2021 IEEE International Conference on Mobile Networks and Wireless Communications (ICMNWC)

Vehicle Number Plate Detection and Recognition using YOLO- V3 and OCR Method

Shashidhar R
Dept. of Electronics and Communication Engineerring
JSS Science and Technology University
Mysuru, India
shashidhar.r@sjce.ac.in

A S Manjunath
Dept. of Computer Applications
JSS Science and Technology University,
Mysuru, India
as.manjunath@sjce.ac.in

Santhosh kumar R
Dept. of Electronics and Communication
Dayananda Sagar College of Engineering,
Bengaluru, India
rsanthosh.kumar665@gmail.com

Roopa M
Dept. of Electronics and Communication
Dayananda Sagar College of Engineering,
Bengaluru, India
surajroopa@gmail.com

Puneeth S B
Dept. of Electronics and Communication
Presidency University,
Bengaluru, India.
puneeth.sb@presidencyuniversity.in

2021 IEEE International Conference on Mobile Networks and Wireless Communications (ICMNWC) | 978-1-6654-3883-4/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICMNWC52512.2021.9688407

***Abstract*—Automatic Number Plate Recognition is one of the many information systems which is used data extraction from given vehicle image and apply the data for further usage in safe, secure and modernistic Transportation System. The Novelty of the project is that even if the image is blurred, our system can deblur the given image and apply it to the Machine Learning models further. In the proposed work, You Only Look Once [YOLO] V3 model for Region of Interest [ROI]; Convolution Neural Network [CNN] for optical character recognition was implemented. After the ROI is detected, it will be enhanced with pre-processing steps before it is fed to CNN model. Dataset of different Indian Number Plates'Font was created, consisting of 6439 images of different alpha- numerical characters. Accuracy of 91.5 percent is obtained. The extracted and sorted characters of the number plate is cross- checked with the Indian RTO database and the information regarding which RTO the input vehicle image belongs to, is provided.**

Keywords—Number plate detection, CNN, YOLOV3, OCR, RTO.

I. Introduction

Intelligent traffic systems optimize the movement of automobiles over transport networks. This optimization includes Automatic Car License Plate Detection and Recognition. Research on Automatic car license plate detection LPR has gained momentum in recent years due to neural networks and deep learning. It can be applied to many areas like traffic law enforcement and road traffic monitoring. To identify License plate technologies such as computer vision and artificial intelligence algorithms can employed. The steps involved in ALPR are image acquisition, preprocessing of the image, finding the region of interest(ROI), segmentation and optical character recognition.

Image acquisition is the initial phase of ALPR. Input images can be extracted from traffic surveillance videos. For research purposes an open dataset can be utilized. The second step is finding the Region of Interest which in this case is a license plate present in the image. Edge detection is most common method to use the number plate detection and also more techniques are used for plate detection. In the next stage after the detection of the plate segmentation is done in order to identify the regions where alpha numeric characters are present. The final step is to recognize the segmented region as alpha numeric characters.

Convolution neural networks(CNN) is excessively being used for object detection applications. CNN is preferable for image classification, character recognition, object recognition and in information retrieval domains due to its effective results. Region based Convolutional Neural Networks is unsuitable for real time applications due to its computational complexity. YOLO architecture commonly called as You Only Look Once. It contains twenty-seven convolutional neural network layers and twenty-four convolutional layers. Because YOLO has problem with detecting minor objects, it is only used for finding ROI. A CNN model is developed for optical character recognition.

The main contribution of the work includes motion deblur of the image using Weiner filter for increasing the output efficiency, using YOLO for detection of license plate in an image and an algorithm to recognize the characters.

The remaining section is as follows section II describes the literature survey of the existing work. Section III explains the methods used for the proposed work. Section IV explains the results of the method used. Finally Section V concludes the proposed work and mention the future work.

II. Related work

Detailed Literature Survey was done on the existing methods and techniques used for ALPR. YOLO-darknet deep learning framework is used by Chen et al. [1] for Taiwan license plate detection. Seven convolutional layers of YOLO and Sliding window process are used here. Abdullah et al. [2] have assembled a dataset of over 1500 Bangladeshi license plate images and license plate detection is based on end-to-end deep learning based system. For detection of digits and for identifying license plates YOLOv3 is used.

Rayson, et al. [3] have proposed automatic license detection system with recognition rate of 96.8%. This work is also based on YOLO algorithm. In real time it can distinguish four vehicles in a single scene due to its high frames per second (FPS) rates. Some license plates images are affected by environmental factors like lighting, bad weather, traffic etc. Considering these factors Hsu et al. [4] have developed a method using deep learning based on YOLO and its variant YOLO-9000 for license plate detection.

Before employing deep learning techniques for license plate detection Abdussalam et al. [5] have preprocessed the image i.e., skew detection and correction for better results. Lele Xie et al. [6] have proposed MD-YOLO framework which is based on convolutional neural network. In real time scenarios for handling rotational problems, prediction the angle rotation and a quick convergence over union evaluation strategy is proposed.

Skewed License plates can be detected more efficiently with YOLO algorithm instead of traditional digital image processing techniques as shown by Dhedhi, Bhavin, et al. [7]. The overall accuracy is 82% with some fault tolerance. For both detection and recognition of license plates Pinto et al. [8] have employed YOLOv3. They have achieved 95% accuracy in license plate detection and 96.2% in recognition of the license plate.

Kessentini et al. [9] have addresses the issue of multi-norm and multilingual license plate detection and recognition. Pipeline architecture with two deep learning stages is employed. Using two stages of YOLO is favorable for multi-norm and multilingual license plate detection and recognition. For Bhutanese license plate recognition Jamtsho et al [10] have used YOLO. The accuracy with a one-layer convolutional neural network is 98.6% with the training loss of 0.0231.

Most of the detection schemes are effective only under specific conditions. Hence to tackle issues Naveen kumar et al [11] suggesting the multi- directional car license plate identification system for a Convolutional based YOLO. It also handles rotation related issues. Pan Gao et al. [12] have trained thirty class convolutional neural network which can execute real time license plate sensing. They have combined the advantages of Dense cconvolutional and resident network. The proposed and efficient network model is RDNet for recognition of the license plate.

Tiny YOLOv3 architecture is employed by Diogo M. F et al. [13] for detection and recognition of Brazilian license plates. Synthetic images are used to train second convolutional network used for character recognition and fine tuning using real time license plate images. Weishan Zhang et al. [14] have proposed an algorithm for scalable and effective license plate recognition. In this algorithm localization the number plate is done using a YOLO network and recognition of the license plate is achieved using multi label CNN.

Vitalii Varkentin et al. [15] have proposed a YOLO based technique for detection of number plate and recognition and got accuracy of 73%. MJ Prajawal et al explained the different convolutional neural network techniques for helmet detection and number plate detection [16] and using the YOLO V2 convolutional neural network detect the license plate number and also non helmet riders [17].

In this proposed work, the input image has been motion blurred which was induced due to the speed. For deblurring the image, point spread function and wiener filter are used to remove the motion blur. Custom dataset was developed for different font character set based upon wide range of Indian number plates. Dataset was converted into specific required format and fed into the neural network, which will train custom fonts. YOLO V3 model was incorporated to get the region of interest which will be fed into the trained neural network which detects the characters present and high accuracy results were achieved.

III. METHODOLOGY

The algorithms, techniques and methods used in the implementation of the project are Weiner filtering for image deblur, YOLO V3 for ROI, image enhancement with segmentation and Convolutional Neural Networks for OCR.

A. Image Deblur

A vehicle when being captured on surveillance camera undergoes planar motion. Hence a blurred image is obtained. Therefore, Weiner Filter is used for image deblurring. Consider planar motion of the automobile as parallel to i-axis. The equation below expresses the intensity recorded at the pixel position (i,j) in terms of unblurred image f(i,j) that might have been produced under ideal conditions.

The blurred image g(i.j) in terms of the ideal image f(i,j) is given by,

$$g(i,j) = \frac{1}{i_T}\sum_{k=0}^{i_T-1} f(i-k,j) \text{ where } i = 0,1,\dots\dots N-1 \quad (1)$$

iT - Total number of pixels with their brightness recorded by the same cell of camera a

N-Total number of pixels in the row of the image

The DFT of the blurred image g(i,j) is given by,

$$\widehat{\mathbf{G}}(\mathrm{m},\mathrm{n}) = \frac{1}{i_\mathrm{T}}\sum_{\mathrm{k}=0}^{i_\mathrm{T}-1} \frac{1}{\mathrm{N}^2}\sum_{l=0}^{\mathrm{N}-1} \sum_{\mathrm{t}=0}^{\mathrm{N}-1} \mathrm{f}(\mathrm{l}-\mathrm{k},\mathrm{t})\mathrm{e}^{-\mathrm{j}\left(\frac{2\pi\mathrm{ml}}{\mathrm{N}}+\frac{2\pi\mathrm{nl}}{\mathrm{N}}\right)} \quad (2)$$

The FT of the point spread function of the degradation process as been identified as,

$$g(i,j) = \frac{1}{i_T}\sum_{k=0}^{i_T-1} e^{-j\frac{2\pi mk}{N}} \quad (3)$$

Blurred images are restored using Weiner Filter and its equation is given by,

$$\widehat{\mathbf{M}}(m,n) = \frac{\frac{1}{i_T}\frac{\sin\frac{(\pi m i_T)}{N}}{\sin\left(\frac{\pi m}{N}\right)}e^{j\frac{\pi m}{N}(i_T-1)}}{\frac{1}{i_T^2}\frac{\sin^2\left(\frac{\pi m i_T}{N}\right)}{\sin^2\left(\frac{\pi m}{N}\right)}+\tau} \quad (4)$$

B. License plate localization (YOLO)

Most of the license plate have different background and foreground color. Need to train the model with YOLO custom weights to successfully complete the localization of the license plate. The recognition and localization of vehicle license plates is a critical task for an ALPR system. The YOLOv3 algorithm is employed, which is the most recent version of the YOLO (You Only Learn Once) algorithm, with numerous design improvements. There are 53 convolutional layers in total. Previously, YOLO was not very excellent at detecting little objects, but thanks to multi-scale predictions, YOLOv3 performs significantly better.

Neural network using convolutions Only convolutional layers are used in YOLO, making it a fully convolutional network (FCN). Darknet-53 is a feature extractor with a more complex architecture. It has 53 convolutional layers, each followed by a batch normalization layer with Leaky ReLU activation, as the name suggests. There is no pooling, and the feature maps are down sampled using a convolutional layer with stride 2. This prevents the loss of low-level properties that is commonly attributed to pooling.

YOLO algorithm used for the object detection and it is one of the fastest object detection algorithms and it is good choice for real time object detection. This algorithm detects the predict class labels and also detect the location of the object too and also detect the multiple objects in an image.

The Fig.1 shows the Bounding box prediction of the Yolo V3. Each bounding box is given scores based on the class that might be associated. Here there is only one class called Number plates. Yolo methodology of matrix-based approach of dividing the image into regions and finding Region of Interest (ROI) is shown in Fig. 2. In Fig. 3 it is shown that different possibilities of ROI are marked by Yolo without any filters. Threshold is kept at 0.95 to filter only the most probable ROI as shown in Fig. 3.

C. License plate Recognition (CNN)

Once the image is successfully cropped for the required part, it needs to be enhanced with image processing techniques and then this will be fed into a CNN model which is developed to obtain the prediction of character. The input format used is 28 * 28 pixel-based image of each character.

CNNs will compare input images pixel by pixel or group of boxes. The regions that appearances for are called landscapes. By definition rough feature contests in roughly the similar places in two images, convolutional neural network gets a lot of improved at sighted likeness than entire–image matching patterns. Every feature is like a small two-dimensional array of values which are pre known to the trained model to compare with feature's contest common aspects of the images. To determine the match of a feature to a spot of the image, simply multiply every pixel in the feature by the rate of the matching pixel in the image. This process of convolution is the reason for convolutions neural network. Features are extracted from various parts of the image for classification purposes. To compare our convolution, the procedure is reprised, padding up the feature with each likely image patch. The response from every convolution is taken and made a new 2D array from it, based on where in the image each patch is located. The next step is to repeat the convolution process N number of times in it's entirely for each of the other features there is a different convolution layer.

The outcome is a set of filtered images, one for each of our filters. It's suitable to think of this entire collection of convolution processes as a single processing step. Added response tool that convolutional neural networks use is called pooling. Pooling is a technique to take huge images and shrink them down while preservative the maximum significant information in them. A small but important layer in this method is the ReLU. Where a negative amount occurs, exchange it out for a 0. This helps the convolutional neural network stay scientifically healthy by observance learned standards from getting stuck near 0 or raging up to infinity.

Bounding Box Prediction

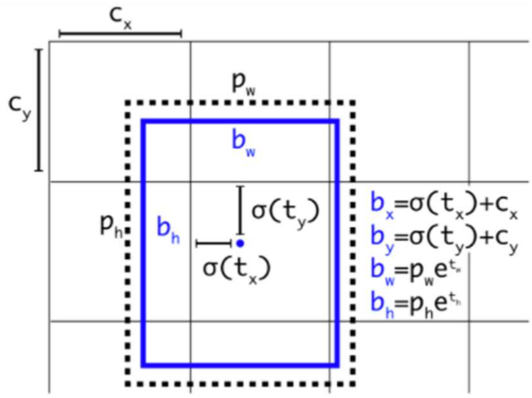

Fig. 1. Bounding box prediction

t_x, t_y, t_w ,t_h are the output of the network, b_x,b_y,b_w, are the transformed values of the each network.

Grid S x S

Fig. 2. Applied bounding box filtering

Fig. 3. YOLO algorithm methodology

Fig. 4. Number plate detection using YOLO

Fig. 5. Image enhancement of the ROI image

Fig. 6. Character by character segmentation of image

D. Character segmentation

The input image from the localized cropped image is passed through image enhancement module which willresult in enlargement as shown in Fig. 5. If the image with 3 times the original sizethen Otus method of adaptive threshold process is used to employ all possible reflections scenarios. The detected number plate is then partition to extract the separate characters. Contour sorting mechanism are deployed to detect all possible contours based upon the size height width and various other parameters such that only the valid contours are kept. As the contours will be in random order, sorting is performed on the contours based on the location from the x coordinate direct on and apply the indices allocated to them and finally obtain a string of characters as shown in Fig.6. After the character segmentation, the final step is the recognition phase. The effectiveness of character recognition completely depends on the value of the segmentation of each character and also the dataset which was trained.

As custom data set was developed for the Indian fonts, the same algorithm was utilized to clean the data-set which was previously available as whole license plates, to remove and segment character by character and then feeding it to already available model to sort them into various classes. Then for the optical character recognition part, segmented the data set from the available Indian license plates one by one and then segregated, cleaned and organized the data into 36 classes each from 0 to 9 and A to Z and finally trained the model withCNN multi layered model. At the beginning feed single frame into the developed model from the traffic database and then perform image pre-processing steps to enhance the image then the RGB channels will be split up and then motion de-blurring will be done to deblurthe image. Then the image which has been successfully de- blurred will be sent to the YOLO model for prediction of ROI for cropping process. Then once the image being cropped thenit will undergo various image enhancement steps such thatit will be magnified and then thresholding, binarization, eroding, dilating and finally segmenting character by character which be fed into pre-trained CNN model which will predict among the 36 class and finally obtain a string containingvehicle details. At the end need to fetch car RTO details from the csv file in the database to display the details about the Car RTO.

IV. Results And Discussion

Two different models are developed, one for localizationof the Number plate using YOLO v3 model and another one for OCR feature. Began with 1200 images of different Indian number plates and after data cleaning, had dropped some of the sub-par images. 80 percent of thoseimages were used for training.

YOLO v3 model was able to successfully detect the ROI needed for further processing of the image which had to be fed intothe image enhancement module. The batch size was set to one twenty-eight. Subdivisions were set to sixteen for faster training. In the license plate detection phase, there was only one class and took filter size equal to eighteen. Pre-trained weights for thedarknet-fiftythree convolutional layers were used as initial weights for training.

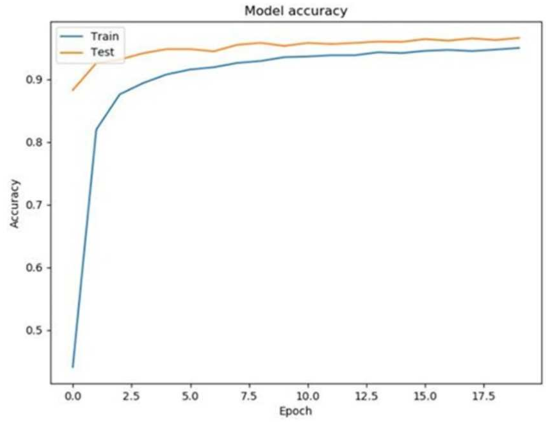

Fig. 7. Model accuracy curve

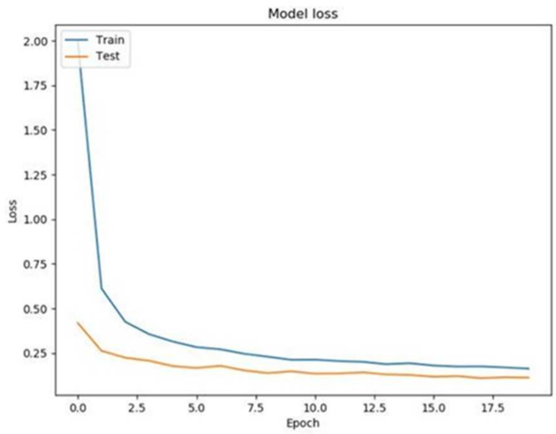

Fig. 8. Model loss curve

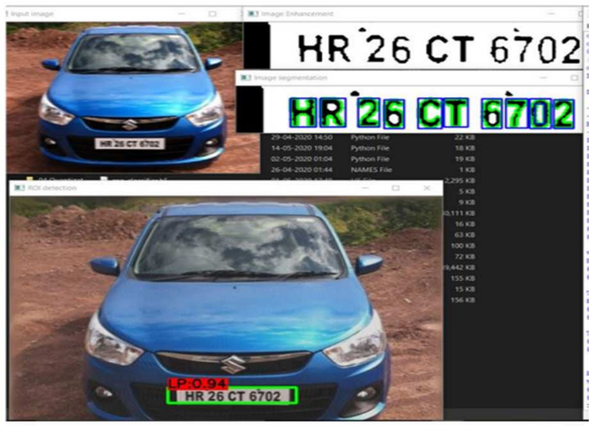

Fig. 9. Final results obtained

Then for the optical character recognition part the data set from the available Indian license plates was segmented one by one and then segregated, cleaned and organized the data into 36 classes each from 0 to 9 and A to Z and finally trained the model with CNN multi layered model and got an accuracy of about 91.5 percent for Indian fonts as shown in Fig. 7. The Model Loss Curve shown in Fig. 8 conveys that the proposed model has good learning rate.

Here it is successfully tuned for all the required hyper parameters in the given model and set the data sample as 128 samplesper run and also did 31 epochs' and trained the model to predict the Indian characters easily. As the image is fed into de-blurring module and then fed into Yolo model to detect the region of interest and crop out the required image from the main image for further processing, then image enhancement procedure will becarried out eroding, dilation, threshold, contour generation and then each character will be fed into the model which was trained to predict the characters and then the RTO Indian CSV will be obtained and the car details will be fetchedand displayed. Fig. 9 shows the final result of the proposed work. Table 1 shows the comparison of the proposed method with existing work.

TABLE I. COMPARISON OF THE PROPOSED METHOD WITH EXISTING METHOD

	Plate dataset	**ROI Model**	**Font Dataset**	**OCR Model**	**ROI Detection Accuracy**	**OCR ModelAccuracy**
Indian ANPR-custom dataset [Proposed]	1500 Images of Indian RTO	Yolo V3	Custom Developed Indian Fonts-6200 Samples of 36 Classes and 28x28 size	Custom trained model with 9 layers of CNN developed with tensorflow	96%	91.05%
Bengala Lisence plate [2]	500 images of Bangladesh	Yolo V3	6400 different fonts from Bangala font da	Yolo V3 for segment ResNet-20 based CNN network to dataset	92%	85%.

V. CONCLUSION

In the proposed work, there is an accomplished dual deep learning based automatic license plate recognition model for Indian road users. Results denote that the preferred technique perform better than the existing methods by far in energizing datasets of Indian fonts with high irregularities, containing Number plates and successfully created a custom dataset of Indian font variants Successfully trained the model to detect the ROI with YOLO V3 and also recognize the given text with our own dataset which was developed and trained the CNN model (Tensor flow) for the custom data set; fetched the RTO details from RTO database and validated our model to get an accuracy of validation accuracy 91.5 percent for OCR model and 96 percent for YOLO model. In the future work, there is a need to enlarge our solution to spot from the given video feed and also fetch the RTO Driver detailswith API obtained from RTO.

REFERENCES

[1] Chen, Rung-Ching. "Automatic License Plate Recognition via sliding- window darknet-YOLO deep learning." Image and Vision Computing, vol. 87, pp47-56, 2019. https://doi.org/10.1016/j.imavis.2019.04.007

[2] S. Abdullah, M. Mahedi Hasan and S. Muhammad Saiful Islam, "YOLO-Based Three-Stage Network for Bangla License Plate Recognition in Dhaka Metropolitan City," *2018 International Conference on Bangla Speech and Language Processing (ICBSLP)*, 2018, pp. 1-6, doi: 10.1109/ICBSLP.2018.8554668.

[3] R. Laroca, L. A. Zanlorensi, G. R. Gonçalves, E. Todt, W. R. Schwartz, D. Menotti, "An Efficient and Layout-Independent Automatic License Plate Recognition System Based on the YOLO Detector," IET Intelligent Transport Systems, vol. 15, no. 4, pp. 483-503, 202.

[4] G. Hsu, A. Ambikapathi, S. Chung and C. Su, "Robust license plate detection in the wild," 2017 14th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), 2017, pp. 1-6, doi: 10.1109/AVSS.2017.8078493.

[5] Abdussalam A., Sun S., Fu M., Sun H., Khan I. (2019) License Plate Segmentation Method Using Deep Learning Techniques. In: Sun S. (eds) Signal and Information Processing, Networking and Computers. ICSINC 2018. Lecture Notes in Electrical Engineering, vol 494. Springer, Singapore. https://doi.org/10.1007/978-981-13-1733-0_8

[6] L. Xie, T. Ahmad, L. Jin, Y. Liu and S. Zhang, "A New CNN-Based Method for Multi-Directional Car License Plate Detection," in IEEE Transactions on Intelligent Transportation Systems, vol. 19, no. 2, pp. 507-517, Feb. 2018, doi: 10.1109/TITS.2017.2784093.

[7] V Ganaprakash, N Kanthimathi, N Saranya "Automatic number plate recognition using deep learning " IOP Conf. Series: Materials Science and Engineering 1084(2021) doi:10.1088/1757-899X/1084/1/012027.

[8] Pinto, Pedro F. A. et al. "PVBR-Recog: A YOLOv3-based Brazilian Automatic License Plate Recognition Tool." Anais Estendidos do Simpósio Brasileiro de Sistemas Multimídia e Web (WebMedia) (2019): n. pag.

[9] Yousri Kessentini, Mohamed Dhia Besbes, Sourour Ammar "A two-stage deep neural network for multi- norm license plate detection and recognition." Expert systems with applications 136 (2019): 159-170.

[10] Jamtsho, Yonten, Panomkhawn Riyamongkol, and Rattapoom Waranusast. "Real-time Bhutanese license plate localization using YOLO." ICT Express 6.2 (2020): 121-124.

[11] Alam, N.-A.; Ahsan, M, Based, M.A.; Haider, J. "Intelligent System for Vehicles Number Plate Detection and Recognition Using Convolutional Neural Networks" Technologies 2021, 9, 9. https:// doi.org/10.3390/technologies9010009.

[12] Gao P., Zeng Z., Sun S. (2019) Segmentation-Free Vehicle License Plate Recognition Using CNN. In: Sun S. (eds) Signal and Information Processing, Networking and Computers. ICSINC 2018. Lecture Notes in Electrical Engineering, vol 494. Springer, Singapore. https://doi.org/10.1007/978-981-13-1733-0_7

[13] D. M. F. Izidio, A. P. A. Ferreira and E. N. S. Barros, "An Embedded Automatic License Plate Recognition System Using Deep Learning," 2018 VIII Brazilian Symposium on Computing Systems Engineering (SBESC), 2018, pp. 38-45, doi: 10.1109/SBESC.2018.00015.

[14] W. Zhang, B. Xue, J. Zhou, X. Liu and H. Lv, "A Scalable and Efficient Multi-Label CNN-Based License Plate Recognition on Spark," 2018 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation(SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI), 2018, pp. 1738-1744, doi: 10.1109/SmartWorld.2018.00294.

[15] V. Varkentin and M. Schukin, "Development of an Application for Car License Plates Recognition Using Neural Network Technologies," 2019 International Conference "Quality Management, Transport and Information Security, Information Technologies" (IT&QM&IS), 2019, pp. 203-208, doi: 10.1109/ITQMIS.2019.8928373.

[16] Prajwal M J., Tejas K B., Varshad V., Mahesh Madivalappa Murgod and Shashidhar R.. A Review on Helmet Detection by using Image Processing and Convolutional Neural Networks. International Journal of Computer Applications 182(50):52-55, April 2019.

[17] Prajwal M J., Tejas K B., Varshad V., Mahesh Madivalappa Murgod and Shashidhar R "Detection of Non-Helmet Riders and Extraction of License Plate Number using Yolo v2 and OCR Method" International journal of Innovative Technology and Exploring Engineering (IJITEE) Volume-9, Issue-2, December 2019 DOI: 10.35940/ijitee.B6527.129219.