Adaptive Smart Signal To Improve Transportation Situation In Urban Areas

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Abstract- *Computer vision is a field of artificial intelligence that trains computers to interpret and understand the visual world. Using digital images from cameras and videos and deep learning models, machines can accurately identify and classify objects. Digital image processing is the use of a digital computer to process digital images through an algorithm. Traffic light control systems are extensively used to control and efficiently manage the flow of automobiles .Other possible solutions are using ultrasonic sensors for detecting vehicles, or using PIC microcontroller that would evaluate the traffic density using IR sensors. The major disadvantages with these systems are it would be very expensive to implement and maintain and are completely dependent on Sensors and Input Factors. Proposing a dynamic & efficient approach to meet the requirements of the traffic control system. The continuous changes of state in traffic and the requirement to respond quickly are the specific characteristics of the environment in a traffic control system. In this approach, image recognition algorithms and machine learning are used to identify the automobile. Reinforcement learning to create a dynamic traffic control model which quickly responds to the actual conditions found in the environment while simultaneously learning about it. In this system another feature is added which is regarding the priority to special/emergency vehicles. Using Google maps as a reference for the city roads.*

Keywords- Smart Signal, Digital Image Processing, Reinforcement Learning, Threshold, IR Sensor, Traffic Control System, Vehicle Priority

I. INTRODUCTION

Traffic lights have become an important part of our life. With increasing traffic and road accidents, it has become necessary to create a safer and more efficient traffic control system. The conventional traffic management systems cannot deal with the variable flow of traffic approaching the junctions. So traffic light control systems are used to manage and control the flow of vehicles through the junction of various roads. The input of a traffic light control system is generally an image, video or readings from a sensor such as an ultrasonic sensor. The output is the timing of the signals according to the vehicle density on each lane. The vehicle count is generally calculated from the given input using detection algorithms . Then based on this count the various techniques are used to control the signal lights such as reinforcement learning or fuzzy-logic.

II. LITERATURE REVIEW

After considering paper [1], we adapted the data-efficient approach to learn and reuse to train the neural network, resulting in a smaller and more efficient network. The network can then easily manage various loads of traffic data that are sent to it. The [2] paper proposes a neuro-fuzzy-driven algorithm for reducing computational time regardless of the hardware used. [3] source proposes an approach that works well with a wide range of camera resolutions, but it cannot be considered because it entails a greater reliance on other sensors, defeating the project's goal. Paper [4] focuses on using ultrasonic sensors as the program's key input, which cannot be considered since ultrasonic sensors are vulnerable to a variety of obstacles on Indian streets.

2.1 Summary of Related Work

The summary of methods used in literature is given in Table 1.

Table 1 Summary of literature survey

Literature	YOLO	Q Learning	Neuro-Fuzzy
J. Zeng et al. 2019 [1]	No	Yes	No
U. Mittal et al. 2020 [2]	No	No	Yes
Tiwari et al. 2020 [3]	Yes	No	No
Chaware et al. 2018 [4]	Yes	No	No

III. PROPOSED WORK

In general, to create the system which works in real time situations few hardware and software upgrades are needed to be done. Introduction of cameras in the traffic system in order to check the density in any lane is needed, to determine the density many Image detection techniques are available. The one proposed in our system is YOLOv3 which works well in an object detection scenario. Our work will mainly focus on the combination of image detection and reinforcement learning models to work on real life scenarios.

IV. SYSTEM ARCHITECTURE

The proposed architecture is shown in Figure 1. Following architecture is described in this Section.

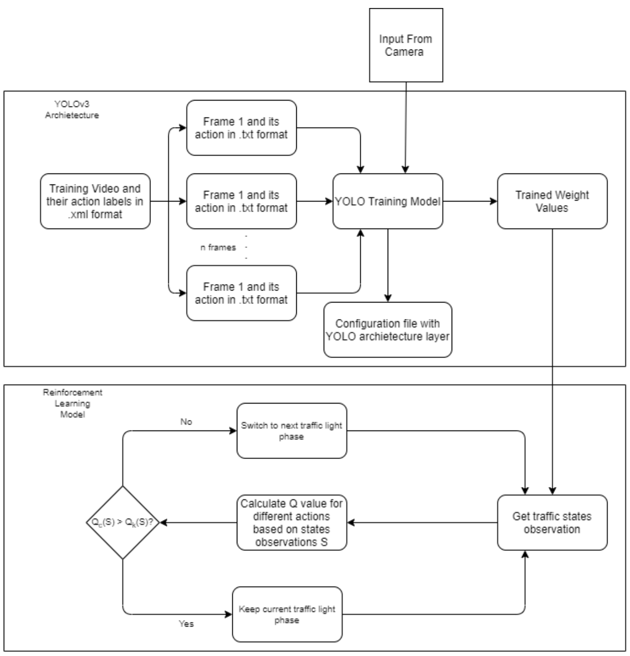

Fig. 1 Proposed system architecture

A. Camera: It is a necessary part for our system as it will give in the input for vehicle recognition. Video taken from the camera should be clear enough to process the count of vehicles.

B. Vehicle Detection (using YOLOv3): The detection of vehicles takes place by applying one neural network to the complete image. This network divides the image into regions and predicts bounding boxes and probabilities for every region. These bounding boxes are weighted by the anticipated probabilities. This model has several advantages over classifier-based systems. It looks at the entire image at test time so its predictions are informed by global context within the image.

- **Image Preprocessing:** This involves converting the video into images and applying various filters so as to reduce the noise in the image.
- **Creating and training CNN model:** In order to detect the vehicles from the preprocessed image we use a YOLO convolutional neural network trained using BIT vehicle dataset. The vehicles detected using this model are then used to calculate the vehicle density of each of the lanes.
- **Calculating the vehicle count:** The output from the YOLO model is used to calculate the vehicle count on each of the lanes which is further passed onto the reinforcement learning model for controlling the signal timing accordingly.

C. Reinforcement Learning Model: The vehicle count values are taken as input in the reinforcement learning model. In order to build a reinforcement learning model we need to define states, actions and rewards.

- **State:** The agent sees states as partly observable, in which the agent can only see a small amount of detail and information about the environment. As a result, for each lane, the system calculates the average travel time, Tavg, and the upstream queue length, L..
- ***Action***: Actions are the various interactions that an agent may have in the system, with each behaviour changing the environment's state according to the simulation's predefined internal dynamics. This simulation is based on a simple intersection, and the agent can only take one of two legal actions: alter or maintain the current step conditions.
- ***Reward:*** The reward function plays an important role in the agent's growth. The agent receives input on the effectiveness of each action it takes in the environment. In general, a poor action will receive a negative reward, while a good action would receive a positive reward. It can be time-consuming to create an accurate compensation feature for a general traffic controller agent. Over the last few years, researchers have experimented with a variety of incentive signals in order to better identify a solid indicator for the DRL agent to learn the best and optimal strategy. Some studies concentrate on common traffic congestion metrics such as cumulative delay shift, average delay and multiple attributes. As a reward function, we prefer the multi-goal styled approach, where we can selectively identify important key attributes that are relevant to our study. As a result, the following is how we describe our incentive function:

$$R = w_1 * \sum_{i \in lanes} L_i + w_2 * \sum_{i \in lanes} D_i + w_3 * \sum_{i \in lanes} F_i * P + w_4 * \sum_{i \in lanes} S_i$$
[1]

D. Output: After the Video input passes through the model frame by frame, the model generates a signal state for a particular signal.

The four steps that are involved in the system:

1) The first step is to get input video from the cameras.
2) Converting the video into real time images which would then be preprocessed
3) Identifying the vehicles from the images using YOLO algorithm and passing on the vehicle count and density as input to the reinforcement model implemented on tensorflow
4) Using the reinforcement learning model to control the signals accordingly.

V. RESULT ANALYSIS

Around 1000 to 1200 vehicles were simulated during each episode, roughly reflecting a standard traffic load during “rush hour” traffic. The agent has a learning rate of 0.0002 and a replay memory capacity of 200. Using static lights in our simulations resulted in a cumulative waiting time of about 330k seconds.The best result we got with our DNN Agent was about 90k. It represents a 72 percent boost. The average wait time is about 160-200k seconds, which is still a major improvement over our previous methods. Our findings include an estimation of the system's vehicle waiting time (WT). The findings were compared to the current traffic system's waiting period.

VI. REQUIREMENT ANALYSIS

The implementation detail is given in this section.

6.1 Software

Processing data from the incoming camera is done frame by frame on a python interface where the data is passed through the program and the results then forwarded to the respective signal controlling interface.

6.2 Hardware

The hardware required for the processing of data Generated at each signal junction by camera will be installed at every junction itself. The Minimum capacity for each of these modules for computing each frame of the video input is estimated to be around or more than 1kFLOPs.

6.3 Dataset and Parameters

The sample inputs used in the system are real time video of traffic from the different cameras present at traffic signals respectively. The sample dataset used in the experiment is the BIT-Vehicle Dataset and Emergency Vehicle Identification Dataset. The BIT-Vehicle dataset contains 9,850 vehicle images. There are images with sizes of 1600*1200 and 1920*1080 captured from two cameras at different times and places in the dataset. The Emergency Vehicle Identification Dataset contains 2,352 images of emergency as well as non-emergency vehicles which can be used for classifying the vehicles. Emergency vehicles include police cars, ambulances and fire brigades.

VII. APPLICATIONS

There are various applications of this domain system. The application is listed here.

7.1 Traffic Light Control System

Traffic light control systems are widely used to monitor and control the flow of automobiles through the junction of many roads. They aim to realize smooth motion of cars in the transportation routes. This is achieved by passing the live feed of traffic as input to an object detection system and then through an algorithm that will decide the flow of traffic. This will have many advantages such as reducing congestion and time spent on the road to improve efficiency, decreasing pollution and reducing the chance of accidents.

7.2 Vehicle Detection

Vehicle detection systems can be used to identify the vehicles based on their features like color, type which can be used to identify vehicle thefts or track suspicious vehicles.

VIII. ACKNOWLEDGMENT

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