Automatic Number Plate Recognition System Using Deep Learning Techniques

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Abstract - This paper illustrates a design and development of a new efficient Automatic number plate recognition system, using image processing and deep learning techniques. This system is implemented at residential parking entries. The Sensor detects the presence of a vehicle and after that a camera captures the frames of vehicles. This information is sent to Raspberry Pi to process the image. Using deep learning SSD-MobileNet model we detect the number plate of the vehicle. We create sequential convolutional neural network that is smart enough to recognize characters after training. The recognized plate number is matched with stored database and displays vehicle status on website. If the vehicle is an un-authenticate one, the gate remains shut and an email is sent to the parking management authority.

***Key Words*: Automatic Number Plate Recognition, Image Processing, Convolutional Neural Network, Authenticate, Un-authenticate.**

1. INTRODUCTION

Security is a prime concern in every Apartment and residential complex which require regulated entry of vehicles. Automatic vehicle access to those residential complexes require a mechanism devoid of human intervention. Our system is designed to operate automatically on a 24/7 basis and check un-authenticate vehicles from accessing entry. The number plate of the vehicle is recognized and automatic access to the rightful member is granted. This system effectuates a competent and methodical paradigm of enhanced structure.

Detecting of number plates on moving vehicles utilizes many algorithms developed for this purpose. However a lacuna is discernible, and remains an evolving part year on year. Our Objective is to increase the safety of vehicles. This technology assists in a criminal investigation and prevents the proliferation of crime.

The craving for residential parking spaces supervised by an automated management system is an ever increasing need for city residents. The authorized vehicle is registered in the parking management system along with their owner information. The plate number is used to automatically enter Authorized vehicle. This system allows residents of that residential complex easy and secure access to their respective parking slots.

2. AUTOMATIC NUMBER PLATE RECOGNITION SYSTEM IMPLEMENTED IN OUR PROJECT

The whole system is composed as follows:

2.1 Raspberry Pi

Raspberry pi is popularly used for real time video processing applications. It is at the heart of the whole system. With Raspberry Pi one has direct access to ports and GPIO pins to build the project. We are using Raspbian Buster operating system because it supports our new Raspberry Pi 4 model B.

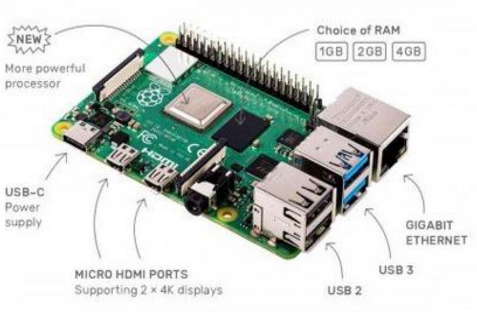


Fig -1: Raspberry Pi 4 Model B

2.2 Camera

In this Project the usage of an image capturing digital camera is instrumental for extracting crystal clear images of vehicles.

Fig -2: Logitech C170 USB Web Camera used in system

2.3 Ultrasonic Sensor

The module has transmitter and receiver and they are similar to two knobs. Ultrasonic pulse when emitted from the transmitter encounters the arrived vehicle and reverberates back to the receiver which displays the coming vehicle distance on the screen.

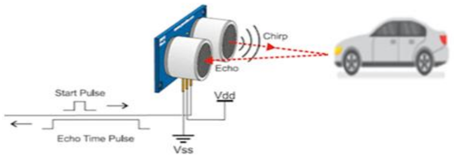


Fig -3: Working of Ultrasonic Sensor

2.4 Servo Motor

The SG90 Servo motor employed in our project is meant to rotate at the gate at some specific angles. Depending on the width of Pulses from the PWM signal, the angle of the Servo Motor's shaft will change.

2.5 Need of OpenCV

OpenCV stands for open source computer vision. This system teaches intelligence to machines and allows computer to see and process data just like humans. The computer vision transforms data extracted from a camera into a new paradigm. OpenCV is an image processing library to read, write and process images. OpenCV is written in C++ language and It has C, C++, Python and Matlab language interface.

2.6 Python

Python is an object-oriented, easy to learn and open source language. Popular for building websites and Frameworks like Django which are used in our project. Widely used in many machine learning and embedded applications.

2.7 Django

Django is a high-level Python Web framework that assists in quick development of clean and user friendly designs. Django supports development of dynamic websites. Django framework is based on MVT architecture.

2.8 LAMP Server

'LAMP' being part of open source software's is usually assembled together thus, enabling the server to host dynamic websites. LAMP symbolizes the Linux operating system conjoining with the Apache web server. Maria DB/MySQL is a database management system.

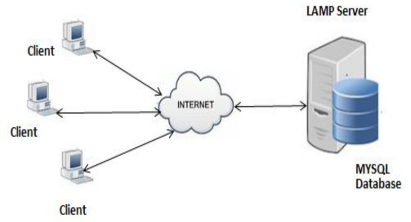


Fig -4: Architecture of LAMP Server

3. SYSTEM DESIGN AND IMPLEMENTATION

This system automatically recognizes an un-authenticate vehicle by using image processing and deep learning algorithms. Record of an authenticate vehicle along with owner information in residential areas is stored on the LAMP server. Whenever the vehicle arrives in the parking system, an ultrasonic sensor detects the distance and presence of the vehicle. By then camera will initialize and capture video frames. The taken image is sent to Raspberry Pi to process the data.

Initializing computer vision, the computer begins to read, write and display operations. Using SSD-MobileNet deep learning model vehicle number plate is detected. By applying image processing algorithms, each character is segmented in one single image and passed on to sequential neural network model. It is intelligent enough to recognize characters from the number plate.

The recognized number is matched with the record database. After that the vehicle status is displayed on the Website created using Django framework. If the number matches, then gate opens which is controlled through the Servo motor. If the number does not match, means the vehicle is un-authenticate and gate remains closed and entry is denied. An email to that effect is sent through SMTP to the parking management authority.

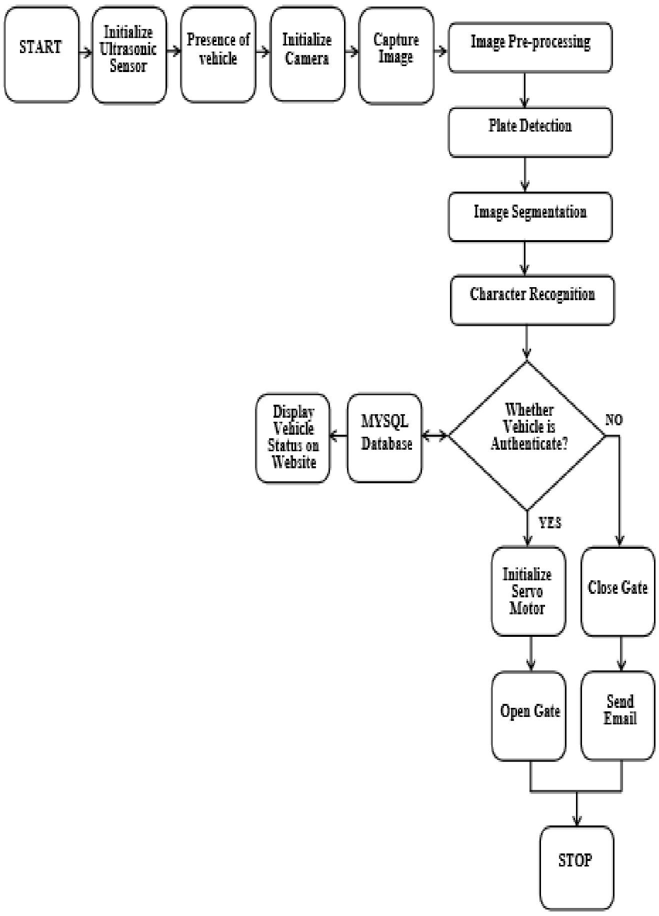


Fig -5: System Flowchart

4. SYSTEM ALGORITHM

4.1 Image Acquisition

Capture input frames of moving vehicle through a video camera.

4.2 Plate Detection

SSD-MobileNet is a deep learning based object detection algorithm used to identify objects in image or video. An object detection model is trained on lots of number plates to detect the location of the number plate. When we subsequently provide an image to the model, it detects output as number plate, the location of a bounding box that contains number plate and a score indicates the confidence that detection was correct.

4.3 Convert RGB to Gray Scale Image

Processing of RGB image is complex and time consuming, hence we convert color image to gray scale image. This image has only a single 8-bit channel ranging from 0 (black) to 255 (white).

4.4 Binarization

In binarization, gray image is converted into an image having pure black & pure white pixel values.

4.5 Segmentation

Segmentation is a very important step going into the analysis of processed image data. An efficient segmentation algorithm subsumes the Accuracy of character recognition. The aim is to compartmentalize an image and which is strongly in consonance with objects or areas contained in the captured image.

5. CLASSIFICATION AND RECOGNITION

Basics of Convolutional Neural Network

CNN is a type of feed-forward artificial neural network. In Convolutional Neural Network, the neuron in a layer will only be connected to a small region of the layer before it.

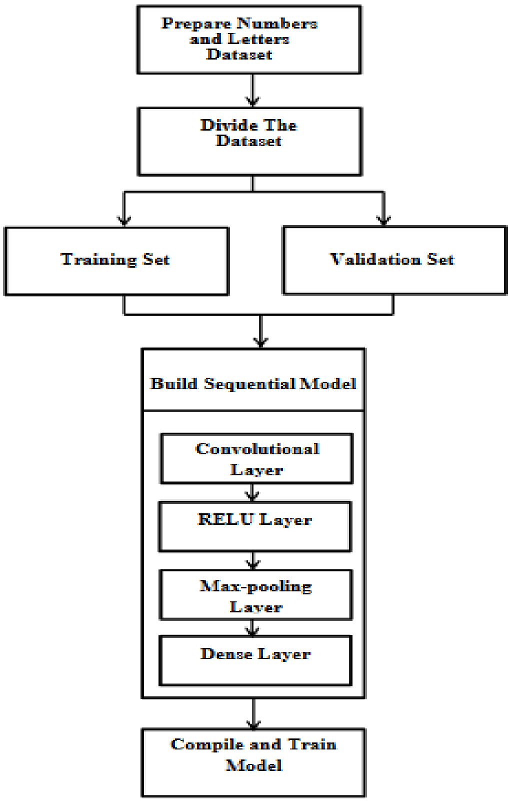


Fig -6: Flowchart of Training CNN model on Dataset

Step 1-Prepare Dataset

For our project a prepared dataset of numbers and letters to recognize characters on vehicle number plate, which in spite of any environmental conditions and at any capturing angle is stored.

Two folders are created, A. training and B. validation folder.

A.Training Folder- In training set, total 36 classes and each class contains 800 images for training. Training folder data is on which the neural network works.

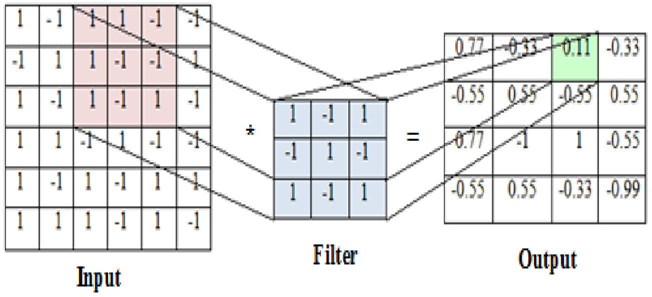
B.Validation Folder- Similarly, In validation set total 36 classes and each class containing 200 images for validation. The neural network while learning through the training set also checks the loss from the validation set.

Step 2- Build Sequential Model

Build the model using deep neural network library called Keras and using Tensorflow as backend. We are using sequential object to model our neural network.

Basically a convolutional neural network has following layers:

Convolutional layer-The first layer is a convolutional layer extracting features from images with a convolution window size and it keeps iterating over the pixels of input image. Add all the pixels and divide them by the total number of pixels and it results in an output for each feature to be forwarded to the next layer.



1	-1	1	1	-1	-1
-1	1	1	-1	-1	1
1	-1	1	-1	1	-1
1	1	-1	1	-1	-1
1	-1	1	-1	1	1
1	1	1	-1	1	-1

1	-1	1
-1	1	-1
1	-1	1

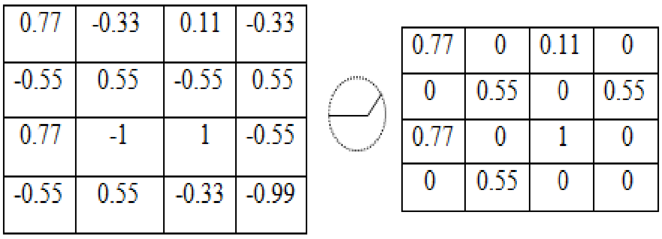
0.77	-0.33	0.11	-0.33
-0.55	0.55	-0.55	0.55
0.77	-1	1	-0.55
-0.55	0.55	-0.33	-0.99

Fig -7: Graphical Representation of Convolutional Layer

ReLU Layer- Rectified linear unit is an activation function used only to activate the node if input is above certain quantity.

$$ReLU(x) = 0 \quad If\ x < 0 \qquad (1)$$

$$= 1 \quad If\ x \geq 0 \qquad (2)$$

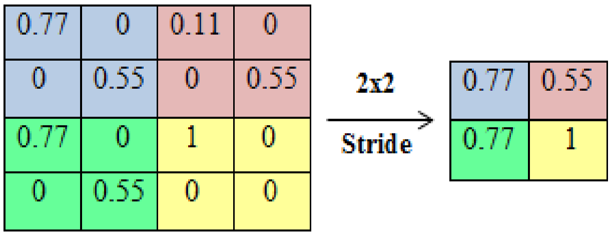


0.77	-0.33	0.11	-0.33
-0.55	0.55	-0.55	0.55
0.77	-1	1	-0.55
-0.55	0.55	-0.33	-0.99

0.77	0	0.11	0
0	0.55	0	0.55
0.77	0	1	0
0	0.55	0	0

Fig -8: Graphical Representation of ReLU Layer

Max-Pooling –In Max-pooling move your window across the filtered image. Take maximum image value and reduce the dimensionality of input which comes from a previous layer.



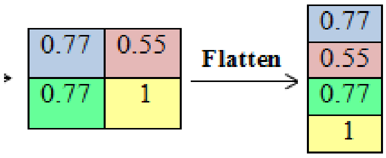
0.77	0	0.11	0
0	0.55	0	0.55
0.77	0	1	0
0	0.55	0	0

0.77	0.55
0.77	1

Fig -9: Graphical Representation of Max-pooling Layer

Dropout –Dropout is used to prevent Neural Networks from Overfitting. Dropout is a technique where randomly selected neurons are “dropped-out” randomly during training.

Flatten –The flatten layer takes data from the previous layer and represents it in a single dimension.



0.77	0.55
0.77	1

0.77
0.55
0.77
1

Fig -10: Graphical Representation of Flatten Layer

Dense Layer – It connects multiple layers into a single array of neurons where the value of each neuron votes toward probability, detailing the accuracy of the image and it helps to create an output layer.

Step 3-Compile and train the model

We use categorical cross entropy as loss function, because we utilize multi-classification in our project. Adam optimizer is used to reduce the loss function. After training for 10 epochs, our model achieved an accuracy of 98.57 %

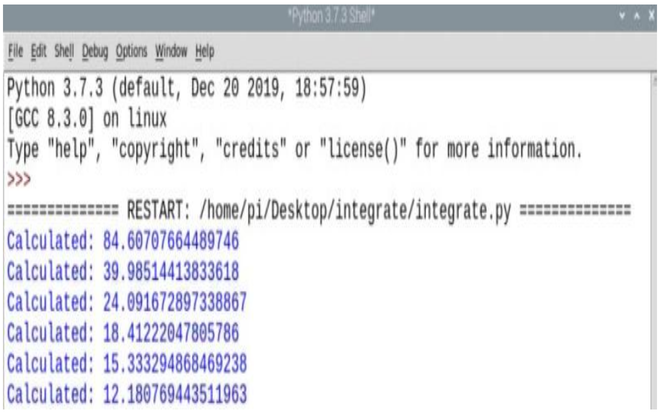
Results of CNN Model- Validation loss has direct relation with accuracy, which in turn means lower validation loss results in higher accuracy. In a result, when validation loss reduces to 0.0335 accuracy rises to 0.98. By using trained model we test input data and it predicts correct output.

Save and load the model -After training, we save all the weights of the neural network. Add requisite weights (**.h5 file**) on the hardware and load it when required.

Character recognition- After segmentation of the number plate, the segmented numbers sent for character recognition and by loading saved neural network weights we recognize the characters on the number plate correctly.

6. EXPERIMENTAL RESULTS

We tested this system on a Raspberry Pi 4 Model B with 2 GB RAM. Equipped with Logitech C170 USB Web Camera. We tested the system on Frame sequence of Vehicle images at Residential Parking Areas. The system is able to detect and recognize most of the vehicles number plate successfully. Figures show some results of our system.



```
Python 3.7.3 (default, Dec 20 2019, 18:57:59)
[GCC 8.3.0] on linux
Type "help", "copyright", "credits" or "license()" for more information.
>>>
============== RESTART: /home/pi/Desktop/integrate/integrate.py ==============
Calculated: 84.60707664489746
Calculated: 39.98514413833618
Calculated: 24.091672897338867
Calculated: 18.41222047805786
Calculated: 15.333294868469238
Calculated: 12.180769443511963
```

Fig -11: Screenshot of vehicle distance detected by ultrasonic Sensor

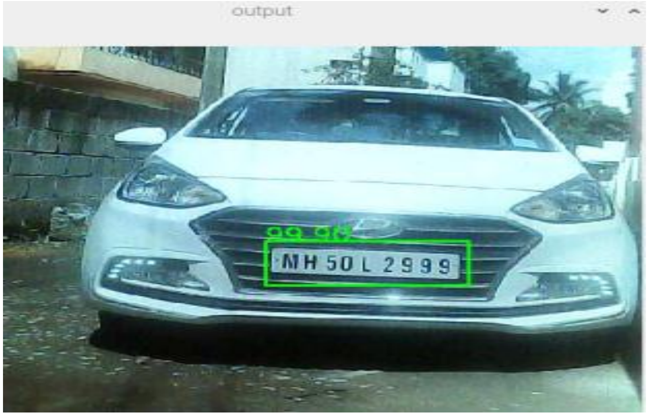


Fig -12: Screenshot of Detected Vehicle Number Plate

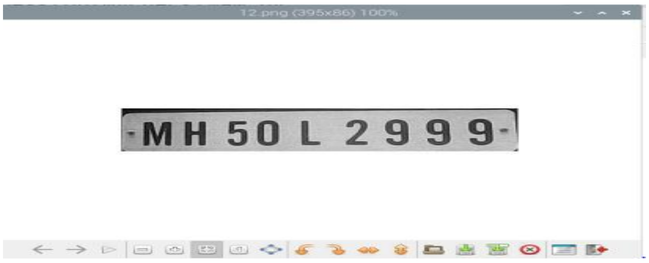


Fig -13: Screenshot of Plate Detection

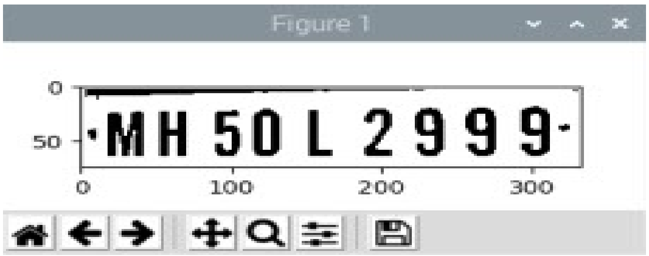


Fig -14: Screenshot of Binary Plate Image

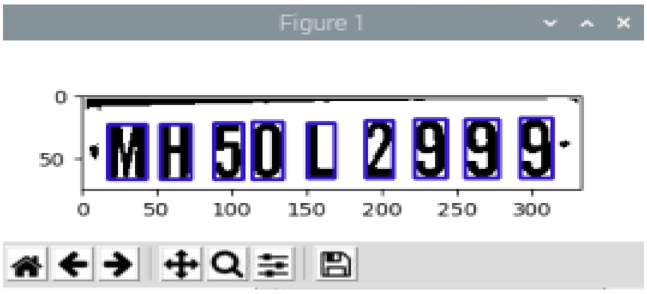


Fig -15: Screenshot of contour applied on Plate Image

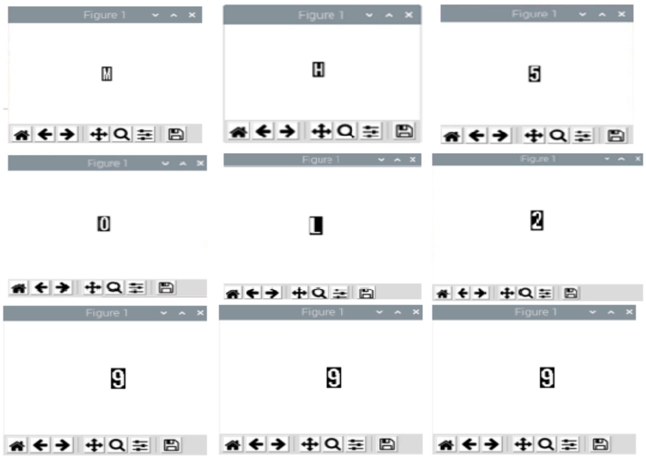
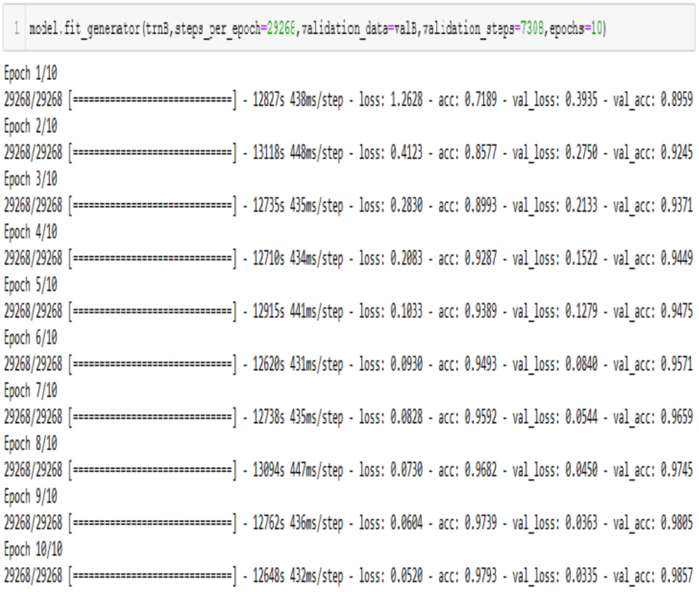


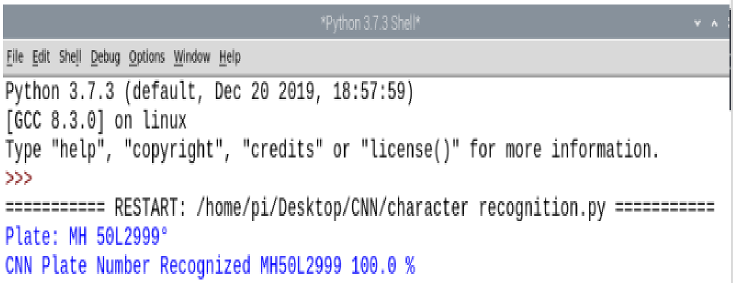
Fig -16: Screenshot of Segmented Number Plate



```
model.fit_generator(trnB,steps_per_epoch=29266,validation_data=valB,validation_steps=7308,epochs=10)
```

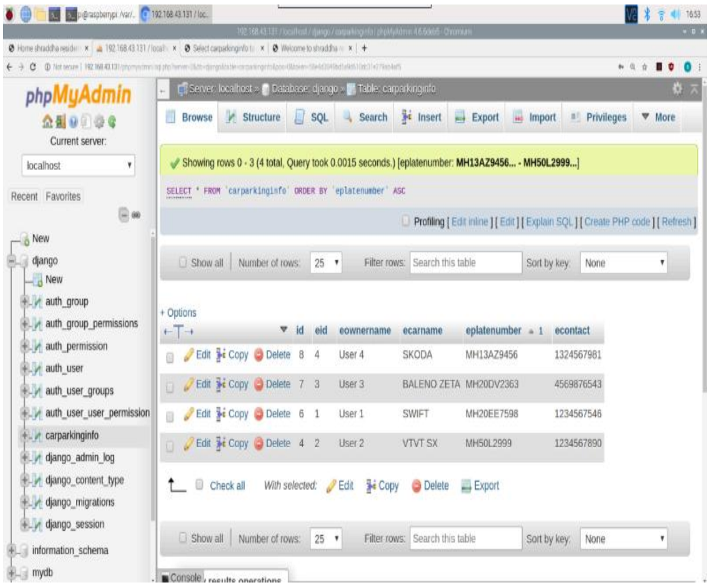
```
Epoch 1/10
29268/29268 [==============================] - 12827s 438ms/step - loss: 1.2628 - acc: 0.7189 - val_loss: 0.3935 - val_acc: 0.8959
Epoch 2/10
29268/29268 [==============================] - 13118s 448ms/step - loss: 0.4123 - acc: 0.8577 - val_loss: 0.2750 - val_acc: 0.9245
Epoch 3/10
29268/29268 [==============================] - 12735s 435ms/step - loss: 0.2830 - acc: 0.8993 - val_loss: 0.2133 - val_acc: 0.9371
Epoch 4/10
29268/29268 [==============================] - 12710s 434ms/step - loss: 0.2083 - acc: 0.9287 - val_loss: 0.1522 - val_acc: 0.9449
Epoch 5/10
29268/29268 [==============================] - 12915s 441ms/step - loss: 0.1833 - acc: 0.9389 - val_loss: 0.1279 - val_acc: 0.9475
Epoch 6/10
29268/29268 [==============================] - 12620s 431ms/step - loss: 0.0930 - acc: 0.9493 - val_loss: 0.0840 - val_acc: 0.9571
Epoch 7/10
29268/29268 [==============================] - 12738s 435ms/step - loss: 0.0828 - acc: 0.9592 - val_loss: 0.0544 - val_acc: 0.9659
Epoch 8/10
29268/29268 [==============================] - 13094s 447ms/step - loss: 0.0730 - acc: 0.9682 - val_loss: 0.0450 - val_acc: 0.9745
Epoch 9/10
29268/29268 [==============================] - 12762s 436ms/step - loss: 0.0604 - acc: 0.9739 - val_loss: 0.0363 - val_acc: 0.9805
Epoch 10/10
29268/29268 [==============================] - 12648s 432ms/step - loss: 0.0520 - acc: 0.9793 - val_loss: 0.0335 - val_acc: 0.9857
```

Fig -17: Screenshot of Trained CNN Model



```
Python 3.7.3 (default, Dec 20 2019, 18:57:59)
[GCC 8.3.0] on linux
Type "help", "copyright", "credits" or "license()" for more information.
>>>
=========== RESTART: /home/pi/Desktop/CNN/character recognition.py ===========
Plate: MH 50L2999°
CNN Plate Number Recognized MH50L2999 100.0 %
```

Fig -18: Screenshot of Recognized Number Plate


phpMyAdmin
Current server:
localhost
Recent Favorites
New
django
New
auth_group
auth_group_permissions
auth_permission
auth_user
auth_user_groups
auth_user_user_permission
carparkinginfo
django_admin_log
django_content_type
django_migrations
django_session
information_schema
mydb
Server: localhost » Database: django » Table: carparkinginfo
Browse Structure SQL Search Insert Export Import Privileges More
Profiling [Edit inline] [Edit] [Explain SQL] [Create PHP code] [Refresh]
+ Options
Check all With selected: Edit Copy Delete Export
Console

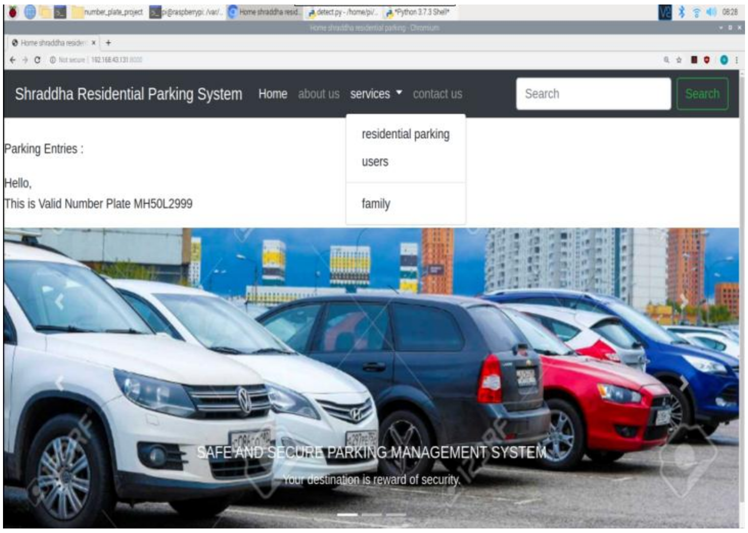
✓ Showing rows 0 - 3 (4 total, Query took 0.0015 seconds.) [eplatenumber: MH13AZ9456... - MH50L2999...]

```
SELECT * FROM `carparkinginfo` ORDER BY `eplatenumber` ASC
```

□ Show all | Number of rows: 25 | Filter rows: Search this table | Sort by key: None

	id	eid	eownername	ecarname	eplatenumber	econtact
□ Edit Copy Delete	8	4	User 4	SKODA	MH13AZ9456	1324567981
□ Edit Copy Delete	7	3	User 3	BALENO ZETA	MH20DV2363	4569876543
□ Edit Copy Delete	6	1	User 1	SWIFT	MH20EE7598	1234567546
□ Edit Copy Delete	4	2	User 2	VTVT SX	MH50L2999	1234567890

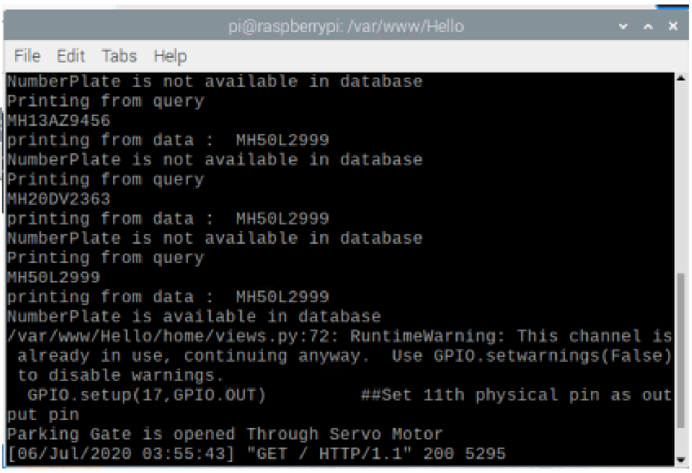
Fig-19: Screenshot of MySQL Database on phpMyAdmin Page


number_plate_project
pi@raspberrypi: /var/...
Home shraddha resid...
detect.py - /home/pi/...
Python 3.7.3 Shell
08:28
Home shraddha residential parking - Chromium
Not secure | 192.168.43.131:8000
Shraddha Residential Parking System
Home
about us
services
contact us
Search
Search
residential parking
users
family
SAFE AND SECURE PARKING MANAGEMENT SYSTEM
Your destination is reward of security.

Parking Entries :

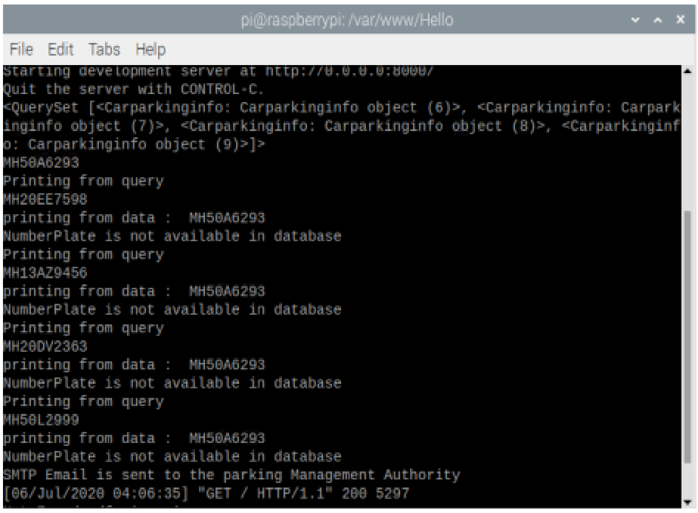
Hello,
This is Valid Number Plate MH50L2999

Fig -20: Screenshot of Vehicle Status on Django Website



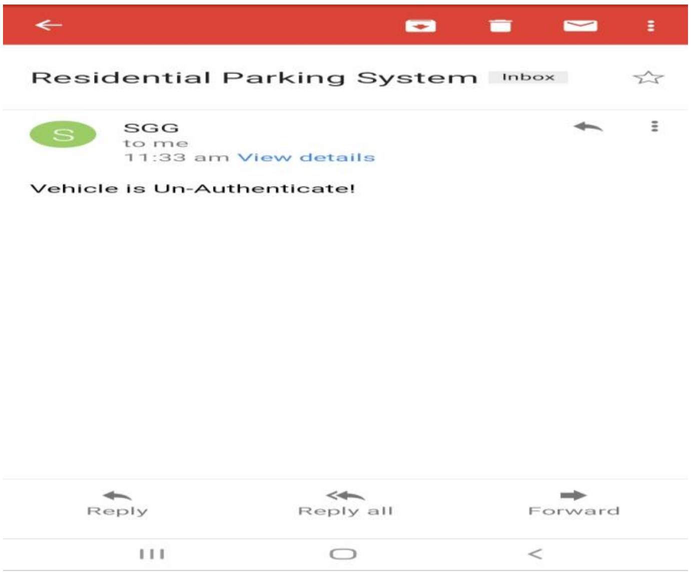
```
NumberPlate is not available in database
Printing from query
MH13AZ9456
printing from data :  MH50L2999
NumberPlate is not available in database
Printing from query
MH20DV2363
printing from data :  MH50L2999
NumberPlate is not available in database
Printing from query
MH50L2999
printing from data :  MH50L2999
NumberPlate is available in database
/var/www/Hello/home/views.py:72: RuntimeWarning: This channel is
 already in use, continuing anyway.  Use GPIO.setwarnings(False)
 to disable warnings.
  GPIO.setup(17,GPIO.OUT)          ##Set 11th physical pin as out
put pin
Parking Gate is opened Through Servo Motor
[06/Jul/2020 03:55:43] "GET / HTTP/1.1" 200 5295
```

Fig -21: Screenshot of Vehicle Authentication Message



```
Starting development server at http://0.0.0.0:8000/
Quit the server with CONTROL-C.
<QuerySet [<Carparkinginfo: Carparkinginfo object (6)>, <Carparkinginfo: Carpark
inginfo object (7)>, <Carparkinginfo: Carparkinginfo object (8)>, <Carparkinginf
o: Carparkinginfo object (9)>]>
MH50A6293
Printing from query
MH20EE7598
printing from data :  MH50A6293
NumberPlate is not available in database
Printing from query
MH13AZ9456
printing from data :  MH50A6293
NumberPlate is not available in database
Printing from query
MH20DV2363
printing from data :  MH50A6293
NumberPlate is not available in database
Printing from query
MH50L2999
printing from data :  MH50A6293
NumberPlate is not available in database
SMTP Email is sent to the parking Management Authority
[06/Jul/2020 04:06:35] "GET / HTTP/1.1" 200 5297
```

Fig-22: Screenshot of Vehicle Un-Authentication Message


Residential Parking System Inbox

SGG
to me
11:33 am View details

Vehicle is Un-Authenticate!

Fig -23: Screenshot of Vehicle Un-authentication Email

7. CONCLUSION

Convolutional Neural Network is a very powerful algorithm which is outstandingly efficient, so that it can be implemented on embedded platform. Efficacy of algorithm can be certified from the afore denoted tests. Results of all these tests are satisfactorily similar. Tests on algorithm suggest that the training of letters and numbers dataset captured from different angles is an important parameter to look out for.

This smart system for vehicle monitoring and inherent security will help vehicle owner to use their vehicles with maximum security and efficiency.

8. REFERENCES

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BIOGRAPHIES

Miss. Shraddha S. Ghadage: She is an M-Tech Student of Walchand College of Engineering, Sangli. She has keen interest in the field of Image Processing and Machine Learning.

Mr.Sagar R. Khedkar: He is an Assistant Professor in department of Electronics at Walchand college of Engineering, Sangli. He has working experience in Embedded system Design, Digital VLSI Design, Data structure and Web Server.