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Real Time Object Detection for Effective Intelligent Transport System using Raspberry Pi

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Abstract :- **Intelligent transport system (ITS) is not just limited to traffic congestion control and information, but also for road safety and efficient infrastructure usage. The problem related to traffic is a complex one requiring proper design and planning for developing a solution. For safety and harmony in the flow of traffic, drivers are expected to pay attention to identify, interpret and follow certain rules while driving. Misinterpretation of traffic signs and signals may lead to catastrophes. An automatic system in a car which detects, recognizes, interprets traffic signs, traffic signals and pedestrians effectively and gives warning to the driver would be of great help in reducing the misinterpretations and accidents. In the present study, traffic sign and signal recognition system has been developed to increase the safety of the road users by installing the developed hardware system inside the car which gives an audio output for alerting the driver. Tensor Flow algorithm was used for the real time object detection through deep learning due to its high accuracy. The algorithm is embedded into Raspberry Pi 4 prototype for processing and analysis to detect the traffic signs, signals and pedestrians from the real-time video which will be recorded by a camera placed in the system and produces an audio output to alert the driver. This work aims to study the accuracy, delay and reliability of the developed system using a Raspberry Pi 4 processor considering several scenarios related to the state of the situation and the condition of the traffic signs and movement of humans. A real-time tested hardware implementation has been conducted for different classes of traffic signs, traffic signals and pedestrians. The result showed more than 98% accuracy and is reliable with an acceptable delay.**

Index Terms **– Intelligent Transport System, Traffic signs & traffic signals, Raspberry Pi, OpenCV, Tensorflow etc.**

1. INTRODUCTION

Road accidents are multi-causal and are often the result of interplay of various factors like driver not able to identify traffic signs and signals in new routes, misinterpretation of pedestrian movement, over speed, use of mobiles, jumping signals etc. Every person, whether a passenger, driver, pedestrian would have noticed various sign boards and signals along the roadside that serve important purposes. These important road paraphernalia help us as route guides, warnings and traffic regulators. As control devices for traffic signs and signals it needs full attention and appropriate driver's response. These road Signs were around us date long back in history and the earliest road signs were milestones, giving distance or direction. In the middle ages, multidirectional signs at intersections became common, giving directions to cities and towns. With the advent of motorized traffic and its increasing pressure on road, many have adopted pictorial signs and standardized their signs to facilitate international travel, where language differences would create barriers. In general it is used to help enhance traffic safety through appropriate caution, regulation and informatory signs. Most of them use symbols in place of words and have international recognition and acceptance. These signs were primarily evolved in Europe, and have been adapted by most countries. In India, Motor Vehicle Act 1988 has laid down the uniform road Signs in its Schedule I which comprehensively explains the shape and sizes of these road signs. Article 5 of Chapter II of the Convention on Road Signs and Signals held on 8th November 1968 lays down the classes of Road Signs, which were broadly categorized into: a) Mandatory signs b) Cautionary signs c) Informatory signs. A further guide to the function of a sign is its color. Mandatory Road signs are generally round in shape with red border and some in Blue circles whichgives a mandatory instruction such as "Compulsory Turn Left" etc. Blue Rectangles are used for information signs. All triangular signs are red. There are few exceptions to the shape and color rules, to give certain sign greater prominence. Examples are the "STOP" and "GIVE WAY"" that are octagonal and triangular, in shape.These signs are obligatory on the traffic which is used by a specific area of road that indicates what must one do, rather than must not do.Violation of these signs attracts heavy fines and punishments. Importantly, violation of these could lead to major accidents also. This Section gives few road sign examples for Mandatory, Cautionary and Informatory categories and a brief description of each sign is presented (Table no 1).

Table no:1

S.N	Sign	Meaning
1		The Most important and prominent road sign. This sign indicates that driver should immediately stop. Usually Police, Traffic and Toll Authorities use this sign at check posts.
2		This sign is used at roundabouts where a specific lane discipline is to be followed. This sign directs the traffic to give way to the fellow traffic on the right side of the driver.
3		This sign notifies that entry is prohibited for all vehicles. Certain portions of an area or road are demarcated as 'NO ENTRY' areas for traffic. This could be entry to a restricted area or no traffic zone. So the driver should obey it and divert his route.
4		This sign designates the speed of traffic on road. The Limit specified must be invariably followed to avoid penal action and accidents on the road.
5		This sign indicates that the driver should drive in left lane for smooth traffic flow. The sign is installed mainly on the roads which do not have divider in between any two way traffic flows on the same road.

The organizational framework of this study divides the research work in the different sections. The System model for resource allocation is presented in section 2. Further, in section 3 shown Concept of Methodology is discussed and in section 4, Simulation Results work is shown. Conclusion and future work are presented by last sections 5.

2. LITERATURE SURVEY

IEEE 802.11p describe how communication takes place with an individual DSRC spectrum channel, which imposes a new section set of requirement on communication system by introducing operating mode of WAVE and IEEE 802.11 in BSS. Advantages of multichannel operations, advanced security and other applications on upper layer [20].A promising technology for vehicular communication for safety measures, evaluation of the performance impact of varying channel conditions done[22],impacts of energy efficient packet error rate, rate of collision and successful packet transmission with respect to throughput performance.

In [24] capable of tackling the severe interferences present in the open based road to developing wireless technology has properly chosen which is a complete DSRC system for Intelligent System using combined digital technology along with reception diversity like spread spectrum. This type of DSRC system is operational in its basic form with several mobile users over a distance of 500 meters and for more efficiency radio channel is categorized.

A new method in [24], which describes cloud-based computing in traffic managing system for metropolitan areas, thus increasing the performance, travellers safety, and to reduce consumption of energy. For routing geographical addressing and cloud-based service discovery mechanism used, and throughput improves by this method.

In paper[30] widely developed cellular network along with communications having device to device(D2D), is a promising technique to support reliable and efficient vehicular communications. Power allocation and Spectrum sharing concentrated on slowly varying information large scale fading of channels. Across all V2I links uniform capacity performance is available and its major drawback is high mobility.

Vehicular networks like VANET which is one of the wireless networks used for vehicular communications on roads. This has more reliability but drawback is conventional routing is not possible. But in [29] overcome the demerit thus by determine reliable routes for this mechanism to find vehicle information from the source vehicle to destination, but for this latency is a problem which is low. In [31], describe about an idea of internet usage by visible light communication, which can give the way for communication to establish a smart wireless network grid, underwater communication grid with mobile services.

Standardization of GPS in cell phones and vehicles in traffic explained in [21].One of the major advantage is increased accuracy when compared to heavily relying on cell information, in triangulation method. Lack of precision in the position and speed measurements is major issue. Long range communication includes Worldwide operability for Access of Microwave s(WiMAX),3G,Global System Communication For Mobile were used for providing wireless access over long distance[27]In this WiMAX contain two types fixed and mobile, which cover 30 miles of range and 70Mbps data rate[28].

Another technology which explained in [25] that is about WAVE and this idea of using TDMA MAC to achieve real-time constraints and it efficiently delivers packets But using centralized way and perfectly avoiding a collision. Communication with Bluetooth is used by Group of Special Interests)for short-range communication, this technology used for calculating travelling time, license plate recognition systems and data collection by using 48bit Control address for Media Access [26].

3. METHODOLOGY

Raspberry Pi is a mini-computer that is capable of running applications as a computer [28]. It is one of the most popular single-board controllers and is affordable with number of resources available. In the present study, Raspberry Pi 4

module is used to run the TensorFlow algorithm and is connected to a camera mounted at the mirror level of the car to record the real-time video. A Raspberry Pi display module displays the related information of the detected traffic signs, signals, and the pedestrians if they suddenly come across the road and a speaker module to give an audio output as an alert to the driver.

Fig.1 shows the complete hardware of the developed system. The system will be deployed in a car on the dashboard and is powered using power car adapter.

LabelImg also known as label image, which is an open-source image labelling tool that is used to label the size of the traffic signs and signals image dataset. Each traffic sign and signal image from the video recording needs to be labelled before starting the training process with TensorFlow software library. The purpose of labelling the images is to identify the traffic signs, traffic signals and pedestrians precisely. LabelImg carries out the process of segmentation of the images and then continues with the process of annotation and interpretation for the each class ofl images. Annotation of these images is important as the bounding boxes will be shown on the traffic sign, traffic signal and pedestrian images, which thus can be easily recognized, as shown in Figure 6. The coding used for LabelImg is Python programming language. After LabelImg annotates the sample set of traffic sign, traffic signal and pedestrian images, they are saved in 'XML' file format, and are ready to be trained and tested by TensorFlow models.

As stated above, in this work, the TensorFlow algorithm is used to train a dataset consisting of five different classes of traffic signs, traffic signals and pedestrians including the Stop Sign, Speed Limit 25,Speed Limit 40, Traffic signals(Red and Green) and pedestrians (Humans). These five classes of objects are considered as they are commonly found on the road and most of them are not correctly interpreted from a distance due to various factors which leads to mishap. For each class, there are 100 sample images with different angles and size, thus give a total of 500 sample images. The training process which is crucial in deep learning model is important to prepare the pre-trained model before the implementation of the real-time recognition system. The pre-trained model segments the size, colour, shape and boundary of the sample traffic regulator and pedestrian images that is used for the recognition.

A. *Deep Learning System Model*

As mentioned above, deep learning can be introduced to improve system performance for typical classification problem. Currently, CNN's (Convolution Neural Network) are used with good prospects in the field of deep learning as they are pre-trained networks and can be used for image classification which shows better performance compared with traditional approaches also good in feature extraction. CNN models are based on convolution, activation, pooling, and full-connected neural networks which consequently recognizes the significant features with next to no human management. Among them, convolution is an effective method to extract object features [4], while pooling is used to reduce the dimension of features [5]. The MobileNet-v2 model created by Google often called as light weight neural network which can solve the classification problem quite well. Hence the proposed framework in this paper is mainly based on this model. In our model, multiple captured images captured through a real-time video pass through three convolution layers and an average pooling layer followed by batch normalization. The activation function used here will be ReLU6.Then the extracted features are fed into a full-connected layer using softmax activation function. Finally, three different types of output results are obtained. The model has three modules: pre-processing images, forward propagation and back propagation. Pre-processing images mainly includes decoding, resizing, and standardizing. Forward propagation defines the detailed CNN structure. Back propagation is responsible for training and optimizing network parameters, while improving the accuracy of the model. All weights in our model are initialized by the normal function and the biases are initialized as zero.

B. *Block Diagram*

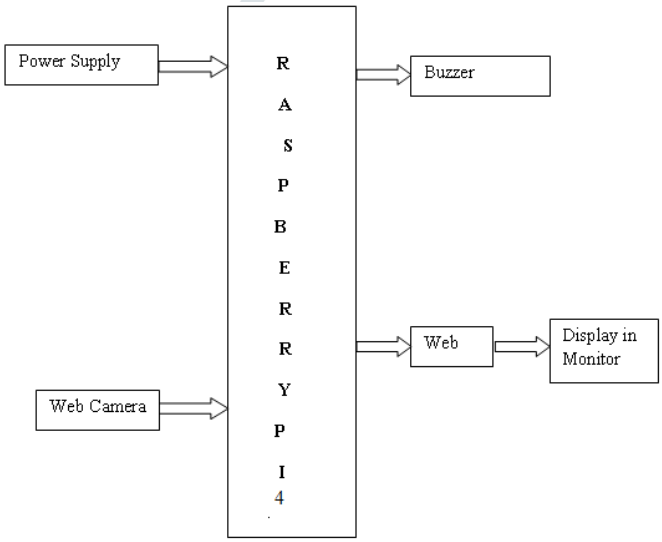

Fig.1: Block Diagram

For autonomous vehicles, the complex processing of video images is one of the main hurdles which can be possible by using our Raspberry pi 4 module. It is portable, easy to integrate and needs 5volts of power supply that can get from battery supply of the vehicle. It has 40 IO related pins and supports all protocols mainly CAN protocol which is used mainly in automobiles. It also supports I2C, serial, Wi-Fi Ethernet, USB. In the present work, the main objective is to build intelligent transport system with effective traffic recognition. The raspberry system is capable of recognizing multiple objects through a camera by plugging a webcam into one of the Raspberry Pi 4's USB slots as in Fig.1. The webcamera which is connected through USB is configured by selecting the port to read the image from the video stream by using Tensorflow and OPENCV models. After detecting the images it produces a voice output of the detected sign which

uses eSPEAK software to synthesize speech as an alert message.

C. Implementation

The implementation of the project is presented in the Fig.2. It explains the complete real time object detection configuration and the flow of the project.

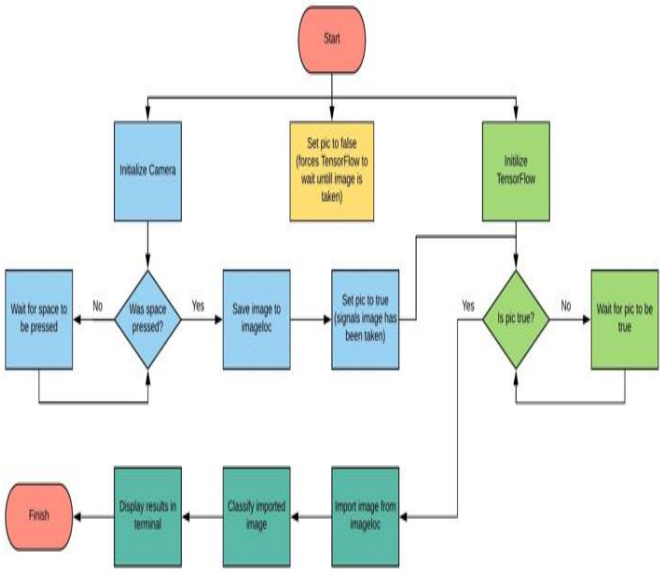

Fig.2: Implementation flow diagram

This flowchart represents the implemented system flow in which the previous images captured for the detection should be cleared from the memory line first and then the camera and the Tensorflow algorithm will be initialized in parallel from where the new images from the real-time video stream will be captured and are stored(allocated) into the memory storage for the image pre-processing. After all the pre-processing is done using the CNN model, the images imported will be compared with the validation data and it has to classify and display it as a result to the viewer.

D. Hardware Used

1. Raspberry Pi

Raspberry pi is a small chip of single board computer. There are various model of raspberry available in the market i.e. the Raspberry Pi1 Model B, Raspberry Pi1 Model B+, Raspberry pi2, Raspberry Pi3 Model B. These all are differ in memory capacity and hardware features like Raspberry pi3 has inbuilt Bluetooth and Wi-Fi modules whereas in previous versions these modules were not available .It has 1.2 GHz 64-bit quad core ARMv8 CPU with 1 GB of RAM as displayed in the Fig.3.

Fig.3: Raspberry Pi Controller

2. Web Camera

Web Camera is used to take the continuous images to get the traffic signs and signals from the real world that looks like in Fig.4. According to the images available through the camera we can send these images to the raspberry pi to perform car's control action.

Fig.4: Web Camera

3. Speaker

Speakers are one of the most common output devices used with computer systems and the most common look like Fig.5. Some speakers are designed to work specifically with computers, while others can be hooked up to any type of sound system. Regardless of their design, the purpose of speakers is to produce audio output that can be heard by the listener.

Fig.5: Speaker

F. Software used

1. Python software

Python is a high level programming language used widely in industries and research work. Different versions of python IDLE is available for programming the python language.

2. Open CV

It stands for Open Source Computer Vision. It has a library of programming function mainly for real time computer

visions. It has over more than 2500 optimize algorithms for set of classical algorithm as well as for the state of art algorithms in the computer visions. It is basically used for image processing in which in the present study it is used for the face detection, object detections, image recognition, traces and also for other functions.

3. TensorFlow

TensorFlow is a Python library for fast numerical computing created and released by Google. It is a foundation library that can be used to create Deep Learning models directly or by using wrapper libraries that simplify the process built on top of Tensor Flow.

4. eSpeak

eSpeak is a compact open source software speech synthesizer that supports a large number of languages. eSpeak uses a "formant synthesis" method. This allows many languages to be provided in a small size. The speech is clear and can be used at high speeds.

4. EXPERIMENTAL RESULTS

In the present work, we have a assumed a car with the prototype developed which is placed at the dashboard of the vehicle moving ahead and the images are captured and are divided into frames through a real time video stream recorded from the camera mounted. The Raspberry pi is used to read the frames with a minimum resolution of the pixels and frame rate set and the FPS rate can be increased using python and Open CV. The FPS is calculated by using the formula

time1 = (t2-t1)/freq
frame_rate_calc= 1/time1

For the object detection, Tensorflow model is used for training and testing where it will grab the frame from the video and resize it to expected shape. It will perform the actual detection by running the model with this image as input and retrieve the detection results. It will loop over all the directions and draw a detection box if confidence is above the minimum threshold. The object detected will be shown with a bounding box labelled with object name and accuracy of the detection in terms of percentage as shown in the figures Fig.6,7,8,9. A real-time alert system is developed using the Raspberry Pi 4 processor. The MobileNetv2 pre-trained model is used to train the system to detect certain traffic signs, traffic signals and pedestrians which are captured through the real-time recording video using Raspberry Pi camera to alert the drivers. Five different classes of images that includes Stop Sign, Speed Limit 25, Speed Limit 40, Traffic signals (Red and Green) and pedestrians (Humans) have been considered for the real-time tested implementation. The performance of the developed system has been evaluated in terms of accuracy, delay and reliability. The results show that the good performance of detecting and identifying traffic sign images which takes 4 images per second and compares the test data for object detection with 1 frames detection per second.

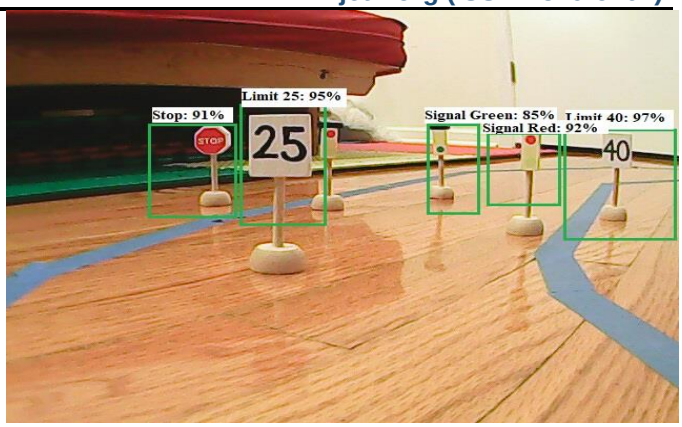

Fig.6: Object Detection

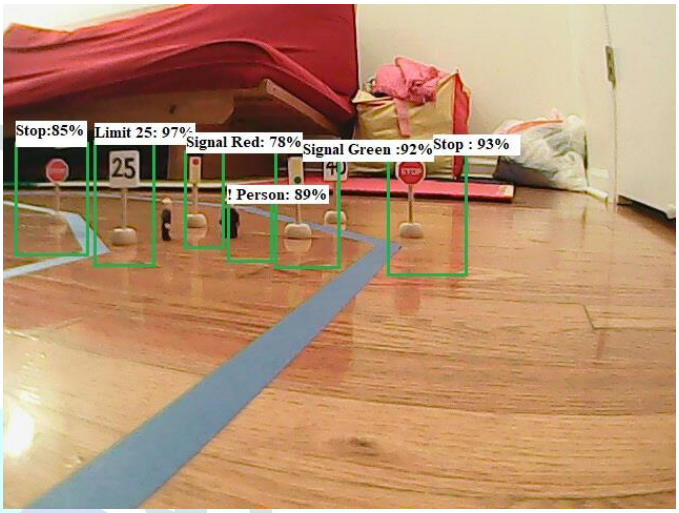

Fig.7: Object detection

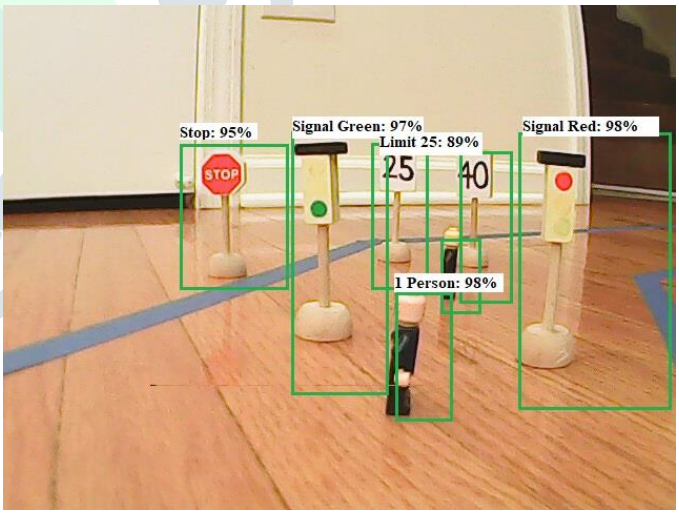

Fig.8: Object detection

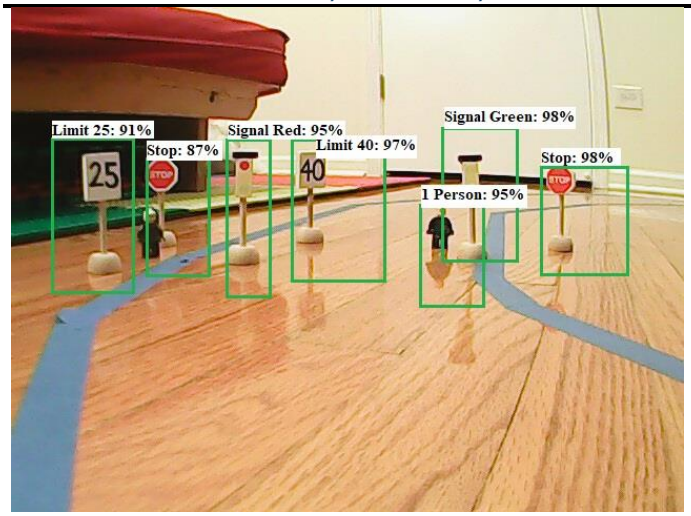

Fig.9: Object detection

5. CONCLUSION

This project's implementation was focused on traffic signs, traffic signals and pedestrian detection, thereby alerting the driver through voice message. The work described in this paper is based on Real time object detection system using Raspberry Pi hardware similar to other applications in the field. For the detection part, Tensor Flow and CNN model MobileNetV2 was used. Experimental results run on these classes of objects shows that proposed structure works on the detecting, identifying and locating traffic signs, signals and pedestrians with better performance and reliability under driving circumstances and meets the continuous prerequisite of a high level advanced driver assistant system.

Future Scope

VLC has extraordinary potential for future ITS environments, as deep learning technique can be acquainted with it to get to the next level framework execution. A real time VLC prototype using Raspberry Pi for detection of traffic sign based on light communication for controlling the vehicle's status and also transmitting the safety messages to the vehicle at the back with an alerting system. We carried out experimental measurements in terms of the eye diagram, beam profile at different link spans and light intensity of LED array for a range of offset angles in between two vehicles for the successful communication.

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