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Safe Drive App: Road Sign Processing and Emergency Services for Smart Vehicle

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Abstract

It is time for updated with the world and technology that is constantly improving. But in an advancing country like Sri Lanka, technology is using sparingly. When it comes to transportation field there are lot of failures in vehicle transportation nowadays. Considering traffic reports and road accident reports within previous years [1], major reasons for traffic congestion and traffic accidents are drivers' negligence and inability to get services quickly. It will be very valuable if there is a system to capture road signs with locations. Then analyse location and camera capture details and store analysed details to a real-time database on a cloud server. When a road sign is identified using CNN algorithm it will be screened in the vehicle and confirmed by a voice alert. And also it is very important to alert the drivers real-time if there is a bad condition on the road by redirects captured data to the web server and send notification to the upcoming vehicles about bad road conditions. Also it will be very useful if a system can recognize driver behaviour real-time using image processing and alert few contacts that relative to driver when driver is an emergency situation.

Keywords: Image Processing, Cloud server, Machine Learning, Convolutional Neural Network.

I. INTRODUCTION

In an ever-evolving world, people also have to adapt with the change. Nowadays people are persuaded to do their most of the day to day activities using automated tools. When it comes to the transportation field there are huge number of automated tools made for vehicles. Therefore, it is no wonder in developing countries such as Sri Lanka, the majority of the population use smartphones and other smart devices for their day to day activities. Hence, innovators tend to make the best solutions by using new technologies for common problems that are faced by people in different sectors.

When considering the transportation field, transportation is affected by different aspects like safety, time and comfortability. As an example, there is a person who goes to office from Kaduwela to Colombo every day. On his journey he will definitely face road traffic or bad situations on the road. Sometimes he might be faced with an accident as a result of careless driving. There are many tools for helping divers in that kind of situation. When studying these facts, it will be very helpful to drivers if a system can alert them about ongoing road situations real-time in a specific area related to the location of the vehicle.

When referring to previous surveys on transportation field, road sign board detection has become a major reason for road accidents. There are lots of road signboard detection apps and devices to alert drivers about upcoming road situations, but there is a problem in the accuracy when using those tools. If the application can detect a road sign using a dash camera placed in a vehicle and store the location of the road sign board into a real-time database. Then next time a vehicle approaches that area, system can alert the driver within a specific time to face the upcoming road situation.

Therefore, drivers may be faced with difficulties on the road due to natural disaster effects on the road like fallen trees. Because drivers didn't know the unexpected natural disaster effects on the road early, they waste their money & time. They must use another direction to navigate to their destination. If drivers alert the road condition early, their time will be saved & they can navigate to their destination without any consequences. Within the proposed solution for this problem, by identifying road situations through image processing, drivers would be alert to road situations that might go unnoticed.

In situations like driving in a new route, drivers will be in need of assistance and might need support in places of difficulty and emergency. If a driver can't contact any person in situations like an accident or adverse health conditions, the

system will recognize the driver's behavior and respond about the situation. In here, the system will contact persons who were added to the contact list in the system and alert them with the location. There are some systems that help to solve some of the issues faced by the drivers, and they reduce the level of causing accidents in roads. Thus, this system is there to bind all the major difficulties addressed by the drivers and to be a guide to assist in the long journey to make smart decisions and help to manage emergency situations. When considering the above information, there would be a myriad of difficulties that are faced by drivers within the transportation process. This research is developed to solve included problems and suggest safe drive application.

II. BACKGROUND

With increasing utilization of technologies, researchers and innovators are enthusiastic to make their researches and appliances based on new technologies for transportation services. Here are some related works included.

There is a research done by four Malaysian students on road sign recognition using an artificial neural network. They have mainly focused on detecting various road signs and minimize FPR. Within their research they have used hybrid color segmentation algorithm to detect various types of road signs and ANN to recognize detected road signs. Their innovation part in here is to develop robust algorithm for the improvement of the accuracy in the captured content. Finally, they have improved the robust algorithm to 0.001 of FPR and 0.33 s of processing time when capturing road signs. [2]

This paper mainly discussed the standard and non-standard road sign detection and recognition. In this research developed a robust hybrid algorithm to evaluate the system performance with other existing methods and eventually to evaluate the classification algorithm performance. Inhere discussed the following two modes: the one is detection mode and it works as a primary stage to collect images from real-time road environments by capturing video from a moving vehicle. The second one is classification, it works with a robust custom feature extraction method and an artificial neural network which is designed to train, test and validate the data. [3]

The paper by Jiandong Zhao,1 Hongqiang Wu,1 and Liang Cheng [4] discussed the road surface state recognition based on SVM optimization and image segmentation processing. The resulting application uses recognition method of road surface state based on SVM (Support Vector Machine) and improves the recognition accuracy and the universality, a grid searching algorithm and PSO (Particle Swarm Optimization). Achieved recognition under hybrid road conditions and different lighting conditions. Detecting Potholes Using Simple Image Processing Techniques and Real-World Footage [5] is a research conducted that used convex hull algorithm to improve road segmentation & used canny filter to convert segmented road to grayscale and apply filter. Achieved to detect & recognize potholes within a range of ≈ 2 m - 20 m.

In this paper, they have discussed the neural network-based algorithm to detect faces in gray-scale images. The system uses a neural network, to analyze each window of the input before it is processed by a “detector” network. They use a change detection algorithm to restrict the search area. Then, use a model of skin color to further restrict the search. Finally, use a candidate detection network to quickly rule out some portions of the input image, before examining them more carefully with the detection network. [6]

This paper describes how smartphones can automatically detect traffic accidents using accelerometers and acoustic data, immediately notify a central emergency dispatch server after an accident, and provide situational awareness through photographs, GPS coordinates and accident data recording. This paper shows how the sensors and processing capabilities of smartphones can be used to overcome the challenges of detecting traffic accidents without direct interaction with a vehicle’s on-board sensors. [7]

III. METHODOLOGY

A. Road Sign Board Detection

A Dashboard camera is linked to the android device (mobile phone or android car play) to capture the video and send to the server segment by segment (around 2 seconds long video segments). In the server a processing queue temporarily store the clips until previous batch finish processing. Each clip is split into frames and added to the frame buffer. Each image in frame buffer is preprocessed in order to identify the road sign segments in the image.

a. Identify Road Sign Image Segments in the Frame

There are certain range of colors in road signs. So, without making the image grayscale to be processed, image pixel matrix is scanned for the colors that include in the road signs. Then masks are added to the frames on top and image is segmented into small parts of images with road signs or near road signs.

As shown in figure 1, data will be capture using a dash camera placed on the left side of the vehicle. The reason is to put it on the left side is most of the road signs are appearing on the left side of the road. Also have to concern about the range of the data that are capturing by dash camera. In this research video data is capturing using a [8] Garmin Dash Camera 65. It can capture data within 180^{o} degree and 60 FPS refresh rate. This camera is working better with high contrast, lowlight and bad weather conditions. Also, it is GPS enabled which is important to capture the location of the road sign. When capturing data there will be damaged road signs and partially covered road signs. By using a Convolutional Neural Network, it will recognize either road sign is damaged or covered by something. Captured data will be send to the cloud server using an API web service. Video data will segment to frames using video frame segmentation algorithm. Then using a convolutional neural network Faster R-CNN algorithm recognize the objects in segmented frames. After recognition process data will be stored to a real-time mongo database with location details.

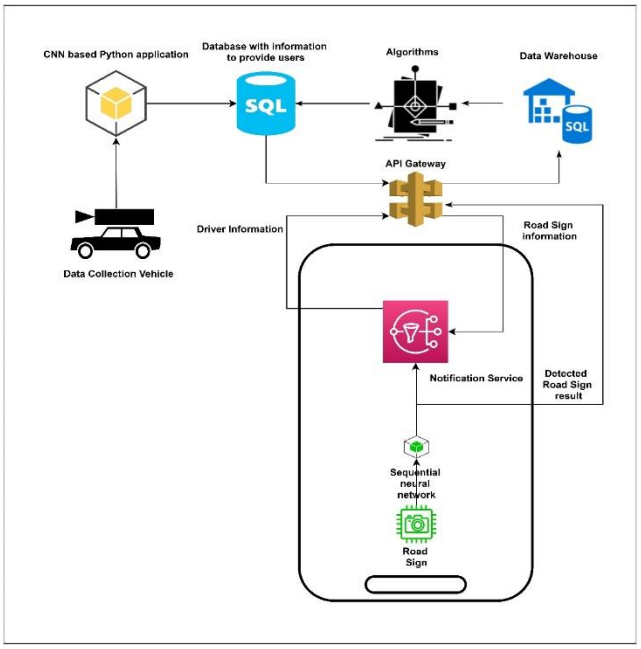

Figure 1: Overview of road sign and location detection

b. Faster R-CNN

Faster R-CNN has two networks: region proposal network (RPN) for generating region proposals and a network using these proposals to detect objects. The main different here with Fast R-CNN is that the later uses selective search to generate region proposals. The time cost of generating region proposals is much smaller in RPN than selective search, when RPN shares the most computation with the object detection network. Briefly, RPN ranks region boxes (called anchors) and proposes the ones most likely containing objects. The architecture is as follows. [9]

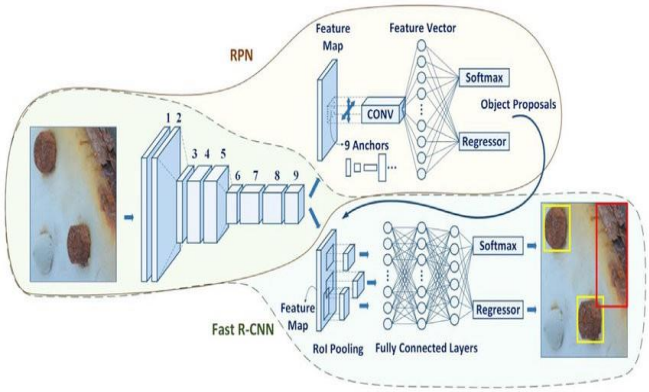

Figure 2: Architecture of R-CNN

Within the model, feed forward network is use with 6 convolutional layers followed by a fully connected hidden layer. Also use dropout layers in between. Dropout regularizes the network to prevent the network from over fitting. All the layers have **relu** activations except the output layer. Output layer operates **softmax** activation as it has to output the probability for each of the classes. **Sequential** is a Keras repository for linear stack of layers. Separate layers in the model requires to detect the input shape it should expect, however it is enough to define input_shape for the first layer of the Sequential model. Rest of the layers do automatic shape inference. To attach a fully connected layer to a convolutional layer must have to flatten the output of the convolutional layer. This achieved by flatten layer.

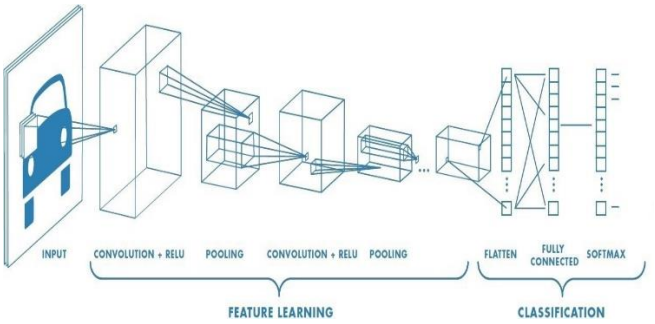

Figure 3: Six-layer convolutional neural network.

B. Notification Service

Since the whole application server is run as a real time, buffered service, when a road sign is detected or any other data or messages that needs attention of the user is acquired it will be sent to the user end application (Mobile app). This push notifications use Google cloud messaging to include a secure and reliable socket.

In the backend service, image segments of road signs that were prepared by the preprocessors. The mobile app's built in UI components will act on stomp messages over the sockets from backend with warnings and other data.

In here designed to get video record of the road from the dash camera and process that video. After that store those processed images to the database and send captured images to verify the road signs and conditions. If that image is real world road sign, then system will recognize it and send a voice alert through the API gateway to the system and also show the road sign in the display unit. If road blocked or had any damage or violence on the road camera will detect that situation and verify the situation after that system will generate the notification for the relevant situation and send it to the other vehicles using centralized system. This entire process is done in cloud platform. This will help the drivers to reduce troubles in driving and even if there are obstacles blocking the signs, the driver will still be informed about them with a voice alert.

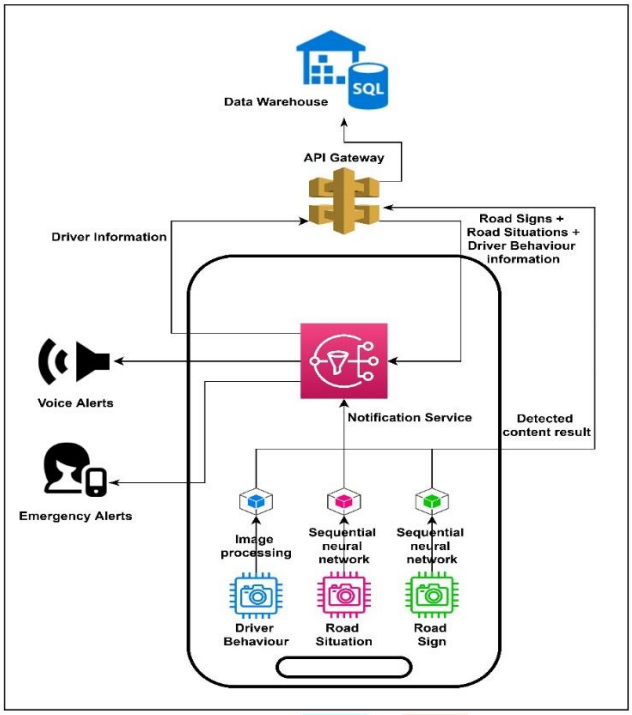

Figure 4: Voice alert system overview

C. Road Situation Detection

The splatted frames of the video stream are enhanced to highlight features that are related to road condition like mud pods (brown color), white lines on road etc.

A pre trained image processing model is used to identify road hazards, bad roads and on road signs and their quantity. Those quantities are used to determine the condition of the road. Additional to that, Google maps API will be used to identify the road grade (E, A, B, C) and that will also be used to quantify the quality.

At the beginning, the captured video data from the vehicle dash camera will be fed into the system. This video will be embedded with the GPS coordinates in order to identify the exact location of the road situation. Then segment the captured video data into frames. Image Pre-processing is essential because the quality of the captured video can change from place to place depending on the video captured time and other environmental distractions. Enhancing the input images is very important for improve the quality of a captured image & produce more accurate results for image analysis. Proposed to use equalize illumination several techniques, Median Filtering Algorithm, Contrast limited adaptive histogram equalization (CLAHE) techniques to remove image noise, enhance the contrast, sharpen, or brighten the input image. In here also the system is using faster R-CNN algorithm to identify objects in the captured images. After recognition process data will be stored to a real-time mongo database with location details.

Figure 5: CLAHE technology example

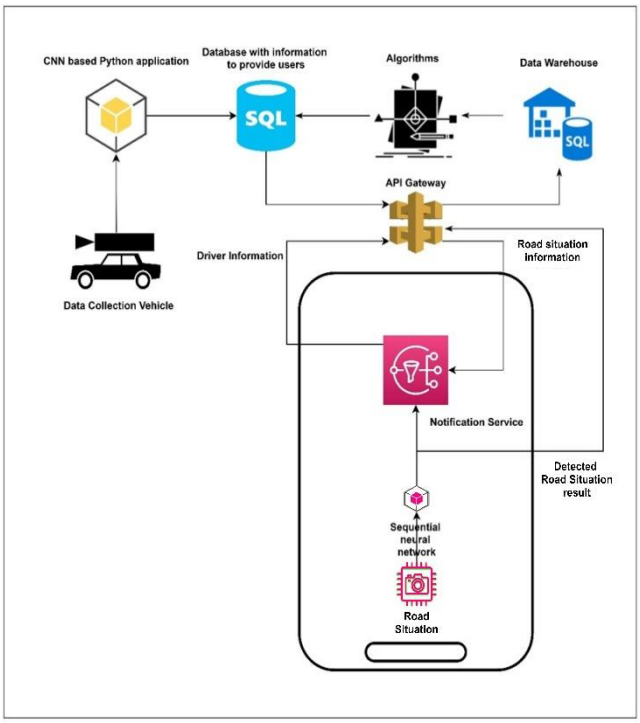

Figure 6: system overview of Road Situation Recognition

D. Emergency Service

Along with the video stream from the android application, real time location data is also streamed to the server. Therefore, the user's location is known by the server and if some emergency situation occurs, relevant parties are informed. An occurrence of an emergency can be submitted by the user or by image processing on the server end.

In here proposed to capture driver behaviour (sickness or any difficulties) and any failure or accidents of the vehicle while driving. Using front camera focused on to the driving seat will captured video of the driver. Back camera is used to capture front view. Captured data will be processed to verify the situation. To verify the driver behaviour here, planned to use face detection algorithms with neural networks. After that get vehicle location and send alerts with location of the vehicle to relevant persons about emergency case. To send alert with location is proposed to use GPS tracker on vehicle with GPS, GPRS technology.

The procedure of managing emergency situations has two main parts.

1. Capturing the video and processing it to collect the driver behaviour & accidents or any other failure of vehicle with corresponding GPS coordinates

2. Fetching the GPS of the vehicle and send the alerts to related pre-inserted persons to inform about the situation.

Overview of the handling emergency situation is shown in the figure 4.0 in the below.

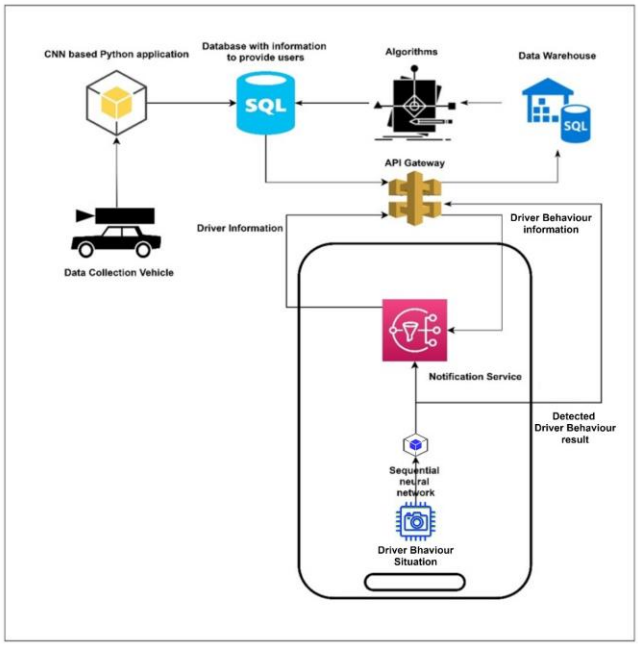

Figure 7: system overview of Driver Behavior Recognition

IV. RESULTS AND DISCUSSION

The performance of each algorithms is evaluated by four experiments. Within the first experiment, the overall performance of the color segmentation algorithms is evaluated by using several images which are selected randomly. In the second experiment, each algorithm is evaluated with respect to the environmental and lighting conditions. Within last two experiments those are concerned with performance, time, and quality of segmentation, respectively. Similar experiments are carried out to evaluate the performance of the shape recognizer. This analysis included a comparison among the ability of the shape recognizer to recognize different groups of signs and analysis of the reasons for failure. With the use of Keras sequential neural network algorithm the test accuracy for the dataset is 98.01%. We captured video data using a mobile phone camera and also the dataset included not only daytime data but also nighttime data. The percentage of lost data of the model is 0.09.

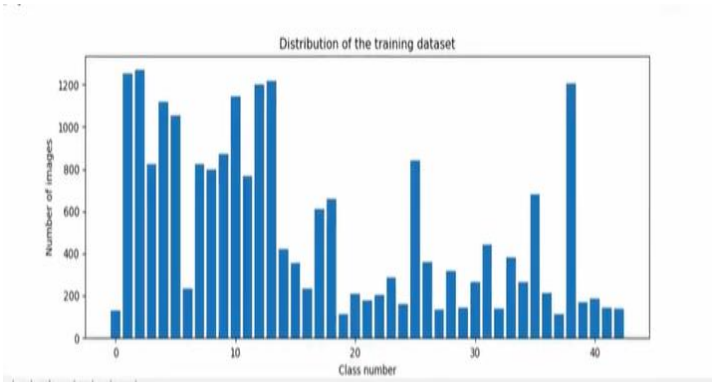

Figure 8: Road sign data classification results

Fig.8 shows how the road signs are split into relevant classes. There are 43 different road signs which is given by the class number in fig.8. Horizontal axis shows the number of images in each class.

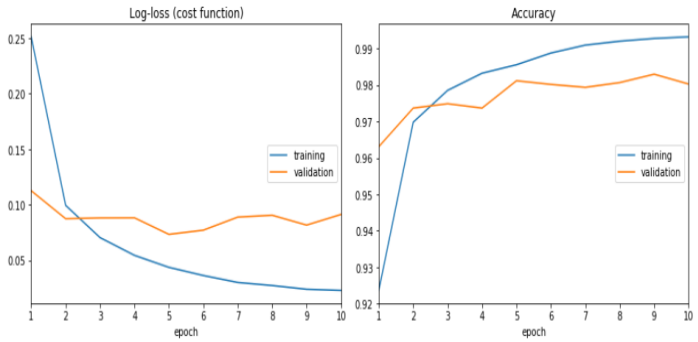

Figure 9: CNN result of Road Sign Detecting

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Test loss: 0.0910546855264
Test accuracy: 0.9801
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Fig.9 is the Loss and accuracy curves of real-time road sign detection.

Figure 10: Result of real-time road sign board detection.

Table.1 shows the result of notification service handle through the node.js WebSocket.

Table 1: Notification service accuracy results.

Test #	Devices near coordinates	Expected notifications	Actual notifications	Accuracy
1	2	2	2	100
2	1	1	1	100
3	4	4	3	75

V. CONCLUSIONS & FUTURE WORK

The paper presents a good preliminary method for road signs and road situations detection & alert the driver about what will appear on the road within a good distance. Recognize location & send notifications about condition on the road early to other drivers in relevant areas through the system. Although when a driver is in an emergency situation, identify the condition through driver behavior. Then warn the driver to concentrate to the road when a driver is in a sleepy or sick mood. Intention of the system is to inform about the emergency situation for 5 contacts such as few close friends and relatives.

The accuracy of road sign board detecting CNN algorithm is around 98%. In here we use mobile phone camera instead of using the dash camera. System will be able to improve accuracy more than this result with the more accurate data captured by dash camera. Furthermore, following methods can be tried to improve the models.

- Try different learning rates and schedules.
- More aggressive data argumentation.
- Experiment with different weight initialization.
- Try different network architectures.

To create a future development of this research can be improved so that the system will be able to navigate drivers to the nearest path when an accident occurred or heavy traffic on the road. Within emergency service can be further developed for informed police stations, hospital locations or insurance service centers when a driver faced an emergency situation. Although within this research project, as a further enhancement can try out on the other types of vehicles like public transportation to reduce road accidents and traffic in the urban areas.

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