Traffic Sign Recognition by OpenCV and Android Studio

Article *in* Technology Reports of Kansai University · November 2020

CITATIONS
0

READS
470

3 authors, including:

Pavel Abdullah
Pázmány Péter Catholic University
5 PUBLICATIONS **12** CITATIONS

SEE PROFILE

ISSN: 04532198
Volume 62, Issue 10, November, 2020

Traffic Sign Recognition by OpenCV and Android Studio

Botan Hamza Hassan[1], Mehmet KAYA[2], Pavel Younus Abdullah[3]

Firat University College of Technology Elazig, Turkey[1]
Syracus University College of Engineering &Computer Science NY, USA[2]
Pazmany Peter Catholic University Budapest, Hungary[3]

ABSTRACT— This paper discusses the traffic signs recognition by Android Studio and Java language with OpenCV library. This is the first project implemented in this way with clarifying the steps scientifically explained. It has a great impact in our daily life which gives notification about our speed and the traffic signs during driving car and makes us less accidents and avoid drivers from over speeding and doesn't miss the traffic signs by the drivers and provide the drivers with pieces of information which help in driving safe and conveniently. The aim of this paper is to amalgamate state of the art technique for Road Sign Detection and Recognition with the goal of conquering greater accuracy with a real-time performance. An extra level of driver assistance is furnished by the Road Sign Detection and Recognition (RSDR).

KEYWORDS: Traffic Sign Detection Recognition, Convolutional Neural Network, Speed Up Robust Feature, Hue Saturation Value HSV, Colour Segmentation, OpenCV, Shape Classification.

1. INTRODUCTION

The universe is governed by a combination of several laws which are environmental, physical and many more. Likewise, mankind has created a set of traffics rules, to guide the people travelling and to regulate the traffic flow. Road and traffic signs are basically symbols/visual stimulus which give information about the roads ahead that can be understood by drivers [1]. They provide the drivers with pieces of information which help in driving safe and conveniently. A driver has to do multiple tasks while driving including things apart from paying attention to the road such as looking at the vehicles around, constantly monitoring blind spots, indicating the lane changes and abiding by traffic rules leading to him/her getting overburdened [2]. This thesis's main proposition is based on the development of a RSDR (real-time road sign detection and recognition) system [3]

Feature selection using ant colony optimization (ACO) and road sign detection and recognition (RSDR) system., 2019). It is based upon four main steps cited below:

- Acquiring image: A digital camera was used and placed in front of the car used to collect and acquire data which was in the form of a live video stream which consisted of several frames.
- Pre-processing Image & Traffic Sign Detection: This part comprises of the following steps: -
- Frames were taken one at a time and converted from the Red, Green and Blue (RGB), into the HSV model i.e., Hue, Saturation and Value for segregation.
- Noise filter was applied to the frames to remove noise from the scene.
- Connected Components Labelling was applied to the objects left in the frame.

In order to remove objects which are not of appropriate size, the Size filter was applied.

- Traffic Sign Tracking: Blob tracking have been used to predict the search region for the sign in the next frame to improve the traffic sign detection time.
- Traffic Sign Recognition Stage (feature extraction): A new traffic sign recognition technique was applied named as "Pattern Matching", which was found to be much faster, and efficient according to the real

time requirements.

1.1 Aim of the Project

Since the research has been done in the real time environment for traffic sign recognition, there are three most important aspects considered, to be achieved by the real-time traffic sign recognition system:

- Speed: To enhance the processing time in traffic sign recognition.
- Efficiency: To check the overall system's response time and take measures accordingly to improve the efficiency.
- Reliability: To make this system more reliable, the project is to be designed in such a way that the predictions are to be very accurate.

1.2 Problem Statement

Robust and well-arranged system is important to cover and find out the attention of drivers during driving over the streets and roads safety, the Traffic Sign Detection and Recognition (TSDR) system has been initiated, especially the traffic signs are not in fine corner or it is faced damaged by external factors. After opening the camera of the mobile in real-time, the video sequences under different conditions (lighting, weather and climate, velocity and quickness, etc.), below factors are predictable:

- Determine a method to extract the traffic signs through driving car in real time by video sequencing the frames to be segmented.
- Coming up with a method to clean the extracted the traffic sign from noise and distortion.
- Coming up with a method to find out the region of interest and identify the traffic sign with alarming notification.
- Coming up with a method to find out the speed meter with alarming notification when the car drives over speed.

1.3 Scope of the project

This approach is with OpenCV to solve the problem of frame extraction, colour segmentation, signs detections and recognition in an end-to-end fashion and speed meter as well, to excute this system all the operations for detection and recognition of traffic signs CNN with the library of OpenCV is used, as Open CV comes with a lot of pre-defined functions. to get frame extraction and fetch the velocity of the vehicle, Region of Interest and Robust Feature methods have been used in this application. Additionally, to achieve better accuracy for color segmentation, in daytime setting the RGB model is used whereas HSV (Hue, Saturation and Value) model is utilized in night time conditions. A very advanced library developed by Intel, OpenCV, is very robust artificially intelligent library. Its capability in performance includes image processing tasks, facial recognition, advanced video surveillance.

2. LITERATURE REVIEW & BACKGROUND

We, as human beings, face the issue of recognition in everyday lives. In the computer vision and pattern recognition communities, object detection and recognition has been discussed a lot over the past few years. When we speak of problems that we can solve with a computer, one of the most pertinent issues that we come across is image analytics and recognizing the objects (Jayaprakash A. a., Feature selection using ant colony optimization (ACO) and road sign detection and recognition (RSDR) system., 2019). It is indeed very difficult to find a universal solution to perceivable issues such as face or object recognition. Because what may work for stationary objects, would not work for moving objects. The problem of image recognition can be divided into further smaller bits. For example, if the object we are looking for is known to us, then it's an object detection sub problem [4]. Let's say, we possess an object class of interest and a reference illustrated picture for scrutiny, with the aim to produce a system which can recognize and ascertain instances of the object in

hand in the given picture to then produce an output with their locations. If the object to be identified in our case is a car, the outcome off the detector should produce something like illustrated in the figure 1. In the specimen discussed here, some typical issues enlisted with object detection are identified. The biggest and crucial problem with the creation of a strong object detector is that the degree of fluctuation in images and videos [5].

Figure 1. The detection algorithm should detect the traffic signs and be identified in bounding boxes discussed earlier.

2.1 General object detection framework

So, to summaries we can say that mainly there are three steps in an object detection and identification structure/model [6].

- For Producing regions of interest or region proposals, a particular Algorithm or Model is utilized. These region proposals can be defined as basically a set of bounding boxes covering the full image that is, an object localization factor.
- Post application of algorithm to get region proposals, visual characteristics are obtained for each of the bounding boxes. These are then assessed, and it is if objects are present in the proposals based on visual features. That is basically identifying an object classification component.
- Finally, all overlapping boxes as shown in figure 1 is collated into a solitary bounding box also called as non-maximum suppression.

2.2 Detection Methods

2.2.1 Scale-invariant feature transform (SIFT)

Scale-invariant feature transform (SIFT) was a feature detection algorithm using the technology of Computer Vision, which will be discussed separately, to distinguish, identify and describe the local features in images. Several of its application included object recognition, robotic mapping and exploration, 3D modelling among other things. Using a bunch of reference pictures, SIFT key points of objects are first derived and then saved in database. The method of an object being detected in a new image is by pitting it and analyzing every feature

of it with the ones in database and then finding candidates based on their Euclidian distance of vectors. After taking the set of equivalent twins, subset of key points which match and possess similarity on the object and its location, scale, and sense of direction in the new image are marked to figure out good matches. From these, each of 3 or more features which have similarity with object and its orientation are then made to undergo another comprehensive model validation. The ones that conform from this step are then removed [7].

2.2.2 HSV Color Space

The most convenient way to combine and generate colors is the RGB model discussed above. The color combination CMYK (Cyan, Magenta, Yellow, Key) is widely used in commercial printers. It's also observed that HSV (hue, saturation, value) and is so popular and convenient that it is commonly used as the color selector for graphics software. So, the spectrum perceived by human eyes which explains the process of color combination is done by these methods [8].

In comparison to RGB and CMYK which are mostly used as primary colors, humans' perception of colors is closer to HSV. It consists of these:

- Hue
- Saturation
- Value

2.3 Machine learning of the approach

2.3.1 CNN (Convoluted Neural Networks)

CNN or Convoluted Neural networks is one of the most known algorithms in the field of image classification and consists of Convolution layers, Activation function layers, max pooling of layers to decrease the dimensionality by not letting go of a lot of features. A feature map is generated by the ultimate layer of CNN [9]. Let's say, if we input a Car or a Forklift image, the algorithm m will come back by telling whether it's a car or a forklift. Its use is not just restricted to that; it is laced up with some remarkable computational abilities which produce great advancements.

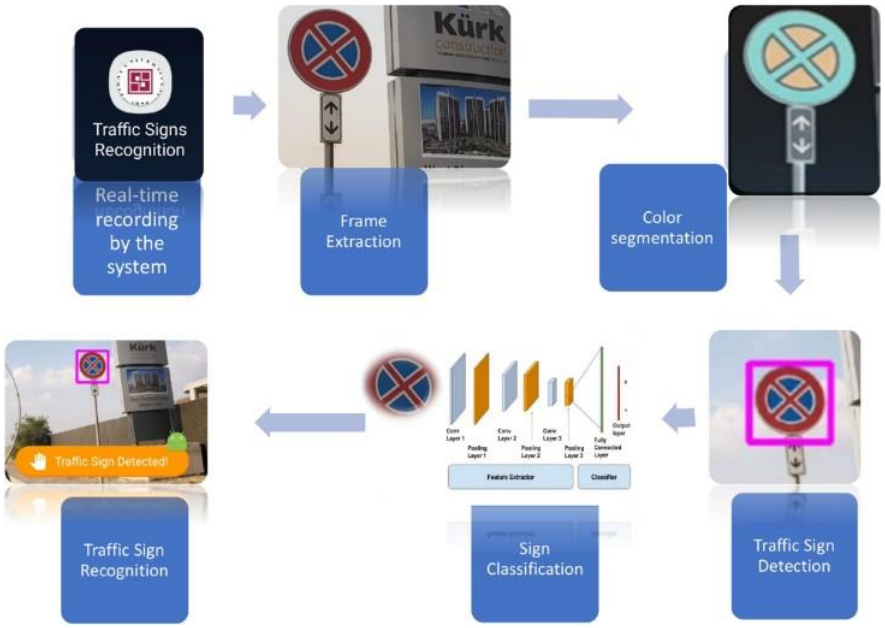

Figure 2. Project Architecture Design

To perform all the operations for detection and recognition of traffic signs, CNN with the library of OpenCV

is used, as Open CV comes with a lot of pre-defined functions. In order to get frame extraction and fetch the velocity of the vehicle, Region of Interest and Robust Feature methods have been used in this application. Additionally, to achieve better accuracy for color segmentation, in daytime setting the RGB model is used whereas HSV (Hue, Saturation and Value) model is utilized in nighttime conditions. A very advanced library developed by Intel, OpenCV is used. It's used because all of the functionalities of most traditional methods mentioned before are imbibed and utilized in Computer Vision's library. This allows and empowers scientists/engineers to execute image processing/segmentation/classification activities with utmost precision and accuracy and enhance its output than would have been achieved if traditional methods were being used. The architecture diagram of the project and it is flowchart is mentioned below for better understanding [10].

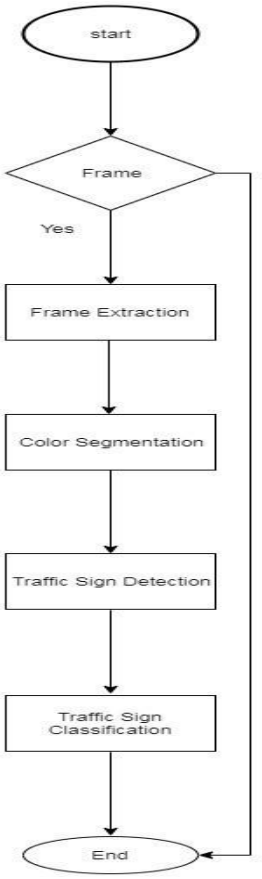

Figure 3. System Process Flowchart

2.4 Feature Extraction Methods

Image Processing has become vital in many spheres of life for instance medicine, disease diagnosis, tumor/cancer detection, satellite imagery analysis etc. But analyzing the whole image captured to find answers for a particular pain area becomes cumbersome, hence sorting out right features play a very vital role in designing solutions for the problem in hand. It is also because demeanor of the images is defined by features only which showcase the time consumed, memory occupied and classification efficiency. Thus, it can only be achieved with the application of proper feature extraction techniques to smoothen image classification, detection and other following processes as well [11].

2.5 Region of Interest Method

To learn and understand more about object detections methods, we need to take and capture images, digital in nature. A lot of methods and equipment are used of which Digital cameras, computed tomography, scanners, and magnetic resonance imaging which get widely used. What we (humans) observe are images in every case.

However, while we transform the images that are observed to the equipment mentioned earlier, we come across are numerical measurable values for every point of captured picture.

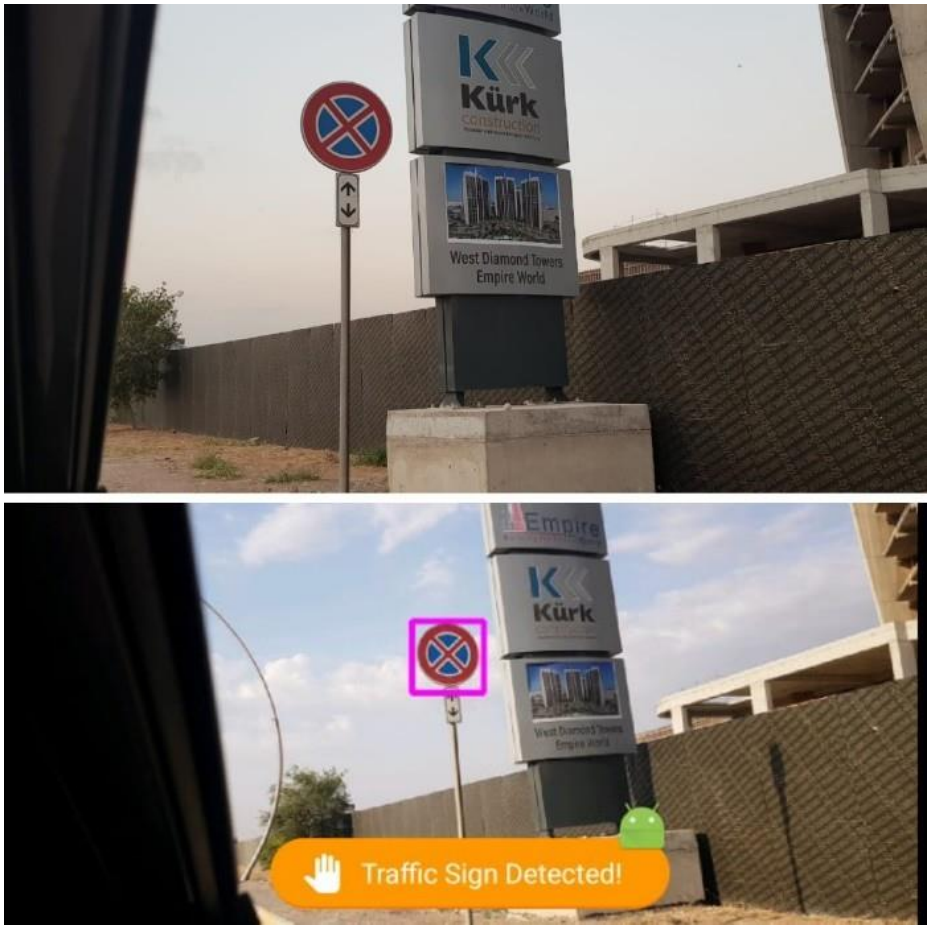

Figure 4. Region of interest detection

2.6. SURF (Speeded-Up Robust Features)

The development of SURF (Speeded-Up Robust Features) back in 2006, was a result of speeding up the process of key point detection and description. Back in the day, SIFT or the Scale-Invariant Feature Transform was earlier used for key point detection but because of its slowness SURF was created. In SIFT, the Laplacian of Gaussian was approximated with Difference of Gaussian for figuring scale-space. But SURF being slightly advanced, digs in a little further and approximates LoG with the help of a Box Filter [12]. A demonstration of such an approximation is orchestrated in the image below. A big bonus and a plus point of this is that, convolution with box filter can be derived easily. It can be done so with the help of integral images as well as parallel for scales varied in nature. SURF relies on determinant of Hessian matrix for both calibration and position.

Figure 5. Removing Distortion

2.7 Color Segmentation Method

A low-level feature map of the input image is selected, from which image is computed. The actualization of the proposed interest operator presented in this paper includes obtaining of the areas with high cluster of the color-specific gradients. Hybrid Methods which include color-based and shape-based methods have their own set of pros and cons. As a result of which, Modern systems in current era are incorporating the use of RGB or HSV models. This is done in order to achieve greater efficiency of the TSDR system. In these hybrid methods, when we consider shape of an object, in color-based approaches it is taken into account after having looked at color, or it is used in shape detection as the main method but integrate some color aspects as well. Coming to color-based approaches, a two-stage strategy is usually used in these cases. Firstly, in the initial stage segmentation is done to narrow the search space [13].

3. TRAINING PROCESS OF TSDR

Image processing is done to analyze, enhance or optimize the features of an image by operating and applying some techniques on an image, in order deduce some useful information from it. It can also put as a type of signal processing in which an image is received by the Image processing method and an image or characteristics/features associated with that image is generated from it. In today's day and age image processing is among quickly growing technologies so much so that it has become one of the critical areas for research within engineering and computer science disciplines too.

Image processing broadly comprises of these steps:

- Obtaining image by the help image acquisition tools.
- Analyzing and modifying the image to make it suitable for next step.
- Deriving output in which can result in modified image or report that is based on image analysis.

3.1 Image Classification Working Principles

Let's try to understand what Image Classification is. It can be described as the task of obtaining the information classes from a multiband raster image. It analyzes the numerical characteristics of different image features and performs data organization by classifying objects into different types. All in all, one can say image classification is like image categorization. As a matter of fact, data classification algorithms typically employ two stages of processing; training and testing. First, characteristic properties of image features are separated based on which a unique depiction of each classification division is created.

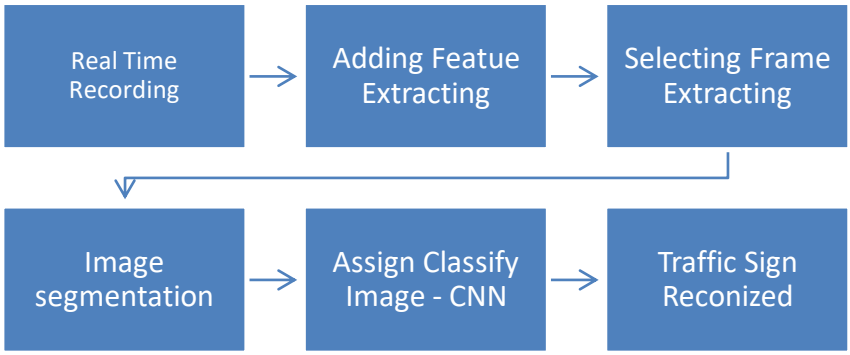

Figure 6. Traffic Sign Training Process

3.2 Image Segmentation in Image Processing Processes

Segmentation in the context of Image Segmentation can be described as the set of methods followed in converting the image i.e. the breaking down the digital image into more segments. In other words, the digital image is broken down into the set of different pixels. The aim of breaking down is to simplify or change the way an image is presented into an easier format or a more convenient format by making to more meaning for machines to analyze and understand better. It can also be described as a method of putting a designation to each pixel present in the image in a way that pixels with the same designation possess certain features. Its primary objective is to locate objects and boundaries such as lines and curves present inside the images [14].

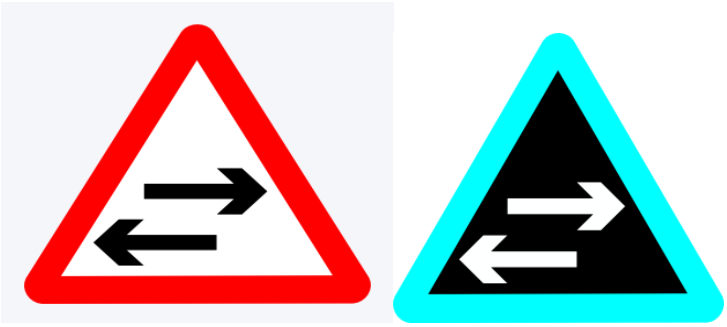

Figure 7. Traffic Sign Segmentation

3.2.1 Noise Filtering Algorithm

Any arbitrary deviation of image Intensity and visibility generally represented as grains in the image can be described as Noise. It can come across in images as effects of photon nature of light or heat emanating from the image sensors which are few of the common reasons for causing it. It can be generated at the time of capturing or image transmission. Because of it, the pixels of the image show different intensity values than the original real theoretical pixel values that are generated from the image. So to remove it, Noise removal algorithm is used which is the process of taking out or lessening of the noise from the image. The noise

ISSN: 04532198
Volume 62, Issue 10, November, 2020

removal algorithms reduce or remove the visibility of noise by smoothing the entire image leaving areas near contrast boundaries. As a result of which these methods can cause cloudiness and lowering of contrast details.

Few of the types of noise that are encountered are [15]:

- Impulse noise
- Additive noise
- Multiplicative noise

Figure 8. Applying Image DE-Noising

3.3 (GTSRB) Traffic Sign Database Description

To implement a recognition, we need to have a dataset, in all computer vision the dataset it would be an essential data to be compared with the detected to be recognized. in order to train an algorithm based on the images are used we need of training data is When doing computer vision projects, training data and test data is essential. If algorithms that train themselves based on images are used, the need of training data would be obvious. so, in this project German Traffic Sign Recognition Benchmark (GTSRB) Dataset is used as essential database and the algorithm is Convolutional Neural Network (CNN).

Figure 9. GTSRD

3.4 CNN (Convolutional Neural Networks)

CNN or Convoluted Neural networks is one of the most known algorithms in the field of image classification and consists of Convolution layers, Activation function layers, max pooling of layers to decrease the dimensionality by not letting go of a lot of features. A feature map is generated by the ultimate layer of CNN. Let's say, if we input a Cat or a rabbit image, the algorithm m will come back by telling whether it's a cat or a rabbit. Its use is not just restricted to that; it is laced up with some remarkable computational abilities which produce great advancements [16].

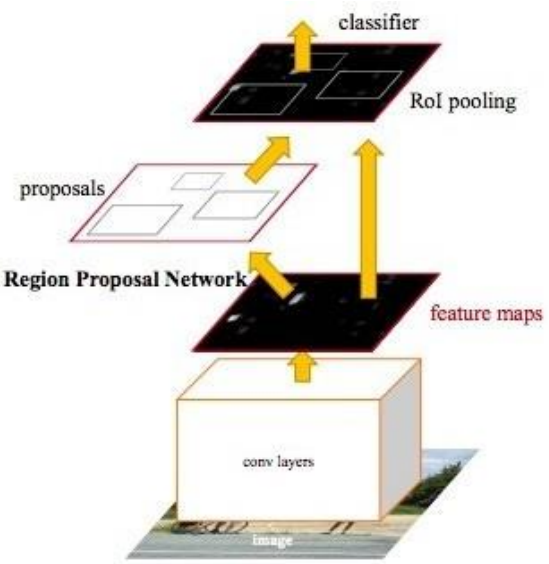

Figure 10. Feature Extraction and training process in CNN

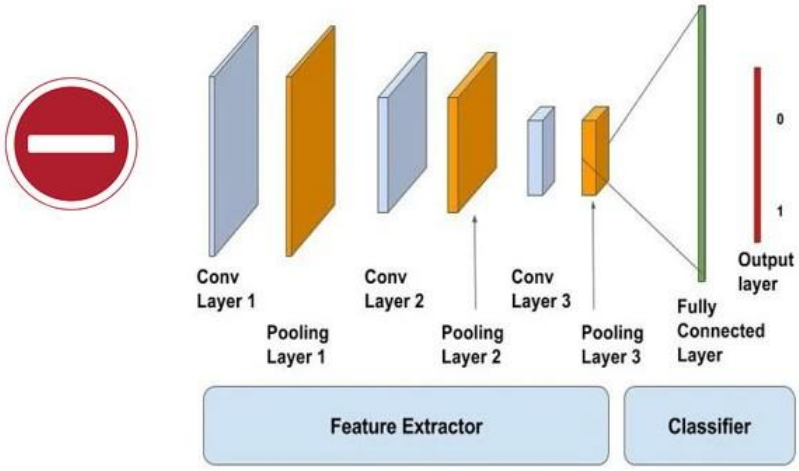

Figure 11. CNN Classifier Procedure

The illustration of the CNN is shown above in the picture. RPN generates the proposal for the objects. RPN has a specific and exclusive architecture in itself. RPN consists of a classifier and a regression. The makers of the advanced algorithm came up with the concept of Anchors, which is the focal point of the sliding window. Classifier regulated the possibility of a proposal having the desired object. Regression regresses the coordinates of the proposals.

"Pyramid of Filters" making the process less time exhausting and more economical cost wise than any other algorithms. These anchors can be assigned labels depending on:

- The anchors with the most magnitude of Intersection-over-union overlap with a ground truth box.
- The anchors with Intersection-Over-Union Overlap more than magnitude of 0.7.

Ultimately, RPN is an algorithm that needs to be trained properly definitely has a Loss Function which can be calculated by [17]:

ISSN: 04532198
Volume 62, Issue 10, November, 2020

$$L(\{pi\},\{ti\} = \left(\frac{1}{Ncls}\right) * \sum Lcls(pi,pi) * +(Nreg + Lreg)) \quad \textbf{(Eq3.4.1)}$$

i → Index of anchor, p → probability of being an object or not, t →vector of 4 parameterized coordinates of predicted bounding box, * represents ground truth box. L for Loss, cls represents Log Loss over two classes.

$$Lreg(ti, ti^*) = R(ti - ti^*) \quad \textbf{(Eq3.4.2)}$$

p* with regression term in the loss function makes sure that, the only condition in which object is identified as yes, then only regression will count, otherwise p* will be null and hence the regression term will become zero in the loss function as well. Ncls and Nreg are the terms representing normalization. Default value of is positive and is done to scale classifier and regression on the same level [18].

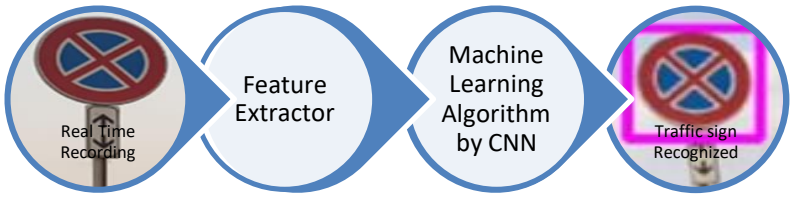

Figure 12. Traffic Sign Recognition Training Process

4. RESULT AND DISCUSSION

To design the project, a smartphone is needed with Android operating system to install the application on it and subsequently opening the camera to record in real time. Installing Android Studio to write and implementing the program on it using Java language. Android Studio is the official Integrated Development Environment (IDE) built on Jet Brains' IntelliJ IDEA software. This is a software is designed specifically for Android development and is also recommended by Google. It has better features and is user-friendly in comparison to Eclipse which is why this is the most suitable IDE for designing applications is Android.

4.1 Using Application

The traffic-sign Recognition system works on Android operating systems on smart phones, it is designed and implemeted to recognize and detect the traffic signs during driving cars. The user opens the application as shows in figure 13.

Figure 13. The system Application Icon

When it opened, directly the phone's camera opens and live video feed of the surroundings act as an input to the software. So, whenever a traffic sign appears in front of the camera it will detect the sign and a pop-up will arrive saying "Traffic Sign Detected". As shown in figure 14. In addition to the sign detection and recognition, the speed of the vehicle is also monitored. Like when the vehicle moves at a speed of more than 120 kmph then a pop up comes saying "You are over-speeding".

Figure 14. When recognize a traffic sign gives us notification alarm of recognizing

Figure 15. Showing real time traffic sign recognition during driving

Lots of test runs as well as experiments were conducted to verify the system.

First of all, the front page of the application which shows different options for detection shows us as below options available:

- Normal: for day mode traffic signs recognition.
- HSV: for night mode traffic sign recognition.
- HSV Settings: for adjust HSV functionalities and settings.

For changing the HSV parameters we have to go to the settings then below box opens through the line of each HUE lower max, HUE upper min, Saturation min, Value min parameters are capable of changing to be increases or decreased for night captures and recognized during night mode in order the process to be more smoothly and to be more accurate especially for the drivers whom has problem with night driving and could not see the traffic signs easily at nights. That's why this system helps the drives to be accurate during night driving and the system detect them the traffic signs in the best manner.

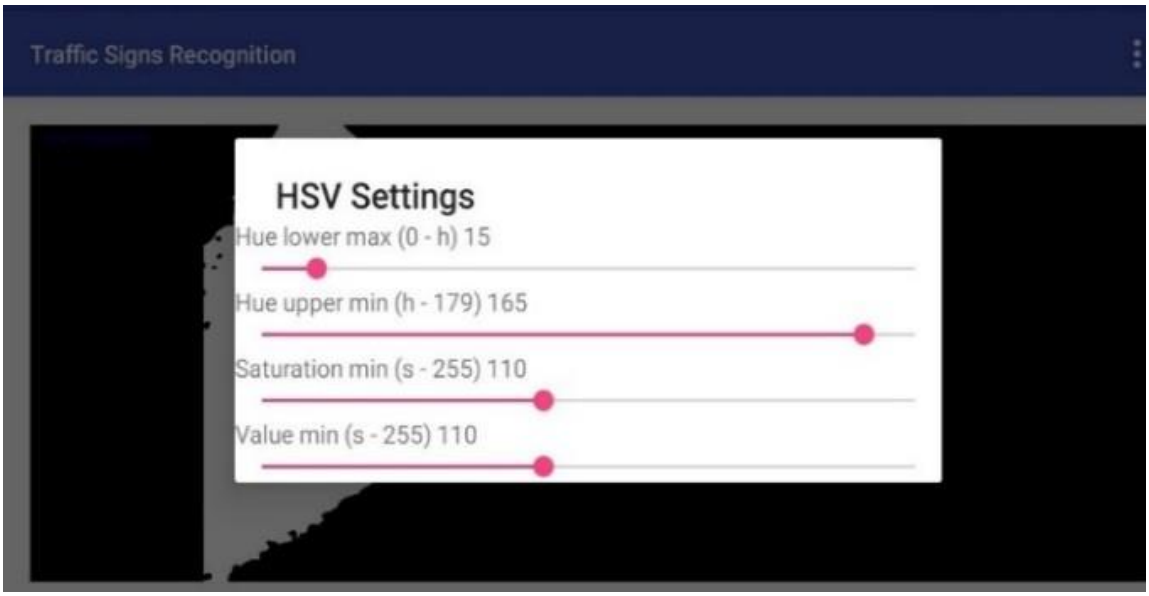

Figure 16. HSV Settings

So, the normal setting indicates the detection during daytime and HSV for nighttime. The HSV Settings option allows user to set the Hue, Saturation, Value according to his/her feasibility as shown in Figure 16. The capability of the system is not restricted or different between daytime or nighttime regarding recognition, as shown in below figure. If we repeat the same procedure to recognize the same traffic sign even the other traffic signs, we change the mode, the mode to HVS if the brightness or the illumination is not enlightenment, so in below figure is shown the same traffic sing detected during nighttime.

Figure 17. Traffic Recognition during nighttime

Finally; we have checked the system in real time for several types of traffic signs have been re cognized. the following stills attached from the test runs depict the application's signs detection and recognition for different shapes of traffic signs:

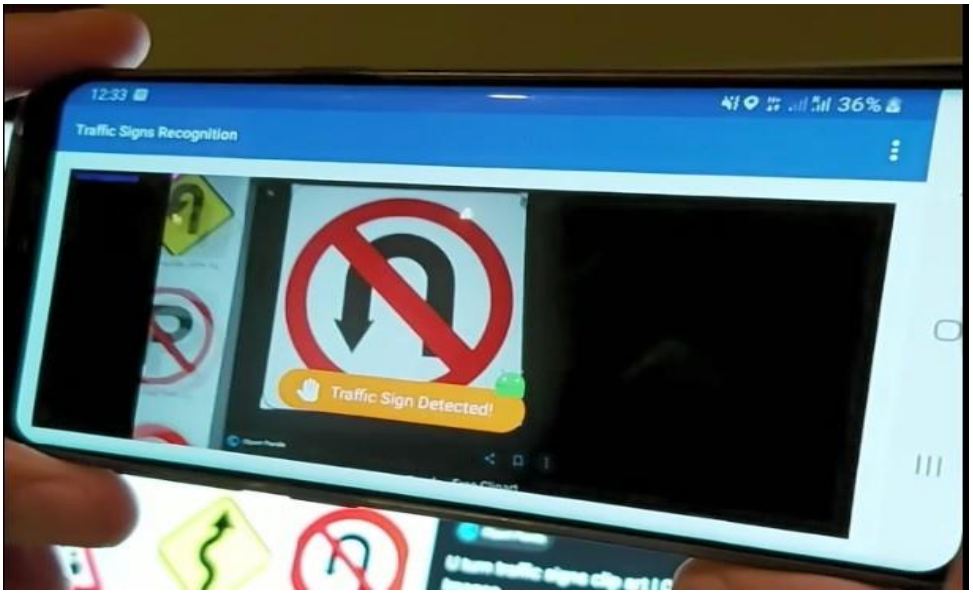

Figure 18. Recognizing types of traffic signs

In below image implies that the vehicle was over speeding which was more than 120kmph then an alarm gives us a notification that the driver drives over speed.

ISSN: 04532198
Volume 62, Issue 10, November, 2020

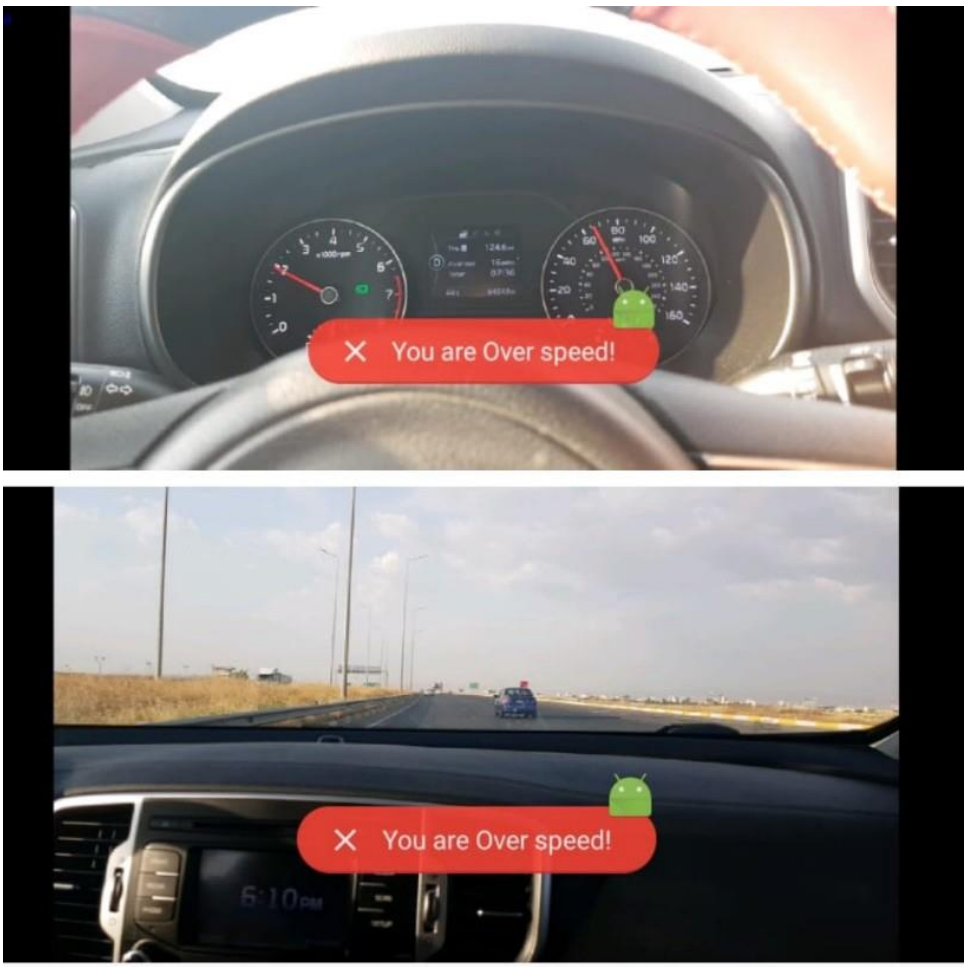

Figure 19. Giving alarm when driving over speed

The above image implies that the vehicle was over speeding which was more than 120kmph then an alarm gives us a notification that the driver drives over speed. All of the above predictions turn out to be accurate because of the Machine Learning techniques imbibed in OpenCV library. There are a lot of techniques which come up with OpenCV, amongst them Normal Bayes Classifier gave the best results followed by K-Nearest Neighbors, Support Vector Machine, Decision Trees and so on. The least accurate prediction was done by Logistic Regression.

5. CONCLUSION AND FUTURE SCOPE

So, all of the above described algorithms OpenCV {RGB, HSV (color segmentation), Region of Interest, Speeded-Up Robust Features}, Convolutional Neural Networks, Normal Bayes Classifier contribute to the research done in development of this software: a highly accurate with fast response and robust Road Signs Detection and Recognition. The application was designed in android studio with the help of OpenCV library programmed by Java language. We have used the Region of Interest (ROI) with Speed Up Robust Feature (SURF) for object recognition. And Red Green Blue model, Hue Saturation Value model for color segmentation during day light and dark respectively. The results achieved from the experimentation cited above prove that our system is a real-time video/image processing software when exposed to a video sequence rather than to a standard approach of traffic sign detection in static images. The results of the test run also prove the convenience of the system. Examining the publicly available data set in real time shows that this system has fast processing speed and robust traffic sign recognition. This application has numerous applications like it will come in great aid to drivers with dis- abilities. In addition to this, it can help the drivers

detect in advance the signs in critical weather conditions like fog, rain, thunderstorm, snowfall and so on. This application's programming interface can be integrated with Maps and Navigation software which in turn can give seamless detection of the traffic signs with speech notification during navigation. Not only this, it can tell at what speed the driver is going on currently and at what speed he/she needs to turn and that too in which direction. This is a very smooth application with precise and accurate predictions because of its design (coded in Java making the application faster compared to applications coded in Python) and the usage of OpenCV with neural networks.

6. REFERENCES

[1] A. H. T. a. B. B. N. Jose, "A novel traffic sign recognition system combining Viola–Jones framework and deep learning.," Springer, Singapore, pp. 507-517, 2019.

[2] W. F. H. S. C. &. B. Farhat, "Real-time embedded system for traffic sign recognition based on ZedBoard.," Journal of Real- Time Image Processing, pp. 1813-1823, 2019.

[3] A. a. C. K. Jayaprakash, "Feature selection using ant colony optimization (ACO) and road sign detection and recognition (RSDR) system.," Cognitive Systems Research 58, pp. 123-133, 2019.

[4] L. a. S.-i. K. Wang, "Forgery image detection via mask filter banks based CNN," Tenth International Conference on Graphics and Image Processing (ICGIP 2018), vol. Vol. 11069, no. International Society for Optics and Photonics, 2019., 2019.

[5] A. K. M. C. B. K. O. N. &. K. A. Bukała, "The impact of distortions on the image recognition with histograms of oriented gradients," International Conference on Image Processing and Communications (pp. 166-178). Springer, Cham., no. Springer, Cham., pp. 166-178, 2019.

[6] B. O. W. S. L. Z. X. &. W. X. Li, "An efficient 3d object detection framework for autonomous driving," Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 1019-1028, 2019.

[7] R. P. S. M. V. K. S. &. P. M. A. Kumar, "TRAFFIC SIGN AND DROWSINESS DETECTION USING OPEN-CV. TRAFFIC," IEEE, 2019.

[8] D. D. K. A. C. A. K. S. M. P. &. H. S. A. Priyanka, "Traffic light and sign detection for autonomous land vehicle using Raspberry Pi," International Conference on Inventive Computing and Informatics (ICICI)-IEEE, pp. pp. 160-164, 2017.

[9] A. a. P. Y. Shustanov, "CNN design for real-time traffic sign recognition," Procedia engineering 201, pp. pp. 718-725, 2017.

[10] M. a. K. V. S. Swathi, "Automatic traffic sign detection and recognition in video sequences," International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT). IEEE, 2017.

[11] A. a. C. K. Jayaprakash, "Feature selection using ant colony optimization (ACO) and road sign detection and recognition (RSDR) system," Cognitive Systems Research 58, pp. pp. 123-133, 2019.

[12] R. A. D. K. S. M. H. A. S. &. C. D. adan, "Traffic Sign Classification using Hybrid HOG-SURF Features

and Convolutional Neural Networks," In ICPRAM, pp. pp. 613-620, 2019.

[13] A. &. J. Z. A. Alam, "Traffic Sign Detection and Recognition," International Journal of Intelligent Transportation Systems Research, 18, pp. pp. 98-112, 2018.

[14] X. S. F. N. J. &. T. X. Xie, "Image classification and segmentation using convolutional neural networks," Pacific Rim Conference on Multimedia, no. Springer, Cham, pp. pp. 200-211, 2018.

[15] M. P. K. D. K. J. K. &. G. S. Ismaeil, "Performance analysis of new adaptive decision based median filter on FPGA for impulsive noise filtering," International Conference on Electronics, Materials Engineering, 2017.

[16] W. Z. Q. Z. C. &. L. J. Hu, "Fast branch convolutional neural network for traffic sign recognition," Intelligent Transportation Systems Magazine, pp. pp. 114-126, 2017.

[17] L. J. W. A. &. E. F. Halawa, "Face Recognition Using Faster R-CNN with Inception-V2 Architecture for CCTV Camera," 3rd International Conference on Informatics and Computational Sciences (ICICoS)- IEEE, pp. pp. 1-6, 2019.

[18] A. C. a. R. K. O. A. Randle, "Towards a motivational based model for effective use of human resource information system in South African Universities," In 2017 International Conference on Information Society (i-Society), pp. pp. 61-67, 2017.