SMART CITY: TRAFFIC MANAGEMENT SYSTEM USING SMART SENSOR NETWORK

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Abstract—by 2050, 70\% of the world population is estimated to migrate toward the city, covering just 2\% of the earth’s surface. This leads to many issues, and traffic congestion is one among them. To continue to serve and improve the life of the growing population, it is mandatory to develop an advanced medium to avoid risks which are likely to occur as a result of overcrowded traffic. Our motive is to develop an autonomous vehicle to free human drivers and thus increasing their safety. The Self-driving autonomous vehicles have intensely become one of the great discovery in the field of technology. Different technologies like deep learning, Artificial Intelligence (AI), etc. are merged with each other and with the smart sensors (SS) to develop this self-driven autonomous vehicle. Computer Vision and Deep Learning techniques are applied to build an automotive related algorithm. This project uses Computer Vision Techniques to identify lane lines on a road and also able to identify 40+ different traffic signals. In this project, we will explore the smart city (SMC) concept and propose a strategy development model that will mitigate the traffic concern issues by implementing traffic management system (TMS) using SS network in a SMC context.

Index Terms—Smart City, Traffic Management System, Smart Sensor Network, Autonomous Vehicle

1. INTRODUCTION

SMC consists of many complex and interdependent systems, and traffic system is one among these. In this phase where the population is growing at a rapid rate, vehicles on the roads are also increasing. As a result of this increase, many risks germinate and cause a real threat to the people.

To avoid these threats, it is recognized that the proper functioning traffic system becomes the mandatory part of this large population world. Many countries follow different methods to better their traffic system and also many countries started to implement different technologies in their traffic system.

By the result of our research, we came to a conclusion that most of the traffic system which is present across the world have some or the other limitations and at some point drivers of the vehicles are found to be one of the reasons of the limitations of the traffic system.

In order to avoid these limitations, we came with an idea of self-driving autonomous vehicle which can surely limit the risks faced today due to the overcrowded traffic. We tried to merge the artificial technology with the SS to develop a boon model to the traffic.

2. EXISTING RESEARCH WORK

A Self-Driving Car RC model using raspberry pi, which captures image using piCamera process it uses OpenCV and controls car steering using ANN [1]. In order to demonstrate the model they have created a physical road like scenario. However, they have not considers many real life scenario that an actual road have like the traffic lanes and moving obstacle. In our model we have simulating it on a simulator with real road graphics. Hence, making it more realistic.
The researchers have proposed a model in which they have invented traffic system which can make decisions and switch to different colors based considering the light intensity [2]. However, in our model we try to implement the intelligence concept so that traffic lights behave on its own based on certain time factors, hence making our model more practical and realistic.

A case has been talked about the TMS that was deployed in Cambridge city having queue detectors on roads which detects and informs the centralized control room about all information [3]. Since the system is centralized, it creates a single point of failure and may slow down due to network issue on the contrary our model is much simpler to use, and we have used decision-making system decentralized in every car. Hence, making the model more robust.

The researchers proposed a model where the camera deployed at roadside will detect the traffic and use OCR to identify the vehicles through number plates [4]. However, this model fails in countries like India where different kind of traffics are use like cycles, donkey carts which don’t have any number plate. On contrary our model uses computer vision for object detection whatsoever it is.

The IOT based TMS is a different solution to mobile traffic flow where traffic can be controlled by on duty officers through mobile using internet service [5]. However, this model has a great failure in the areas without internet. In contrast to this, in our model we tried to control the traffic system without the use of internet.

A TMS based on IOT and Big Data uses vehicle detection system at an interval of every 500-1000m [6]. The sensors then send the data to central management system. System analyzes the data based on previous data. Finally, the instructions are sent on Android app. Hence, make the system centralized and much complex. However, our model is much easier and don’t have single point of failure.

A Real Time TMS has been proposed by researchers formed by small network of MU (Mobile unit) JU(Junction Unit) and RSU (Road Site Unit) that are interconnected to each other[7].

The main focus of all these setups is to automate the traffic light. Automating traffic light is a good but it’s not solution but a part of solution. Our model provides much broader and complete solution for efficient traffic management.

Prithvinath Manikonda presented an intelligent TMS using RFID technology [8]. The model uses Dijkstra’s algorithm. The model consists of GPRS module, RFID reader, passive tag and micro controller. System creates a map of the shortest path based on information collected. The algorithm used in this model is too basic and specific to do certain tasks only. Traffic control is still manual. Hence, create huge risk of error. Various existing work focus on light control only. Smart traffic light control system by Bilal Ghazal uses PIC micro controller and IR sensor to find traffic density [9]. It provides dynamic timing slot for traffic light at junction or crossing. A hybrid approach (combination of centralized and decentralized ) has been used in this paper [10]. Using IOT (Internet of things) combined with AI this model takes the input of traffic density using camera and sensors. AI is used to process and analyze the input.RFIDs are used to prioritize the vehicles. We have implemented a similar approach along with autonomous car(AC) to mitigate human errors while driving and openCV for object detection. Hence, making the use of technology to cut down the cost.

3. BACKGROUND

A. Machine Learning

It is a sub field of computer science precisely speaking part of AI that provides machines with the
ability to learn new things without being explicitly programmed for it. It uses the existing data or input data to detect patterns in it and adjust program action accordingly. Supervised learning algorithms can be applied on what they have learnt in past to new data however unsupervised algorithm draws inference from data sets.

B. Artificial Neural Network

It is one of the widely used tool in machine learning. As the name says these are systems consisting of brain which behaves as normal human behave. These neural network consists of input layer, output layer and a hidden layer. The hidden layer consists of certain units which converts the input into a usable form for output layers. These are one of the acclaimed tools for identifying the patterns which are very complex and numerous for a human to identify and make the machine to recognize.

C. Computer Vision

Humans have eyes and brains to see and visually sense the world around them similarly. Computer Vision adds eye and brain to computers. Computer Vision is an important disciplinary of computer science which gives computer high level understanding of digital images or videos and various objects in it. It consists of automatic extraction, analysis and understanding of useful information from input images. Theoretical and algorithmic visual understanding can be achieved through it.

D. Sensors

These are sophisticated devices which responds to certain inputs from physical environment. These inputs could be heat, light, distance, sound or any kind of environmental phenomenon. The output is generally in the form of signal that is converted to human-readable medium for further processing. IR sensors are one of the type of sensors which emits or detects infrared radiations to sense a particular physical condition. These IR sensors can be used to detect different climatic conditions which play a major role in our research.

4. PROPOSED METHODOLOGY

A. Neural Network

Firstly neural network is trained so that it only needs to load trained parameters thereafter. It makes the prediction very fast. As shown in Figure 1, a total of 38,400 (320 x 120) nodes are there in input layer and 32 nodes in hidden layer. In the final output node there are 4 nodes that gives decision to steering of car i.e. to the steering control system: forward, backward, left and right. Each frame is further cropped and converted into a numpy array. Trained images are further paired with train label for training the neural network in openCV we have used the back propagation method. In order to generate predictions, similar neural networks are constructed and then loaded with trained XML file format.

B. Object/Obstacle Detection

In our model we have adapted the shape-based detection. The webcam has been used in model that will collect the image and pass that to our Image Processing Model. The Image Processing Model, shown in Figure 2, will first convert the image to Gray Scale Image and pass it to
HAAR Cascade detection. OpenCV provides a trainer as well as detector. First of all trained cascade classifiers are used to detect the sign boards and traffic light: Red, Green, Yellow. As every object has its own training set, Hence, any number of signboards can be identified. Then Gaussian Blur will be applied to RIO(region of interest). Finally, the signs or traffic light color can be detected and determined simply based on pattern matching and position of bright spot respectively.

![Fig. 1: Obstacle Detection Process](image)

C. Image Processing

Real time image will be collected all around the vehicle giving it 360 degree control. Apart from ultrasound sensor image captured using webcam is major input for model. All the decision and inference will be taken based on image captured and US sensor input. On average of 10 frames per sec image has been captured. Finally, all captured image has been passed to the model for further processing and detection, as shown in Figure 3.

![Fig. 2: Image Processing Method](image)

D. Traffic Light and Symbols

Every Sign boards have their training data. We have included STOP, SPEED LIMIT, START sign boards. Similarly, other 42 commonly used signs can be added to model. 3 major/commonly used traffics light color red for STOP, Green for START, and Yellow for get Ready has been included in proposed model.

5. PROPOSED SYSTEM ARCHITECTURE

DIAGRAM Smart city in itself is a very big picture consisting of smart economy, people, transportation, governance, environment and living.

However, we are focused on its most prominent part, smart transportation. In order to better
demonstrate the feasibility and effectiveness of TMS, we have made a systematic architecture by which we can depict entire picture at a glance. As shown in Figure 4, we can easily say that the whole TMS is a combination of Data collection and management (DCM), Data analytical model (DAM) and Service Providing. Dedicated sensors for traffic flow, location detection and video processing has been used. In physical setup GPS, webcam and Bluetooth devices will be used.

![Fig. 3: System Architecture Diagram](image)

### 6. TESTS AND RESULTS

The result we got after simulation is quite appreciable. Prediction of testing samples returned 86\% accuracy (On avg.) and training samples returned 96\%. In simulated driving situation predictions are generated roughly 10 times/sec (streaming rate 10 frames/sec). However, the accuracy of image processing can be affected by many factors: (i) bad weather condition (ii) blurred sign boards (iii) low light. Overall, the AC could successfully navigate on track with the ability to detect lanes. The AC could not only detect the obstacles in its path but also various traffic signs, as shown in Figure 5.

![Fig. 4: Traffic Sign Detection using HAAR Cascade Classifier](image)

In order to avoid front collision and respond to traffic lights and traffic signs the AC uses the openCV and Artificial Neural Network processing. Based on the decision obtain the AC is able to control...
the steering system and take turn or could continue the same path or lane. Hence, a reliable and human-free driving experience was successfully obtained, as shown in Figure 6.

![Autonomous Driving Mode Simulation](image)

**Fig. 5: Autonomous Driving Mode Simulation**

7. CONCLUSION AND FUTURE THOUGHTS Effective Implementation of our “SMART CITY: TRAFFIC MANAGEMENT SYSTEM USING SMART SENSOR” in totality is to provide a solution for upcoming SMC generations that are more likely to face major concerns like traffic congestion, pollution, and road accidents due to overcrowded vehicles on road and rapid population growth. Humans are many times more prone to commit mistakes than machines hence it’s time to bring “machines with mind” in picture because safety and security of each and every individual is of prime concern. Hence, mitigating the traffic concern issues by implementing TMS using SS network in a SMC context. In the future, we wish to develop an Android App that can monitor the live traffic load / Jam during journey and help the TMS Model to take the best route or decision of changing of routes live. Here the HAAR CLASSIFIER has been used which is pretty much basic and simple but able to fulfill general demands. However, HAAR CASCADE FEATURES by nature is rotation sensitive. Stop signs and traffic lights are fixed objects, but considering a broad real life scenario in near future we will establish advance technology based on computer vision and image processing that could work even for rotated object.

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