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CNN Based Traffic Sign Recognition System Using OpenCV

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Abstract - *Traffic sign recognition system is very much necessary to ensure the safety while driving. These systems help drivers to easily identify the sign and follow them. In the proposed system, the dataset is first trained using Convolutional Neural Network (CNN) algorithm. A Graphical User Interface (GUI) has been designed where the user can upload an image which is given as input to trained model on which the classification has to be performed. The main constraint in CNN is that, in order to feed dataset of images to CNN they must all be of same size. In order to achieve this, pre-processing is performed to resize all images to a standard size. Features from the images present in dataset are selected and extracted to classify them under different categories. As a result, the meaning of the uploaded traffic sign is displayed on the interface and the same is sent as a message to registered mobile number through twilio cloud communication service. Based on the correctness of the prediction made, the accuracy of CNN model is determined.*

Key Words: **Traffic Sign Recognition, Convolutional Neural Network (CNN), Graphical User Interface (GUI), Tensorflow, Image Pre-processing, Classification, Feature Selection and Feature Extraction.**

1. INTRODUCTION

In 1885, the first automobile was invented and currently the world has evolved to a stage of inventing robots to ride the cars. Automobiles have become significant in everyone's life as it has introduced convenience to people. Today cars have become primary means of transport and their number has been increasing day by day which has also led to traffic and frequent road accidents. The integral parts of our road infrastructure are traffic signs. Traffic signs provide information that is critical for road users, which tell them to take necessary actions thereby reducing accidents. Traffic signs tell the user the state of the road, warnings, prohibitions, instructions etc. Designing of Traffic signs is done in such a way that they are easy to read with highly saturated and contrasting colors. Traffic signs are split into three categories such as Regulatory Signs, Warning Signs and Guide Signs. The shape of the Traffic sign conveys important information regarding the message provided by traffic sign.

Approximately 1.3 million people die because of car accidents every year which means on an average there are3287 deaths per day. India has highest rate of road accidents in the world. As per report issued by Stanford Law School, almost 90% of all vehicle crashes are caused due to some type of negligence by driver such as over speed driving, aggressive or reckless driving, Drowsy driving, Drunk driving, Distracted driving or misinterpretation of Traffic Sign. Without road signs this number would have been much more higher. Hence there is a need for system that automatically detects, recognizes and interprets the meaning of Traffic signs.

Traffic Sign recognition has received an increasing interest due to the wide range of applications that a system with this capability provides, like driving assistant system. To get the best outcome for autonomous vehicles or self-driving cars, the maximum accuracy needs to be achieved. This can be done when system interprets accurate traffic signs and make the decisions of driving in correct directions.

In [1] Sunitha.A has proposed a system that uses combination of CNN-SVM, where CNN is used for feature extraction and SVM is used for classification. In [2] Ying Sun has proposed a system where Hough Transformation is applied on input images which generates area of interest and recognizes area of traffic sign. CNN is used for Classification and Identification of image. In [3] RebaiKarima has proposed a system that extracts the characteristics from images and sorts them under multiple groups. Lenet-5 is used to extract the data representation of traffic signs to perform recognition. In [4] Mohit Singh has proposed a system that uses Color based segmentation and CNN to classify the traffic sign and give beep sound to alert the driver when traffic sign is recognized.

2. METHODOLOGY

1. The selected database is properly segregated, pre-processed and then renamed into proper folders.
2. The model is properly trained using CNN and then classification takes place.
3. The input test image is acquired, pre-processed and then converted into array form for comparison.
4. The comparison of test image and trained model takes place which is followed by display of result.

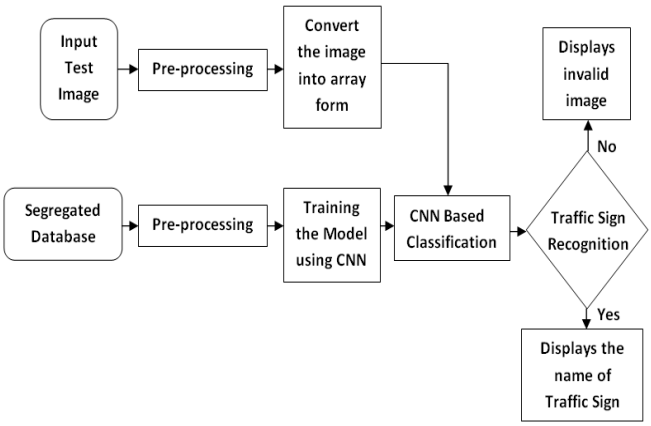


Fig -1: Steps involved in Methodology

The dataset is collected from Kaggle named German Traffic Sign Recognition Benchmark (GTSRB) and Traffic Sign Classification. Out of 43 classes from the dataset, 7 classes namely Stop, Turn Left Ahead, Turn Right Ahead, No Left Turn, No Right Turn, Turn Left and Turn Right. A total of 1,012 images have been trained, out of which 672 images belong to the above 7 classes and the rest 340 images are randomly trained.

Fig -2: Sample Dataset

This dataset is segregated into different folders, pre-processedand then renamed, so that each folder represents a particular class of traffic sign. All the images from these folders are labelled and given to CNN model for training. Later classification of these images takes place.

A GUI is designed from which user can upload an image from test data. Pre-processing is applied on this image and then given to trained model where comparison takes place between test image and trained model. After this, the label of uploaded traffic sign is displayed on GUI and the same is sent as an alert message to registered mobile number using twilio cloud communication service.

3. SYSTEM ARCHITECTURE

Data pre-processing is applied to images that are taken from dataset. Feature selection and Feature Extraction are applied to the pre-processed images. Then classification is done based on the results from previous images.

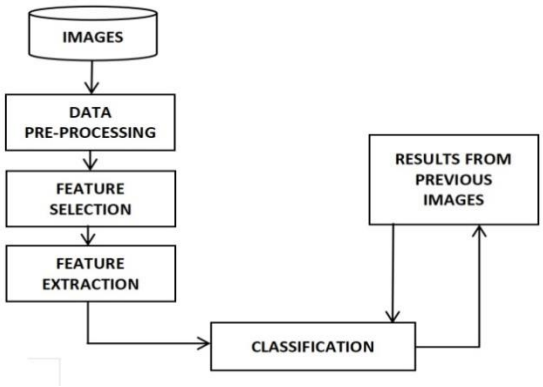


Fig -3: System Architecture

4. FLOW DIAGRAM

Initially, the dataset which consists of traffic signs is pre-processed. This pre-processed data is given for data Preparation where the dataset is split into training set and test set and thus the training data is obtained. Using this data the model is trained and the prepared model is saved.

When the user uploads the image, that image is pre-processed and then given to saved model. After performing classification, the model returns the label or class to which the image belongs to.

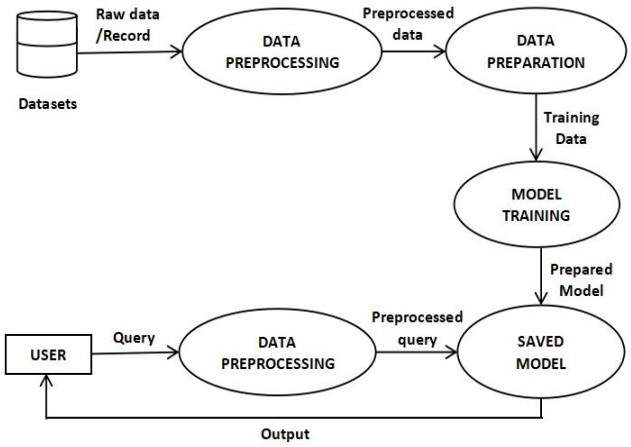


Fig -4: Flow of Data

5. IMPLEMENTATION

5.1 Training Phase

Dataset containing images of Traffic Signs is acquired. Images are segregated, renamed based on its meaning and then stored in Training Directory (TRAIN_DIR). Each image from TRAIN_DIR is assigned a class label based on the name given to it.

i) Pre-Processing: Data pre-processing is a required task for cleaning the data and making it suitable for a machine learning model which also increases the accuracy and efficiency. The main constraint in CNN: In order to feed a dataset of images to Convolutional Neural Network they must all be of same size. Hence each image from TRAIN_DIR is read using cv2.imread( ) function and resized to a standard size of 50x50 using cv2.resize( ) function.
Each resized image and its class label is converted to array format and then appended to training_data array. This array is shuffled and then saved in the form of NumPy array file.

ii) Feature Selection: It is the process of reducing the number of input variables when developing a predictive model. It is used to identify and remove redundant features that don't contribute to the accuracy of a predictive model thereby fastening the training process. The unrelated data disturbs the performance of the model being developed. In feature selection, there are M original attributes out of which N attributes that play a significant role in determining the classification accuracy are chosen such that N<M. Hence it is important to perform feature selection.
The features selected in proposed work are color, size, shape, texture and so on.

iii) Feature Extraction: In order to minimize the number of features present in a dataset, creation of new features from the existing ones takes place which summarize most of the information present in original set of features. It is a process which reduces the dimension of the images taken from the dataset.
Feature Extraction is performed by CNN which involves various Convolutional Layers followed by Max-Pooling Layers and Activation function. Hence there is no need for manual feature extraction. When the network is trained on a set of images they learn the features. Hence there is no need for training the features.

iv) Classification: It is the process of analysing an image and identifying the class or label under which the image falls. Image Classification is performed by CNN, where the classifier is made of Fully-Connected Layers.

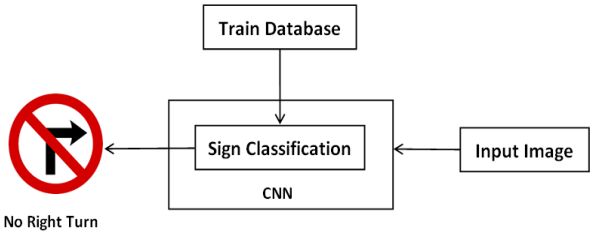


Fig -5: Classification Process

v) Convolutional Neural Network Model: In the proposed work three layers of CNN have been used, they are Convolutional Layer, Pooling Layer and Fully-Connected Layer.

Convolutional Layer: This layer effectively extracts various features from input images. A mathematical operation of convolution is done between input image and filter/kernel of size 3x3. Filter slides over the input image and dot product between parts of input image and filter is obtained. This results in a Feature map which provides information about the image.

Pooling Layer: It decreases the size of convolved feature map by decreasing the connections between layers. The largest element from feature map is taken by Max Pooling. It acts as bridge between Convolutional and Fully-Connected Layer. The pooling layer helps to reduce computation cost, number training parameters and thereby controlling overfitting.

Fully-Connected Layer: The output from final Max-Pooling Layer is fed as input to this layer. Here extracted features are compared with features of test image and similar features are associated with a specified label. Usually the labels are encoded with numbers for easy computation and later on they will be converted into their equivalent strings.

Dropout Layer: When new data is given to a particular model that works very well on training data, overfitting occurs and it has negative impact on performance of that model. This problem is resolved by using dropout layer. During training process, few neurons are dropped out from the CNN model.

Activation Function: It computes weighted sum of inputs and biases from which a decision can be taken whether a neuron can be activated or not. In proposed work, two activation functions have been, they are ReLU (Rectified Linear Unit) and Softmax.

ReLu – It allows only positive values and rejects negative values. It converts all negative inputs to zero thereby preventing the neurons from getting activated. As a result of this, only few neurons will be activate at a given point of time.

Softmax Function: It is used while dealing with multi-class outputs. For a given input it maps the output to a number between 0 and 1in such a way that their total sum is 1.

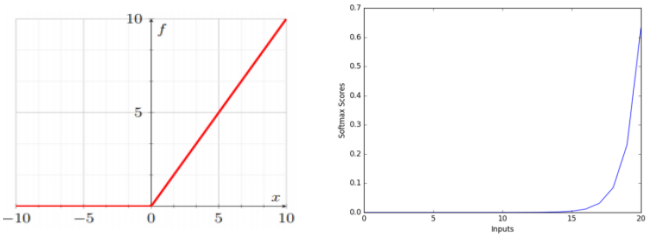


Chart -1: Graph indicating ReLu and Softmax activation function

In the proposed work, the image(s) of shape 50x50 having 3 channels (RGB) with batch-size as None is given as input to input_data( ) function, which results in 4D [batch-size,50,50,3] Tensor that is given as input to CNN. The layer used in CNN is Convolutional Layer that receives incoming 4D Tensor as input and uses thirty two 3x3 convolutional filters as well as ReLu activation. It outputs 4D tensor which is given as input to Max Pooling layer that uses 3x3 pooling kernel. The next four layers are the combination of Convolutional layer and Max Pooling layer where Convolutional layer uses sixty four, one twenty eight, thirty two and sixty four 3x3 filters respectively and all Max Pooling layers use 3x3 pooling kernel. The next layer is Fully-Connected layer that receives incoming 4D tensor as input,it uses ReLu activation and outputs 2D tensor which is given as input to Dropout layer. In dropout layer 80% nodes are kept and remaining 20% nodes are dropped out randomly from CNN. 2D tensor is given as input to the next Fully Connected layer which uses Softmax activation to classify the image(s) into 8 different classes. The output of final layer that is 2D tensor is given as input to regression layer which uses Categorical Cross Entropy loss function to calculate errors and Adaptive Moment Estimation (adam) Optimizer along with its learning rateto minimize the loss function. This CNN model is named, loaded and then stored.

From the collected dataset, 793 images are taken as train set and 199 images are taken as test set. The CNN model is trained using train set and test set with epoch of 90 and then the trained model is saved.

5.2 Testing Phase

A GUI is created which enables user to select, upload and analyse an image. The image uploaded by user is read using cv2.imread( ) function and resized to a standard size of 50x50 using cv2.resize( ) function. The resized image is converted to array format and then appended to an array. This array is then fed to CNN model which returns the label/class to which the image belongs to. This result is also sent to registered mobile number of driver or concerned person using twilio cloud communication service.

6. RESULTS

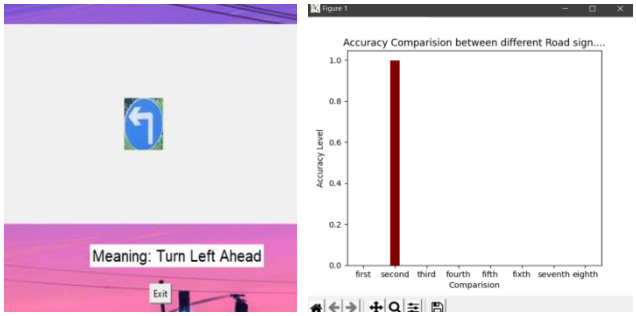
A GUI is opened which asks user to upload an image and a button named Get Photo is displayed. As the user clicks on the button, the folder containing images of Traffic Signs is displayed from which user can select an image of theirchoice and further user can click on analyse button to obtain the meaning of the Traffic sign that is uploaded. If uploaded image doesn't belong to the trained 7 classes, a message "Invalid image" is displayed.

model 0
The predicted image is STOP SIGN with a accuracy of 99.28314685821533%

Fig -6: Stop Sign Recognition and its accuracy

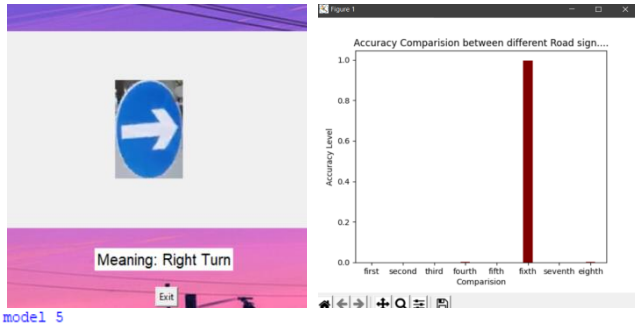
model 4
The predicted image is NO RIGHT TURN with a accuracy of 98.17581772804268%

Fig -10: No Right Turn Recognition and its accuracy



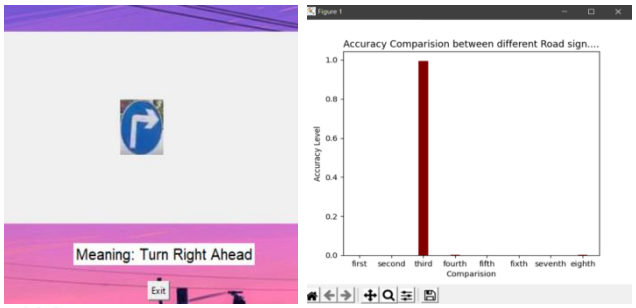
model 1
The predicted image is TURN LEFT AHEAD with a accuracy of 99.67808723449707%

Fig -7: Turn Left Ahead Recognition and its accuracy



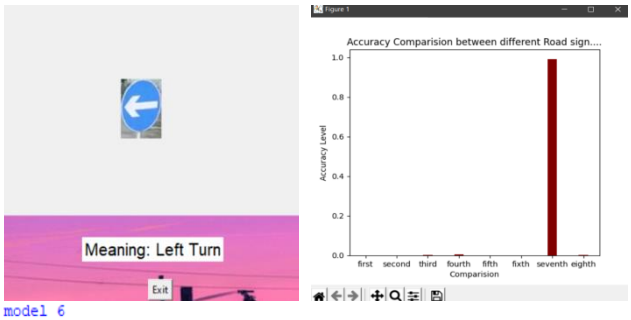
model 5
The predicted image is RIGHT TURN with a accuracy of 99.54179525375366%

Fig -11: Right Turn Recognition and its accuracy



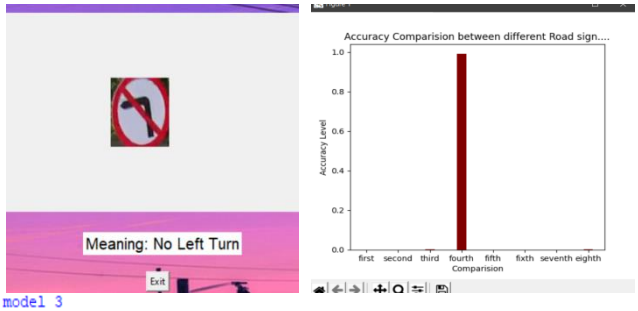
model 2
The predicted image is TURN RIGHT AHEAD with a accuracy of 99.34777021408081%

Fig -8: Turn Right Ahead Recognition and its accuracy



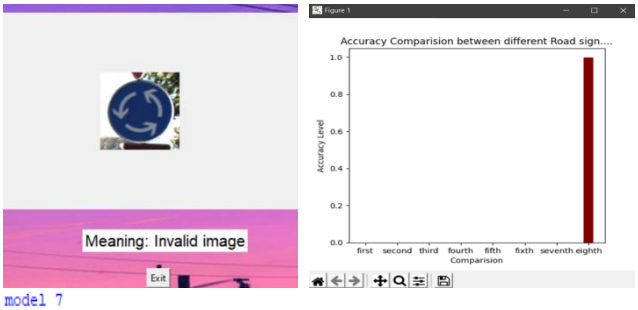
model 6
The predicted image is LEFT TURN with a accuracy of 99.05231595039368%

Fig -12: Left Turn Recognition and its accuracy



model 3
The predicted image is NO LEFT TURN with a accuracy of 99.09836053848267%

Fig -9: No Left Turn Recognition and its accuracy



model 7
The predicted image is INVALID IMAGE with a accuracy of 99.70979690551758%

Fig -13: Invalid Image Recognition and its accuracy

7. CONCLUSION AND FUTURE WORKS

In this paper, Traffic Sign Recognition System is developed where pre-processing, feature extraction, feature selection are performed to obtain better results. The images are pre-processed for better quality and easier detection. Feature extraction is performed by CNN algorithm itself, hence there is no need for separate feature extraction technique. The system recognizes the traffic signs and provides assistance to the manual driving system or autonomous driving system. The advantages of this system is that it provides the message to the user which helps in controlling steering commands of vehicles, hence it reduces human efforts and chances of accidents. The average testing accuracy of all the traffic signs is 99%. In the future, real time datasets can be considered for evaluation which leads to higher accuracy in predicting the traffic signs for the driver or autonomous vehicle on the path. This system is able to recognize only seven classes of traffic signs, hence the scope of traffic sign recognition is limited. In order to increase the scope, the dataset containing different classes of traffic signs can be used.

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