is completely a very helpful and stress-reducing solution. The main purpose of this paper is to reduce the wait time of the traffic based on each lane. The long queue of vehicles caused due to the traditional system is reduced so the workload of the

officers is a bit reduced. Further changes are to be made in the upcoming systems to bring a lot more accuracy and give us a higher priority for the vehicles captured in the camera.

Existing system:

The author describes the process of collecting the data in the form of images for reference background images. These background images are then enhanced by RGB to grayscale conversion and gamma correction.

The technique used for edge detection is Prewitt operator method. The image is captured with the time-lapse of 1 minute followed by image enhancement. Pixel to pixel comparison of the newly obtained image and the background image is done for background subtraction. Prewitt algorithm is used for edge detection which computes an approximate gradient of the image intensity function.

At each point during the image processing, the Prewitt operator is calculated which is either the vector gradient or the normal of the vector. After this edge-based image matching is carried out. The methodology used for the object detection in MATLAB is comparatively slower than YOLO V5 which we have used to implement our project.

As the picture is captured in a loop after the 1-minute interval, which is a time-consuming process and can lead to incomplete data. This problem is overcoming by capturing the image when the signal goes green for the crowded lane which saves time and gives more accuracy[12]. In our project, we have additional functionality which detects an ambulance or makes way for VIP. In this paper, the author[21] describes the process of collecting data in the form of video to track the object throughout the signal area. The video populated gives the background statistical model from the first few minutes which then moves forward by filtering the image by removing noise and misdetections. This model also distinguishes the object of interest from the surroundings. The object obtained by the end of this step is then tracked till it leaves the signal area. OCR algorithm has been used for number plate recognition. This process is categorized into three steps. The first step, called Number plate extraction, detects the number plate and passes the information to the next step. In the second step the number plate received is pre-processed to remove noise and then the result goes for segmentation in which characters are extracted from it. In the final step, optical character information is converted to encoded text and the characters are recognized using template matching. This project also takes care of ambulances passing through the signal in emergencies [7]. The drawback of this system is that it is a slower approach as MATLAB is used for detecting objects of interest. In our proposed system we have used YOLO V5 which is comparatively faster than MATLAB. This project mainly speaks about the use of image processing algorithms that are Fast-R-CNN and Yolo. These algorithms are one of the top-notch algorithms available over the past years for the detection of objects in a live feed and require enormous computational resources, but the problem is that the features used are for all objects which are not required. We require only vehicles (feature) to be detected, so according to that the algorithm is modified and the timer algorithm is added then later the whole algorithm is processed in IoT.

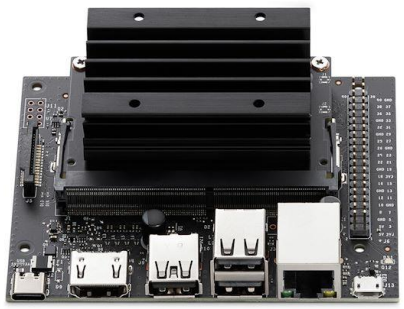
II. REQUIRMENTS

A. Jetson Nano developer kit

Jetson nano is a small yet powerful part of the entire project which helps us to run multiple neural networks in parallel applications. Jetson Nano has nearly Half the GPU Computation Power [3]. The GPU-Graphics processing unit (GPU) specifications were created by NVIDIA Maxwell architecture with 128 NVIDIA CUDA® cores and the CPU is a Quad core ARM Cortex-A57.The memory capacity of

jetson nano is 4 GB 64-bit LPDDR4, 1600MHz 25.6 GB/s

Fig.1 Jetson Nano Kit



B. Raspberry pi cam

The resolution of Raspberry Pi is 4056x3040 pixels and the image size is 6 MB. The raspberry pi camera module V2 is picked based on [4].

Fig. 2 Raspberry Pi Cam

C. Ultrasonic sensors

As already known the task of the Ultrasonic sensor is to measure the distance between any two objects which is fixed as a target by the program. The ultrasonic waves are faster than sound audible by humans.[5]

III. PROPOSED WORK

The smart traffic system starts from capturing the live feed video from the camera which is being attached to four-way signal. Step two is processing the input feed video to calculate the number of vehicles waiting for the signal. With the help of the input obtained and based on the algorithm the classification is done and the signal which has the greater number of vehicles are categorized and the waiting time for that signal is reduced. This process is done mainly with the help of the YOLO algorithm and object detection methods.

A. Detection

From the live video feed, the vehicles in that video are taken into account. The description of every vehicle is calculated through object detection methods which include the model of the vehicle the color size and more features.

B. Processing in IoT

The main program receives all the input feed from the previous step to make further progress. With the classified data, the estimated time for every vehicle is calculated. Timer algorithm is used to make sure every lane has the exact output of time so that the signal can be changed accordingly

C. Time estimation

As discussed in the previous step the estimation of time plays an important part in the whole project. Reducing the waiting time of vehicles is one main objective of this whole program.

D. Combination

Now with the help of the results obtained the result will be given in the form of a collective data set that is connected to a frontend so that whoever sees the results displayed can understand the output very easily. Three main modules are used in the detection and classification process

E. Object detection

Input data is required for any object detection. The video input captured from the jetson nano and the raspberry pi camera classifies each vehicle based on their type, model, color, and also the number of vehicles in each lane is also noted. Therefore, the input to be used in the main program is obtained.

F. Main program

The main program deals with all the algorithms and the code stuff. Data mining is done with object-detected data. The hectic task of managing the lanes with the help of the data is done in this step. As we have taken the example of a four-way lane the traffic and the vehicles in every lane are calculated to input them in the timer algorithm which further manages the timer in the signal of each lane.

G. Front end

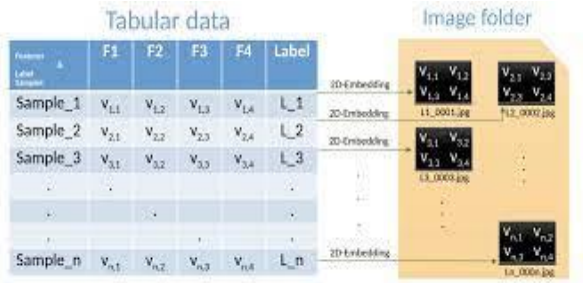
The obtained results are briefly explained in the form of graphs and diagrams in the dashboard created with the combination of reacting and flask. Displaying the controls and the time managed by the program is also displayed.

Fig. 3 Highway Lane classification

III. CONVOLUTIONAL NEURAL NETWORKS (CNN)

Comparing all the CNN features for better understanding. There are four types of CNN. the first one is CNN which divides the input image into multiple regions and then categorize them into different classes there is no prediction time for this type the main disadvantage is to have a lot of test result to predict and high computation time.[6]

Fig.4 Tabular data with neural network



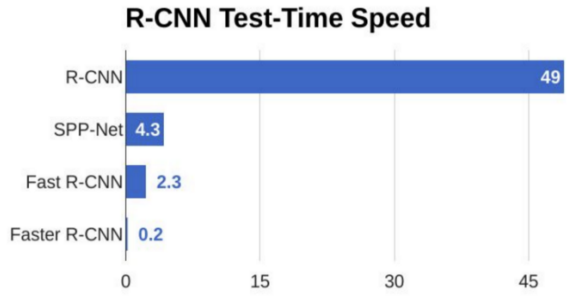
Next comes the Region-Based Convolutional Neural Networks i.e. (RCNN) which has a very selective search that extracts 2000 regions from each image. The prediction time is from 40-50 seconds max. It uses 3 different models for prediction which is a lot of time to process. The next update was fast RCNN here every image is passed only once where the feature maps are extracted for prediction generators. the prediction time is 2 seconds and the limitation is selective search is slow so the computational time is still high.

The very recent development is Faster RCNN. This replaces the selective search with the regional proposal which works faster. The prediction time is0.2. This algorithm is used in our project.[7]

Faster RCNN was presented by Ross Girshick, Shaoqing Ren, Kaiming He, and Jian Sun and was the only famous object detection architecture during 2015's. The region proposals were generated by Region Proposal Network (RPN). Region of interest (ROI) pooling layer helps in the extraction of the fixed feature vector.

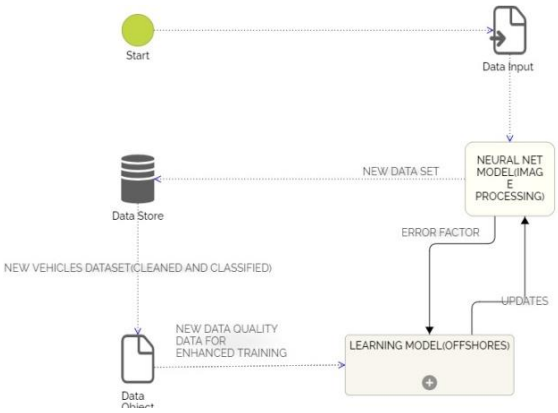
RCNN is trained for providing the result of the detected object as classifying and bounding at the same time and also providing the accurate percentage of the detected object. Higher GPU maintenance and memory utilization help us choose PyTorch It also has numerous libraries present for easy classification.

Fig. 5 Comparison of Faster R-CNN



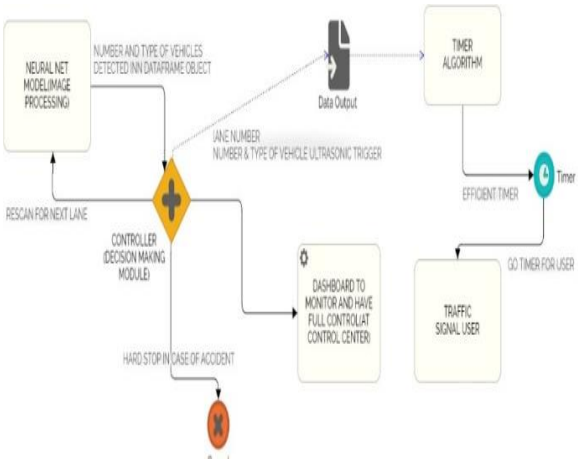
The data input is taken from the Neural network module. The data input can be Images saved videos or any Live feed videos. Image processing takes place in this step. A new data set is formed from the image processing phase. That data set is stored in a database. In other cases, if the image processing step fails it will generate an error message which will not end the process. Instead, it will verify with the existing learning models and provide updates accordingly. From the Datastore, the data object is passed on in the form of a new vehicle dataset. The new vehicle dataset is cleaned and classified removing all the redundant values and also the low-profile outputs. The above-mentioned details are cleary mention in the block diagram given below:

Fig. 6 Collection of the required data for further process



The number and the type of vehicles detected in the data frame object are passed on to a decision-making module. The decision-making module is also known as the controller as this part decides whether to push the process further or to rescan the next lane. The lane number and the type of vehicle are gathered with an ultrasonic trigger this is the data output. From the data output, the result is fed into the Timer algorithm. In the timer algorithm, the efficiency of the timer and is processed into the Traffic signal. From the controller, we further process the data output to the dashboard and control all the activities from there.

Fig. 7 Work flow process



IV.YOLOv5

Glenn Jocher the author of You Only Look Once (YOLO) v5 had to face a lot of controversies when all the code was in the repository for Ultralytics LLC [8]. Comparing the older and newer versions, the new YOLO framework has fewer compatibility issues than the older version [9]. YOLOv5 has a direct interaction with the kernel compared to the older version. Darknet framework as we know it in other words as a deep learning algorithm helps us to perform object classification and detection with the video or image obtained as input. As mentioned in numerous data-providing blogs YOLO is known for the very fast images processed per second and while comparing with the existing ones this is the best object detection algorithm [10].

Non-max suppression filters all the boxes using the threshold on the probability of detecting the

accurate boxes. Normal suppression algorithms can be used but it provides a huge collection of the result so to get rid of the low score we select the box which has accurate and has a high probability result from the class. To prevent the overlapping of boxes we choose non-max suppression. Filtering the threshold is done through the Yolo filter boxes command. After the filtering process, the wrapping process takes place. the output of the Yolo encoding is taken.

Fig.8 Non max suppression

A. Why Python?

Python is used as the base development language in our project as it has a lot of libraries and is the best when it comes to multilingual interconnection. Tensor flow allows us to work with the start to the end of all possible solutions which we require.

B. Pytorch

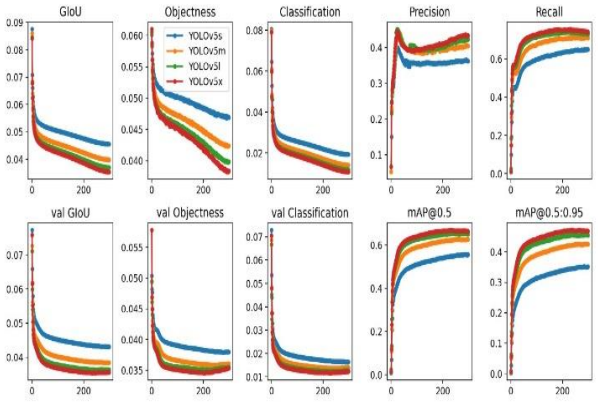
Torch library is the mainly used application when it comes to PyTorch. This open-source library has an inbuilt framework that is more efficient than TensorFlow as TensorFlow deals completely with dynamic graphs used as a library.

Fig. 9 Image with exact accuracy

V. RESULT AND ANALYSIS

Data mining is used in our process in which the streamed data is fed into the algorithm which results in the classified data. Here the data set updating and the classification is to be studied. As the input form is a live feed video there is no explicit time duration. The accuracy of the objects detected is calculated by Total number of objects by number of objects detected. Compared to server storages cloud storage is considered as a better option for the future work.

Fig.10 Precision Graph



VI. CONCLUSION

The proposed system helps people to reduce the waiting time. Instead of the long-haul waiting time we are benefited with less waiting time. The work of the traffic department is also slightly stress less in this process. Furthermore, the study presents the problems in metropolitan areas all over the world caused by congestions.

This paper achieves the utmost output which helps us dealing with the future development indeed. Advanced Public Transport Management Systems (APTMS) promotes information sharing and supports the implementation of ITS within the public transportation environment. The elimination of the image influence is when the preprocessing of the object happens. The Accuracy of this project is 80 percent.

The Data mining algorithm will reach an update of the cloud infrastructure. The cloud infrastructure will have a future development of data updating and the classifier algorithm will be updated accordingly. Ambulance detection issues may vary in the future as India has different kinds of ambulance varying in size so this challenging issue may be solved in the future.

Fig.11 Performance metrics

MODEL	SIZE (PIXELS)	MAP^{VAL} 0.5:0.95	MAP^{TEST} 0.5:0.95	MAP^{VAL} 0.5	SPEED V100 (MS)	PARAMS (M)	FLOPS 640 (B)
YOLOV5S	640	36.7	36.7	55.4	2.0	7.3	17.0

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