Classification of Road Objects using Convolutional Neural Networks

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Abstract

Driving is the primary means of transportation for many people around the world. Whether the use is to assist human drivers or create autonomous driving, the use of machine learning can create safer road conditions. Drivers must consider other objects on the road, most commonly other vehicles and pedestrians. These three components, road signs, pedestrians, and vehicles, make up a large majority of objects that a driver will encounter when on the road. This research applies machine learning algorithms, specifically Convolutional Neural Networks (CNN), to classify these road objects. The goal is to create a classification model that can reliably classify road objects and classify the different road signs into individual classes. The results showed high accuracy in classifying the objects, even at lower resolutions and poor conditions.

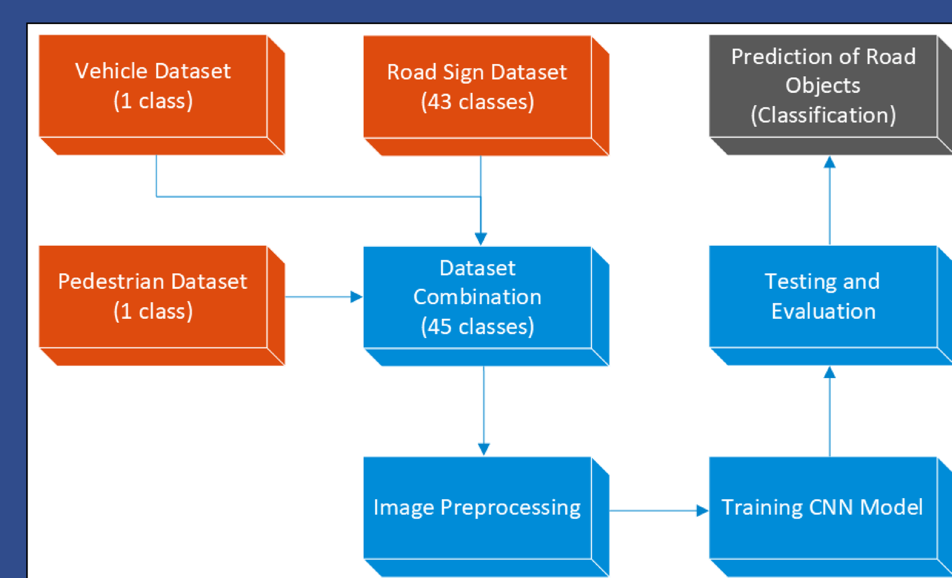
Introduction

Operating a vehicle on the road requires the acknowledgment of a variety of different objects. Most of these objects must be visually detected and comprehended by the driver, such as pedestrians on a crosswalk. This is a key component of the driving task for both humans and self-driving models. The number of road accidents around the world is not negligible and there is a need for increased safety. Acknowledging road objects is a crucial part of operating a vehicle, and failure to do so is a common cause of accidents. In general, three main objects are encountered by drivers that need to be acknowledged to safely operate the vehicle, road signs, pedestrians, and other vehicles.

In this work, we will utilize Convolutional Neural Networks (CNN) to create a classification model for road signs, pedestrians, and vehicles. Previous research by others shows the strength of using a CNN or multi-scale CNN for problems related to road object classification [1] [2]. The inclusion of pedestrians and vehicles is to build upon previous research on road sign classification and advance classification models to include more of the objects that are commonly encountered by drivers while also still maintaining high accuracy for road signs.

Methodology

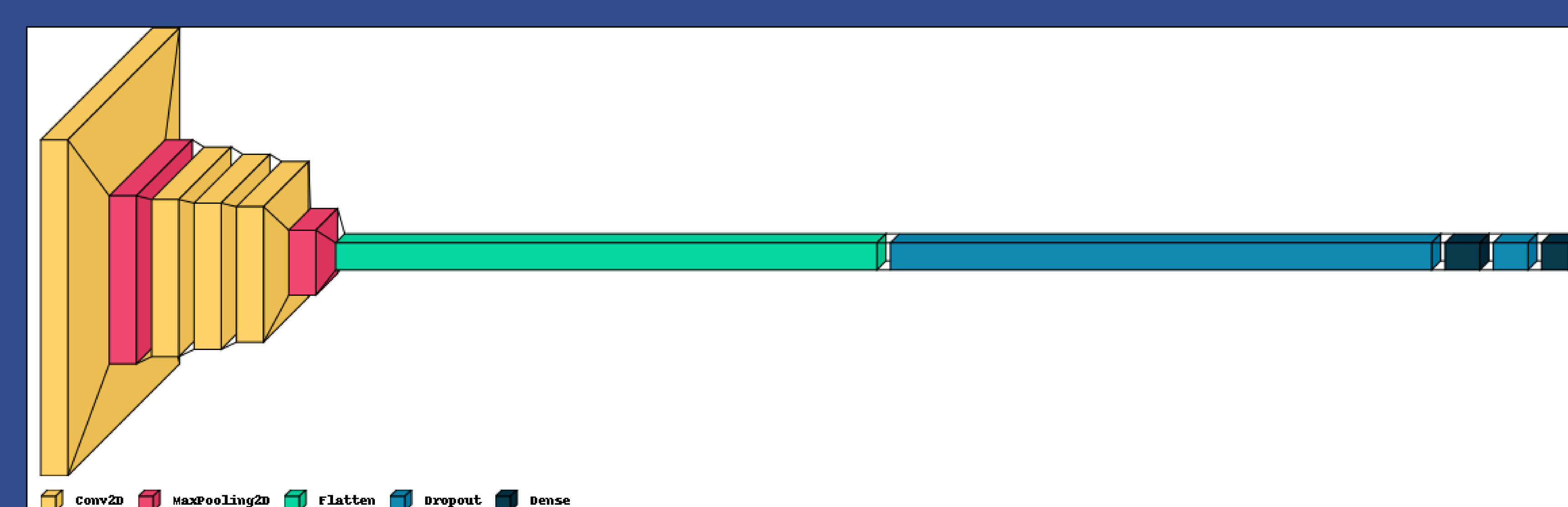
For implementing the model, the Python language was used because of the extensive libraries. The Keras framework with Tensorflow was used to build the neural network and the Anaconda platform was used to manage the packages [3] [4]. The dataset used is a combination of 3 data sources which are road signs, pedestrians, and vehicles. The overview of the process is shown below.



Algorithm

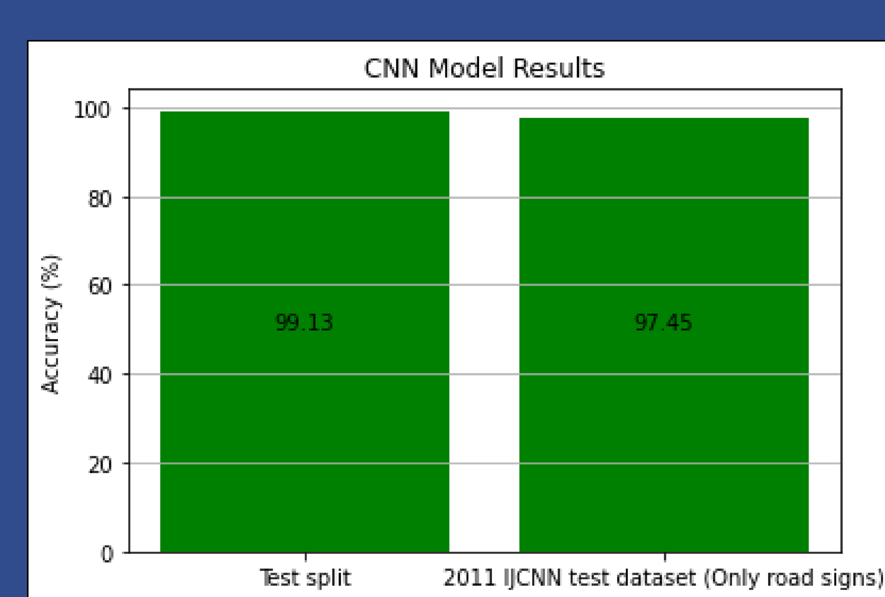
The method that was used to classify the road object is a CNN because of its strength in image classification. Convolutional Neural Networks use nodes that imitate human neurons to made decisions. It is like an artificial neural network with the added convolution layers. Convolution utilizes the dot product of different regions of the image to condense the size of the input and reduce learning time.

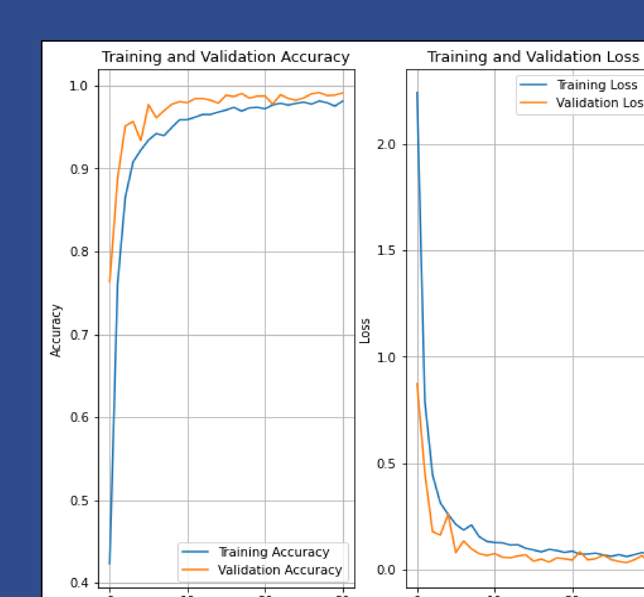
The CNN used takes a 4-dimensional array as an input. The elements in the array for image classification are batch size, height, width, and depth. The batch size is the number of samples that will be processed, which can vary and is not predetermined. The height, width, and depth are determined by the image that will be inputted. The graphic below shows the layers in the CNN, notice how the dimensionality of the input is reduced as it progresses through the model.



Results

To test the model, two test sets are used. The first set consists of test data from splitting the dataset into training, validation, and testing sets. From the test set of 5104 images, an accuracy of 99.13% was achieved. The second method of testing focused on just the road sign classes using the International Joint Conference on Neural Networks (IJCNN) 2011 test dataset [5]. Since the road signs consisted of 43 out of 45 classes, it was important to have a good performance on road signs. The result was an accuracy of 97.45%.





Conclusion

Convolutional Neural Networks can be used to classify road objects at a high level of accuracy. Even with very poor lighting conditions and low resolutions, images can still be classified at an acceptable level, even for applications with risks involved such as self-driving. In this work, road signs, pedestrians, and vehicles are classified, with emphasis on distinguishing the road sign types. The testing results concluded that not only does the model created identify road objects at a high accuracy but can identify road signs at a competitive level compared to models designed to only classify road signs.

Implementations of a model such as this could be used to display information to the driver, such as road sign information or pedestrian warnings. With the inclusion of pedestrians and vehicles, driver information systems can start to implement driver aids that gather more than just basic road sign information [6].

Improvements to the model could include adding other important road objects such as cones and traffic signals. Considering the dataset that was used, the road signs this model can classify are only German signs and signs that are similar. Making a dataset with more universal road sign classes would be ideal to create a universal classifier.

References

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