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Traffic Sign Detection and Classification Using CNN

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Abstract: Traffic sign detection and classification is a crucial task in the field of autonomous driving, driver assistance systems, and traffic control. The objective is to propose a method that involves training a CNN on a large dataset of traffic sign images, which allows the network to learn the relevant features and patterns required for accurate detection and classification. Working on multiple datasets of standard benchmark and others helps to explore the difficulties and short comings of a CNN model proposed. Results are aimed to be helping in correct detection of a traffic sign and reducing the loss also using the GUI with the help of Tkinter.

Keywords: Convolutional Neural Network (CNN), Graphical user interface (GUI), Dataset, Tkinter**.**

I. INTRODUCTION

In recent years, road safety is becoming increasingly critical above all in developing countries. In fact, there are considerable amount of the people lose their lives due to traffic accidents every year. According to the 2018 Global Status Report on Road Safety released by the World Health Organization, every year over 1.35 million people around the world lose their lives in road crashes. Also, between 20 and 50 million people are injured or disabled. Generally, most of the traffic accidents are caused by the ignorance of the rules, failure to detect the traffic sign and distraction of the drivers. The majority of these accidents can be avoided by following the signs presented in road scene. Hence, to get better road safety different initiatives have been taken such as the development of an automatic road sign recognition system that can make driving safer and easier. Since the last decade, benefiting from the development of the Intelligent Transportation System, traffic sign detection and recognition system based on image processing have achieved significant progress.

However today’s core advanced technologies are furthering our goals and helping with automation in every field making the need for a human in those areas invalid, because a human is prone to making mistakes, but a machine in his/her place would certainly be more efficient, both in terms of speed and accuracy. Traffic signals are of various types. The datasets consisting of various types of images of traffic signals will be given as input. The model is developed using convolutional neural network for the detection, classification and processing of the images.

Traffic Sign Classification is very useful in Automatic Driver Assistance Systems. A convolutional neural network is a class of deep learning networks. The CNN is used to examine and check visual imagery. It is also used to train the image classification and recognition model because of its high accuracy and precision. The first step is to select the dataset and data preprocessing, then building a cnn model. Then training and testing the built model using the dataset. Finally the output will be displayed on the graphical user interface.

The main results of this item are summarized as follows: (i) structure a CNN model to classify signature images by groups allows us to detect and understand traffic signs that play an important role in driving. (ii) Obtaining the correct output from the data necessary to produce the correct results required for the entry of traffic signs. (iii) Create products to help people understand traffic signs, one of the most overlooked but crucial parts of our daily lives. (iv) Analyze various materials such as image and video datasets and different properties of image datasets. (v) Success of CNN proving the best performance of all neural networks.

The rest of this paper is organized as follows. Section 2 presents recent works related to traffic signs detection and recognition techniques. Section 3 details the methodology that is used in the proposed method. The section 4 involoves the architecture that is followed. Then section 5 involves the results and analysis and then followed by section 6 involving the conclusion and then section 7 depicts the future scope and finally the conclusion.

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II. RELATIVE WORK

This section reviews the research literature in describingtraffic sign classification and detection using cnn to solve predictive problems.

(Thunga Saiteja, Katam Rishik Kumar., 2021)[1]
Traffic confirmation is usually done in two steps: address and next classification. Many localization methods have been proposed. Precise control of traffic signs can be found in the input images using the Generalized Hough Transform (GHT) algorithm. Therefore, a simple pattern matching technique is used in the classification step. The training and testing of the proposed system was done using data from GTSRB German Traffic Sign Comparison.Evaluation of systems designed to detect and classify traffic signs in real life shows a significant decrease in performance. Studies have shown that some factors in the image signature, such as changes in illumination, contrast, and rotation angles, cause adverse effects. Therefore, due to the limited number of preexisting samples, quality assurance cannot be achieved using simple methods such as sample comparison. They say that performance can be improved by combining local algorithms that work well with recognition using convolutional neural networks, which have been widely used in recent years. They have a CNN model that can classify traffic sign images into their categories.This CNN model allowed them to detect and understand traffic signals that play an important role in driverless cars. A CNN model that categorizes signature images.

(Anurag Velamati, Gopichand G.,2021) [2]
The biggest restraint encounter during the project was the computational power requisite for training and test data. The most important thing to do is to convert the image to a small size for ease of calculation. They do not change the color of the image as they want the image to retain its maximum properties for the subject.After resizing the image to the same size, the image be supposed to be converted to NumPy arrays.

(Manjiri Bichkar, Suyasha Bobhate, Sonal Chaudhari.,2021) [3]
Claimed to be a highquality solution for traffic sign discovery, they first classified traffic sign images using neural network networks (CNNs) in the German Traffic Sign Recognition Benchmark (GTSRB). The data were divided into subdatasets for training and validation of 85% and 15%, respectively, then images of Indian train signs were determined using the Indian dataset, which will be used as test data when increasing the classification model. The system they developed helps to identify electric or selfdriving cars properly and accurately. The system consists of two parts that control the traffic signs from the environment and classify the traffic signs as recognized by CNN. In this system, CNN models are created using different filters such as 3×3, 5×5, 9×9, 13×13, 15×15, 19×19, 23×23, 25×25 and 31×31.On this basis, the model with the best accuracy is also used as the detection model. To classify traffic signs, they used the GTSRB dataset containing 50,000 traffic sign images divided into 43 different groups. This data is divided into training methods and validation. India data can too be used in testing for the model to use the training change.

(Ying-Chi Chiu, Huei-Yung Lin, Wen-Lung Tai.,2021) [4]
In their labor, they adopted the Faster RCNN used at Detectron as the basis for their detection algorithm. They used their technique to improve vehicle classification and recognition accuracy. Their work propose a new twostep approach. The first stage usually locates traffic signs and the second stage uses cropped areas for image classification. dissimilar traffic detection schemes, RCNN, Faster RCNN, etc. It uses two-stage detectors

(Ayoub Ellahyani, Ilyas EI Jaafari, Said Charfi.,2021) [5]
In his effort, the gratitude of vehicle signs in crime scene images goes through two main stages: detection and recogniti on. Many research groups combine a monitoring phase to procedure a series of scene images. The inspection step is do ne by color, shape, or both. Using different data and focusing on specific categories, such as hazards or speed limits set by certain systems, makes these methods tricky to compare. Their work describes a list of publicly available documents and a comparison of the findings.

(Adonis Santos, Patricia Angela Abu, Carlos Oppus, Rosula Reyes.,2020) [6]
The plan of the realtime detection and recognition system begin with acquire images that are used to train and then test the detection and recognition model. The system was urbanized in Python using OpenCV, science kit learning and Pytorg libraries and implemented on a microcomputer with camera border and speaker. The data they selected consisted of a total of 2,194 images to be tested at the model level. Of these, 2,170 are traffic images from online sites, and different traffic signs have different sizes and positions of the images. These are equivalent to six sets of signs and one more set for images without traffic signs at a resolution of 1366x768 pixels.

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III. METHODOLOGY

We build a CNN model that classify the traffic sign images into their respective categories. This model enables us to detect and understand traffic signs which plays a crucial part in autonomous vehicles. A CNN model typically consists of several layers that are stacked on top of each other to learn increasingly complex features from the input data .Layers are used in CNNs to enable the model to learn increasingly complex and abstract features from the input data. Each layer performs a specific computation on the input data and passes the result to the next layer, allowing the model to extract more and more relevant information as it progresses through the layers. In addition, layers in CNNs can also be regularized using techniques such as dropout or weight decay, which prevent overfitting and improve the generalization of the model to unseen data. This allows the model to perform well not only on the training data but also on the testing data, ensuring its effectiveness in real-world applications. Here are some of the cnn layer that we have used while designing.

They are:

- Convolution layer.
- Maxpooling 2d layer.
- Activation layer.
- Flatten layer.

Convolution layer: The convolutional layer applies a set of learnable filters to the input image, generating a set of activation maps that highlight the presence of certain features in the image, such as edges, corners, and other visual patterns that are relevant to traffic sign classification. The filters in the convolutional layer are learned during training, using backpropagation to adjust their weights to minimize the loss function of the model. This allows the model to learn filters that are optimized for the specific task of traffic sign detection, such as identifying the shape, color, and content of different types of traffic signs. The number and size of the filters in the convolutional layer can vary depending on the architecture of the CNN model. A larger number of filters allows the model to learn more diverse and specialized features, while a smaller number of filters can make the model more computationally efficient. The size of the filters can also affect the sensitivity of the model to different types of features in the input image. The convolutional layer is a critical component of a CNN model for traffic sign detection, allowing the model to learn relevant features from the input image and improve its accuracy in classifying different types of traffic signs.

Maxpooling 2d layer: to reduce the spatial dimensionality of the feature maps generated by the convolutional layer, making the model more computationally efficient and improving its ability to generalize to new data. The MaxPooling 2D layer works by dividing the feature maps into non-overlapping rectangular regions and taking the maximum value within each region. This effectively reduces the size of the feature maps by a factor determined by the size and stride of the pooling window. By reducing the spatial dimensionality of the feature maps, the MaxPooling 2D layer allows the model to focus on the most important features in the image while discarding irrelevant details, such as noise or minor variations in the input data. This makes the model more robust to variations in the input data and improves its generalization to new data.

Activation layer: The activation layer is a non-linear transformation applied to the output of the convolutional layer. The purpose of the activation layer is to add non-linearity to the model, allowing it to learn more complex and abstract features from the input image. The most commonly used activation function in CNN models for traffic sign detection is the Rectified Linear Unit (ReLU) function. The ReLU function sets all negative values in the input to zero, while passing positive values through unchanged. This results in a sparse activation map that highlights only the relevant features in the input image while suppressing noise and irrelevant information.The activation layer is a critical component of a CNN model for traffic sign detection, allowing the model to add non-linearity to the feature maps generated by the convolutional layer and learn more complex and abstract features from the input image.

Flatten layer: The Flatten layer is a type of layer in a CNN model that is used to transform the output of the convolutional and pooling layers into a 1D vector that can be used as input to the fully connected layers. The output of the convolutional and pooling layers is typically a set of 2D feature maps with spatial information about the input image. The Flatten layer reshapes these feature maps into a 1D vector without altering their content, allowing the fully connected layers to receive a compact input that summarizes the relevant information from the input image. By using the Flatten layer, the model can leverage the full expressive power of the fully connected layers to perform high-level classification tasks based on the learned features from the input image. the Flatten layer does not perform any computation on the feature maps, but simply reshapes them into a 1D vector. Therefore, it does not add any non-linearity or feature learning capabilities to the model. Its role is simply to transform the output of the convolutional and pooling layers into a suitable input format for the fully connected layers.

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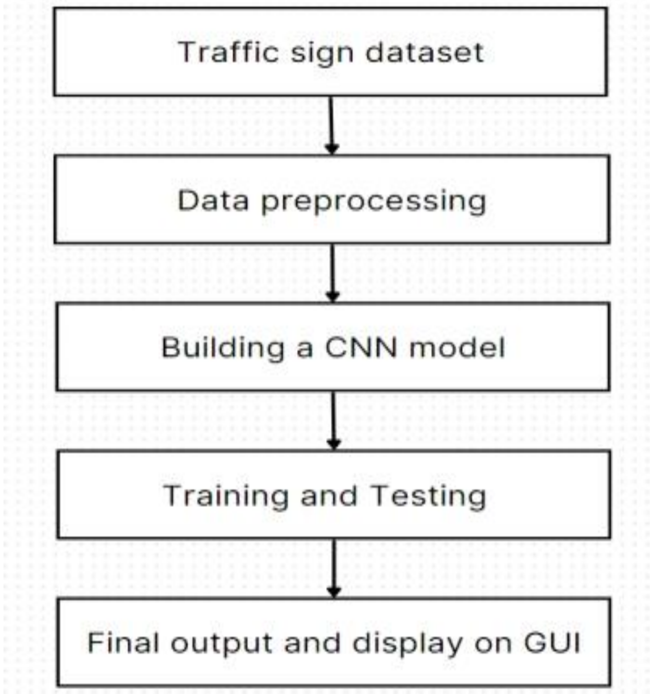
IV. ARCHITECTURE

The architecture diagram is a visual representation of the actual flow of the project. The flow of how the system works is depicted in the following figure.



Traffic Sign Dataset: A traffic sign dataset is a collection of images and corresponding labels that are used to train machine learning models to recognize and classify traffic signs. The dataset typically consists of images captured under various lighting conditions, weather conditions, and camera angles, and includes a variety of traffic sign classes such as speed limit signs, stop signs, yield signs, and more. The images in the dataset are often captured from different perspectives, distances, and angles, to simulate real-world scenarios and to ensure that the machine learning models are robust to variations in the appearance of the traffic signs. The labels in the dataset provide information about the class of the traffic sign shown in each image, as well as any additional information such as the speed limit or other regulatory information.

Data preprocessing: Data preprocessing is an essential step in preparing a dataset for machine learning model training. The purpose of data preprocessing is to clean, transform, and reshape the data to ensure that it is suitable for use by the machine learning algorithm. In the context of a traffic sign dataset, data preprocessing may involve several steps, including Image resizing and normalization, data augmentation, label encoding, data balancing and data splitting.

Building CNN model: Convolutional Neural Networks (CNNs) are a popular type of deep learning model used for image classification tasks such as traffic sign recognition. The CNN model consists of several layers, including convolutional layers, pooling layers, and fully connected layers. The architecture is designed to learn and extract features from the images and to classify the traffic signs. Once the CNN architecture is defined, the model needs to be compiled by specifying the loss function, optimizer, and evaluation metric. The loss function measures the difference between the predicted and actual labels, the optimizer updates the model weights based on the loss, and the evaluation metric is used to assess the performance of the model.

Training and Testing: Training and testing a CNN model involves feeding the prepared dataset into the model, and using backpropagation to update the model's parameters and minimize the loss. The model is trained on the training set using backpropagation to update the model parameters and minimize the loss. This is typically done in multiple epochs with a batch size of data fed through the model at each iteration. Then the model is evaluated on the validation set to assess its performance. This step is important for tuning the model's hyperparameters, such as the learning rate or number of layers. Once the model is trained and tuned, it is tested on the independent testing set to evaluate its ability to generalize to new data. This step is important for assessing the model's performance in real-world scenarios.

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Final output and displaying on GUI: After training and testing the CNN model, the final output typically involves using the model to classify new traffic sign images. The saved model weights are loaded into the model to make predictions. Any necessary preprocessing steps such as resizing and normalization are applied to the new traffic sign image. The model predicts the class of the new image based on the learned features. The predicted class is displayed on a GUI, along with the corresponding image and any additional information such as the probability score or class label.

V. RESULTS AND ANALYSIS

The CNN model which is developed for traffic sign detection was found to be the best performing model with 85-90% accuracy. The high accuracy and recall rates indicate that the model is effective in identifying the road traffic signal and classifying in a appropriate manner.

VI. CONCLUSION

The successful detection and classification of traffic sign images can be seen in the project developed. The consideration of the simplicity, accurate and other components is done and the CNN model is trained and tested. The input variations of image and video is also been considered and classified to the best extent. The module of future works is also implemented as live detection can be used with refining and modifying for specific needs. As part of CNN model, the accuracy of training the model is been acceptable with 85-90% and the increasing epochs has also resulted in minimum loss.

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