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An Efficient Framework for Controlling Traffic Signal using Reinforcement Learning Model through ANN and Fuzzy logic

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Abstract- Vehicular traffic is on the rise throughout the world, particularly in developing countries like India. Most of the causes of the traffic jams are the timer set for every signal. There are already set timers which are the same for every signal. In our project, we present an idea to change the time frame based on the number of vehicles currently at the junction rather than a generalized time frame for every junction. This can resolve various problems associated with large traffic jams. For achieving the above output, we are using reinforcement learning along with various decision-making and classification algorithms. RL has been extended to use MARL techniques for simultaneous coordination amongst multiple agents. The algorithms like Canny Edge Detection, Bayesian Networks, Artificial Neural Network and Fuzzy Logic are secondary processes which if aggregated together gives us final results. In the market, such intelligent and smart traffic monitoring systems are currently in various cities like Bangalore managed by the Bangalore City Traffic Police known as the "Bangalore Traffic Improvement Project - B-TRAC 2010". This paper implements a project which plans to optimize and find potential advancements areas in such existing projects for the betterment of human life**.**

Index Terms- Reinforcement Learning (RL); Multi-Agent Reinforcement Learning (MARL); Artificial Neural Networks(ANN); Fuzzy logic(FL); Bayesian Networks(BN)

1. INTRODUCTION

Vehicular traffic needs to be handled very carefully. The future of the human race depends upon increasing growth of usage of transportation mechanisms. The need to regulate such high density of travel modes is need of the hour as we are on the brink of automobile revolution. Even high populated countries like India have large portion of road travelers which needs to be managed effectively. Otherwise it would lead to an uncoordinated state which would then lead to chaos. The methodologies used in achieving our outcome are fuzzy logic and artificial neural networks. Canny edge detection is also used for further enhancement.

Fuzzy logic is applied for several intersections in the network of roads. It contains a fuzzy controller which requires a constant input to determine the output. The fuzzy logic based controller is for an intersection of four roads which are isolated, having left and right turning movements. It also queries the system to get the latest traffic conditions and stop if required.

Artificial neural network also plays an important role in detection of the network of roads. Areas of pattern/image recognition, classification and forecasting are within the applications of ANNs.

Canny edge detection helps in the resolving the problem of noise from gradient operators. Gaussian filters are used for smoothing operations of local gradients. It is then followed by edge detection using thresholding technique.

2. LITERATURE SURVEY

Reinforcement learning allows machines and software agents to automatically determine the ideal behavior within a specific context, in order to maximize its performance.

RL learning is generally by interacting with the environment. It has to deal with two things – exploitation and exploration. To obtain a lot of reward it must refer actions it has done in the past and ignore those with penalties and repeat which give reward. For that, it needs to explore new opportunities i.e. take risks to find the best and worst results for future references. We have to accept that it is interacting with an uncertain environment. A RL model usually consists of 1) set of environment states, 2) set of actions, 3) rules of transformation, 4) rules that determine reward, 5) rules that describe what agent observes. When this implemented in our project, the agent will perceive the state of the system or the environment, it then learns to commit an action or transformation which will maximize the total reward

of the system. While doing so it also takes into account the effect of the rules of the state action pairs. The information gained from one state of the system is given to other agents for future reference.

This is one of the main principles used behind the usage of RL in traffic control monitoring systems. In our GUI, we are giving a scenario as real to the possible scenario in real life with traffic overload and taking indicators and other signage into consideration. This kind of a state will provide the specific results and reduce human error.

After examining the state, the process of action selection and updating is mandatory. It then refers to the old states simultaneously working on finding new states. Then all the visited stages are recorded and saved. The reward system comes now when all the visited states are examined for their values. The ones with maximum and minimum reward are marked. The one with the maximum number of vehicles then will get a larger time frame than the ones with lesser number of vehicles.

Multi – learning reinforcement learning is used mainly for transmitting data from one agent to another. This is useful when inputs and outputs are to be generated for a system which has been given in parts. These parts are actually the decentralized version of the system as a whole. RL and its extension MARL is generally considered when an unknown environment comes into the picture. This learning mechanism helps in maximizing its reward and penalty with each iteration. The controller used for the given system has to map the current state of the environment with the optimal control action. Thus, in our project we map the number of vehicles with the timer and an optimal decision is produced after each and every step.

Now using RL and MARL in traffic monitoring system is a rigorous task because of the stochastic i.e. not very easily predictable nature of traffic and its surrounding environment. Therefore we use other kinds of algorithms along with this to analyze and get the best result. Those algorithms are–

(1) Fuzzy logic
(2) Canny edge detection
(3) Artificial neural network

2.1. *Fuzzy logic*

Fuzzy logic has gained immense popularity in image processing field. It makes the work of decision making simpler for programmers. It works in the way that humans think rather than giving and taking decisions in 1 and 0.
According to Zhao [1], the edge detection algorithm works by dividing an image into 3-fuzzy parts. After this calculation, the maximum entropy is deduced to find the best edge. Russo and Ramponi [2], used fuzzy rule based operators which is built on the IF-THEN-ELSE rule. Computer scientists have developed various fuzzy rules to evaluate the extension of the timer based on the suitability of the vehicles at the current time. These calculations are based on the "degree of confidence". They have also modeled to manage the two intersections which help in developing fuzzy control rules. This in turn helps in selecting the best time frame for the given scenario. Chiu [3] applied fuzzy logic for managing n number of joints in the network. Fuzzy logic is divided in two parts – (a) Fuzzy sets and (b) Fuzzy rules. The sets are used for the discovery of saturation and also amongst adjacent signals which minimizes stops. The coordination of the intersections is also handled by these sets.
Fuzzy logic is implemented with the help of system known as fuzzy controllers. This has a few steps, the first one being where the Bayesian network after calculating probability gives to the fuzzy controllers for further processes. Second step consists of classifying it in fuzzy sets and fuzzy rules. Then these are mapped and the final output consists of the fuzzy rules.

2.2. *Canny edge detection*

Canny edge detection is the widely used algorithm for any kind of edge detection. In our project we have fixed cameras and other image capturing devices on poles and other things available in the surrounding environment. These systems capture the images in the given time slot for every signal.

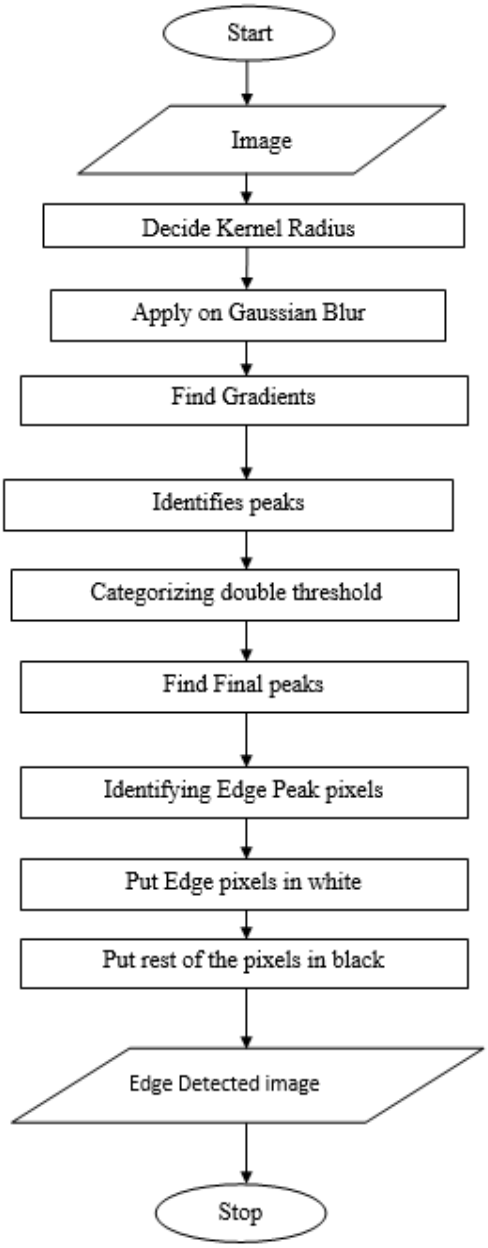

FIG. 1 - CANNY EDGE DETECTION PROCESS

According to the urgency need, we plan to implement classification of urgent vehicles like ambulance or fire brigade in our project. This will be classified by the neural network. Now, for canny edge detection we are using Gaussian filter which is used for smoothing of edges and removing extra and unwanted noise. This step is extremely necessary because removal of noise and smoothing of edges make it easier for further processes to simply prepare the input for the most optimized output.

The Gaussian smoothing operator is a 2-D convolution operator that is used to `blur' images and remove detail and noise.

After this the output of the Gaussian filter is given for calculating white count pixel. This gives input to artificial neural network.

2.3. *Artificial neural network*

The input to this is the smooth and noiseless edges. Therefore it can finally classify the type and number of cars. This after classification is given to fuzzy logic for taking the best decision.

Amongst many types of neural networks, multi layer perceptron neural network is the best for such type of classification. These will classify the number of vehicles between three density ranges – low, moderate and high. A specific number boundary will be given to every range. For example, 0 – 50 can be considered low initially, 50 – 100 can be moderate and 100 above can be high. The biggest advantage of ANN is that it allows variables with large values and also that they are error tolerant. This gives us specific and most optimal output.

ANN also has the capability of learning from past processes which help in further processes and this can enhance the quality of training data given each time. ANN has three layers – input layer, output layer and hidden layer. The hidden layer is where the maximum computation takes place. As we are thinking of implementing prediction of vehicle behavior for further signals, we will need the training data set of the calculated.

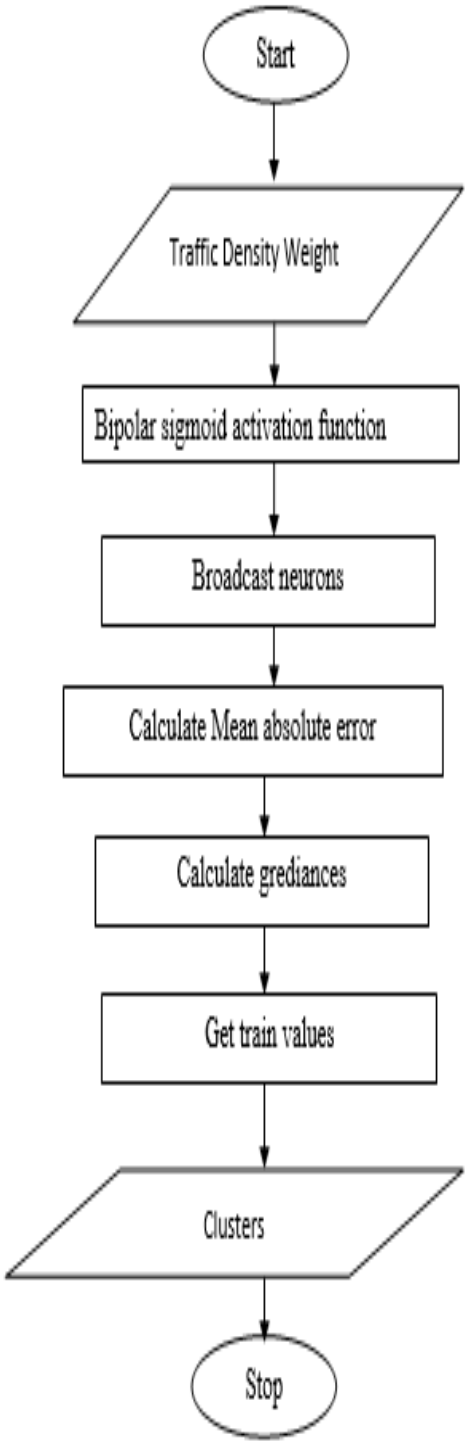

FIG 2. - ARTIFICIAL NEURAL NETWORKS PROCESS

3. SYSTEM ARCHITECTURE AND OVERVIEW

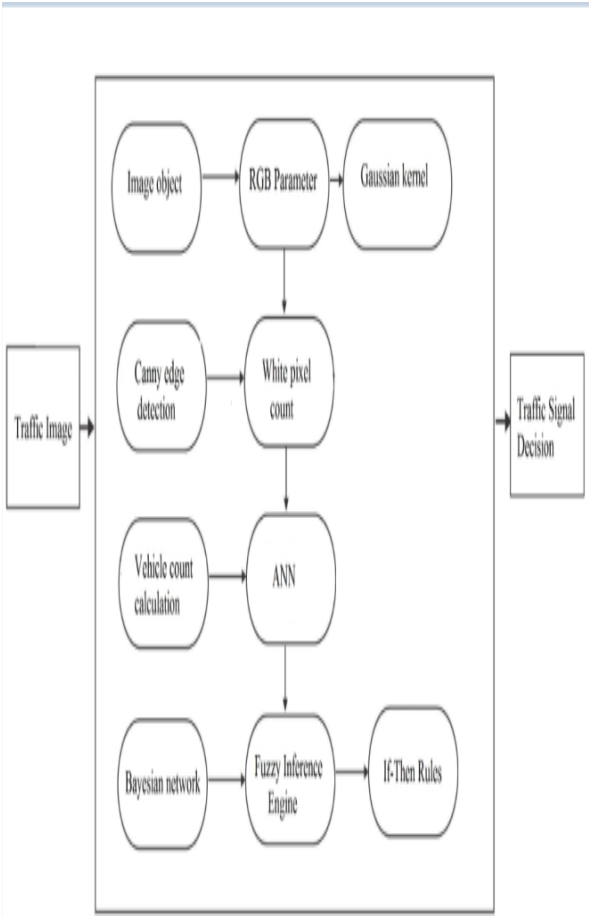

FIG 3. – SYSTEM ARCHITECTURE

6. CONCLUSION

This kind of project can be implemented in the upcoming smart cities. The Make – in - India campaign by our present Prime Minister is a backbone for these kind innovative projects. The major cities can implement this project using the required hardware though in our project we are using it only on display systems using appropriate graphical user interfaces. We have implemented concepts of fuzzy logic, ANN, Bayesian network and canny edge detection using the hardware used for implementation. But the most important concept is the concept of RL which is the driving force for such kind of projects as they need constant interaction with the environment. Without the constant output from the real time environment, this project will not give significant results which can be used to bridge the gap between humans and technology. Because of RL, the system is on its way to become an independent functionality which is able to take decisions on its own without any human intervention. In the future, maybe we will not see any human traffic police personnel managing the roads because the system will be the new handler

making our cities and towns safer and friendlier to live in.

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