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Deep Reinforcement Learning and Image Processing for Adaptive Traffic Signal Control

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Abstract **- In this paper, a traffic control system is build which can easily keep traffic in control using image processing techniques and deep reinforcement learning is presented. In this method, a camera is used in each stage of the traffic light in order to capture the roads where traffic is bound to occur. Number of vehicles in these images is calculated using image processing tools and different timings are allocated according to the count and based on the model trained using deep reinforcement learning along with a green signal for vehicles to pass. In this paper, we implement an intelligent traffic model that controls the amount of time a for which light runs green, based on the density of cars standing.**

Keywords- **Number of cars (density), Traffic system, Deep Reinforcement Learning, Image Processing.**

I. INTRODUCTION

With an increase in the pace at which we lead our lives, time is of the essence. Mismanagement of traffic leads to wastage of time is on the road being stuck in traffic jams. In today's world where technology has transcended all barriers it has now become easy to solve most human problems and one of these problems include traffic congestion. Traffic congestion has increased drastically over the years and has had negative impacts that include road rage, accidents, air pollution, wastage of fuel and most importantly unnecessary delays.

Main reason of traffic congestion is improper traffic management systems. The first gas lit traffic light was invented in London in the 1860's to control traffic caused by horse carriages in the area and it was operated manually by police officers.[2] Since then traffic lights have adapted giving the luxury of smooth movement of traffic. The electric traffic light came soon after in the early 1900's, and this was later replaced by the automated traffic lights which are still used in a number of cities today. This system works like clockwork with the lights changing at regular intervals, but soon people realized that the system had a flaw. In many occasions vehicles had unnecessary waiting periods because the light would be red even when the opposite road was empty.

II. LITERATURE SURVEY

Uthara E. Prakash, Athira Thankappan, Vishnupriya K. T, Arun A. Balakrishnan.
"Density Based Traffic Control System Using Image Processing"
In this paper traffic is managed using image processing which is done using Matlab. A USB based web camera is set up and according to the frames number of vehicles is counted and if the count crossed a predefined threshold then the traffic is detected then according to the density of traffic the signal is turned green, red and yellow. A counter is used to show the time duration of green and red signals implemented with the help of seven segmented display. Arduino board is used to control the LED's representing red and green signals as well as the counter that displays the time for which the green/red signal will be active.

Sheena Mariam Jacob, Shobha Rekh, Manoj G, J.
"Smart traffic management system with real time analysis"
This papers helps to solve the issue of the traditional methods of traffic control and management. It uses ultrasonic sensors in combination with image processing as inputs and the inputs are given to Raspberry pi which is the processing element and the output is obtained in the terms of red and green signals. Basically, the roads are divided into three lanes say lane1, lane2 and lane3 ultrasonic sensors detect the presence of vehicles on each of the lanes and simultaneously images are taken and the average value is calculated which is then classified into high, low and medium traffic .The collected data is then send to cloud where it can be stored and used for different experimental analysis and prediction in case of system failure.

Xiaoyuan Liang, Xusheng Du, Guiling Wang, Zhu
"Deep Reinforcement Learning for Traffic Control"
Currently the system used for traffic management is not that efficient because it is static in nature i.e. it works same for all the traffic scenarios. In the paper a deep

reinforcement learning model is proposed which works on high dimensional Markov's decision process and develops such an intelligent model that studies the current traffic scenario and takes decisions according to the density. The model has to be trained well so that the reward is minimum possible waiting for vehicles at the traffic intersections. As the time passes, the model will become more and more mature and advance and result in optimal traffic management. The model is simulated using Simulation of Urban Mobility (SUMO) in a vehicular network, and the simulation handles different traffic problems using the proposed model.

Er. FarukBin Poyen, Amit Kumar Bhakta, B. Durga Manohar, Imran Ali, Arghya Santra
"Density Based Traffic Control"
Existing system for traffic control fails in the case of heavy traffic in a particular and unnecessarily increases the waiting time of other vehicles. In this system the principle used is changing the delay of the traffic signal based on the number of cars passing through the installed sensors placed on the intersection of the four way road. The sensors used are IR sensors that contains an IR transmitter and an IR receiver to detect the passing vehicle and then send the information to the microcontroller, then according to the density of the detected traffic the glowing time for the respective signals are decided. The lights glow for longer time when the density is more and for shorter time when density is lesser.

Tan Kok Khiang, Marzuki Khalid, and Rubiyah
"Intelligent Traffic Light Control by Fuzzy Logic"
In today's condition traffic monitoring follows a fixed pattern and the condition becomes chaotic in heavy traffic scenario which is mostly managed manually by traffic police. In the proposed paper the developed system makes use of fuzzy logic which is used to mimic human intelligence in chaotic and dense traffic conditions. The best part of fuzzy logic is it makes the computer understand the terms and conditions like 'heavy traffic' or 'light traffic' and for instance if the traffic in south part is more than the traffic in east, west or north part then the signal for south block glows green for more than the usual time. The software used to implement fuzzy logic is 'Visual studio'. Both the situations such as traditional and proposed are simulated in order to better understand the difference in both the conditions. This can be used by undergraduates or above to have a better understanding of fuzzy logic and its related terms and conditions and how actually the fuzzy logic works because the simulation is highly graphic and user friendly. [3]

III. PROPOSED SYSTEM

The aim of this project is to control traffic signals with the help of deep reinforcement learning. This paper describes a system which uses image processing along with deep reinforcement learning model for regulating the traffic in an effective manner by taking images of traffic at a junction. In this approach steps such as image acquisition, image processing and implementation of the algorithm to change the duration traffic light as per the density of traffic on different roads at a traffic signal is taken into consideration. The number of objects in a given image is counted. Image processing is a method to convert an image into digital form and carry out certain operations on it, in order to get an enhanced image or to extract some useful information from it. Now the image is taken from the current traffic scenario and the acquired image is completely unprocessed and transferred to the processing element. The image is further converted to a gray scale image which is then converted to binary image containing only black and white colors.

The image is then enhanced so that unnecessary noise is removed. After that image thresholding is carried out using which image is isolated into foreground and background and then further processing is done to count the number of vehicles on the road. This problem reducing the waiting time for vehicles at the intersection usage dynamically changing every cycle’s duration of a traffic light via learning from past experiences. Generally, one would extend the duration for the phase having relatively more vehicles in that direction. Training a person to be a master who knows how much time should be allotted to a cycle based on current traffic situation. Reinforcement learning is a possible way to learn how to control the traffic light and not use human resource for controlling it. RL updates the model by receiving states and rewards from the environment constantly. It later becomes a mature and advanced. We use the deep reinforcement learning to learn the timing strategy of every cycle to optimize the traffic management.

To approach this problem, we use Q-Learning, where an agent, based on the given state, selects an appropriate action for the intersection in order to maximize present and future rewards.[3] The state-action pairs, also called Q values, are learned and saved to a table where their values are continuously updated until convergence, where an ideal policy is found. We formulate traffic signal control problem as reinforcement learning problem where an agent interacts with the intersection at discrete time intervals t. The goal of agent is to reduce the vehicle waiting time at the intersection. Here in the problem approach, an agent first observes intersection state S t at the start of time step t, then selects and actuates traffic signal action at. After agent takes an action on traffic signals, intersection state then changes to a next state St+1. The agent earns reward Rt at the end of time interval t as a consequence of its decision on selecting traffic signals. This reward is guide for agent to achieve its goal.

Reinforcement Learning Model

A reinforcement learning task involves training an agent which interacts with its surrounding. The agent reaches different situations known as states by performing actions. Rewards can be positive or negative, depending upon the action. [1]

The agent has single goal which is to maximize its total reward across an episode. This episode is anything and everything that happens between the first state and the last or terminal state within the environment. We reinforce the agent to learn to perform the best actions by experience. This is the strategy or policy. Recall that the goal of the agent is to reduce the waiting time of vehicles at the intersection in the long run. By observing the state, agent decides to make an action according to some action policy.

$Q\ (st, ai)$ =R (st, ai) +γ max $Q\ (st{+}1, ai)$

Where R is the expected reward given state S at time t if action ai is taken, and γ is a discount factor applied to expected rewards from all future states.[1] Typically, an iterative process is used to build the values of this function, with the expected reward for choosing a state slowly modified based on the agent's experience.

1. Model Development

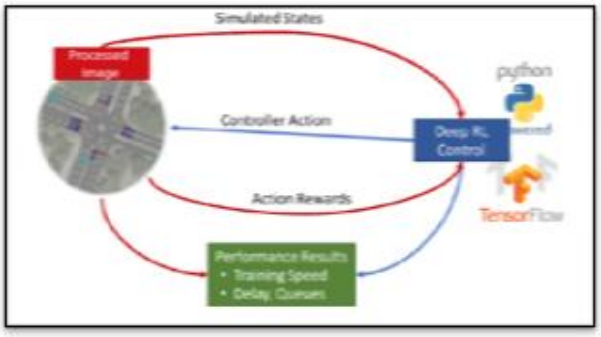

Fig.1. Q-learning model.

IV. FUTURE SCOPE

More advancement can be made to proposed system for identification of vehicles which break the signal as well as in case of any accidental situation. Further modifications can also be made to the system that permits red beacon vehicle to be given highest priority in any emergency situation. More improvement can be done in system to work perfectly in foggy season or in heavy rains.

V. CONCLUSION

An efficient density based traffic control system is simulated and implemented which provides time saving traffic control mechanism. System uses image processing to detect density of vehicles on roads which eliminate need of extra hardware like various sensors or RFID tags. The traditional technique has a drawback of time being wasted on green light on empty road. This drawback is avoided in this system by changing time of green light according to density of traffic. System reduces huge traffic queue and the workload on traffic officer.

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