Road Signs Recognition Using Convolutional Neural Network

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Motivation

With the development of the automotive industry, more and more vehicles are on the road. In recent years, the concept of autonomous driving has become more and more popular. At the national level, many countries have incorporated autonomous driving into their top-level planning. Our team takes road sign recognition during driving as an example to explore difficulties in autonomous driving industry.

Fig.1 sample road signs

Dataset

In this project, we selected “German Traffic Sign Recognition Benchmark (GTSRB)” as the modeling dataset. In The International Joint Conference on Neural Networks 2011 competition, this dataset was used as the official training set and test set of the competition.

Fig.2 sample training road sign images

The dataset has 43 classes with a total of about 52,000 images. The training set has nearly 40,000 images, and the test set has about 12,000 images.

Approach

1. Data Preprocessing

Since the total amount of data in the data set is limited, in order to increase the total amount of training data, the existing training data pictures can be used to rotate, flip, etc., so as to obtain new pictures to expand the data set. Through this flip operation on the original picture, the amount of training picture data has increased from nearly 40,000 to more than 60,000.

2. Network Design

Our base model is a simple CNN model, it provides good recognition accuracy for most of the testing cases but behaves poor for pictures taken with certain angles. To enhance our model and avoid overfitting, we **revised the model** with following approaches:
1. Add STN layer to enhance the spatial invariance of the network.
2. Batch Normalization Layer and Dropout Layer are added to the general neural network structure proposed in the paper: Multi-Column Deep Neural Network for Traffic Sign Classification of Dan Ciresan et al. of IDSIA Laboratory. After Batch Normalization processing, the distribution of the output data of each layer can be more concentrated; while the dropout layer can make the model more generalizable and alleviate the problem of overfitting. We adopt CrossEntropyLoss Function as the loss function throughout the training.

Space Transformer Network, proposed by Google's Deep Mind team. The traditional convolutional neural network has certain spatial invariance, even if the picture has been translated to a certain extent, the neural network can still recognize it. The STN network can perform spatial transformation operations on the feature map, including operations such as translation and rotation, which enhances the spatial invariance of the network. The biggest advantage of the STN network is that it can be directly added to other neural networks as a layer to increase the spatial invariance of the network.

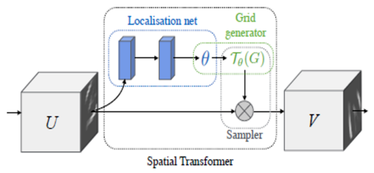

Fig.3 STN Network Modeling Structure

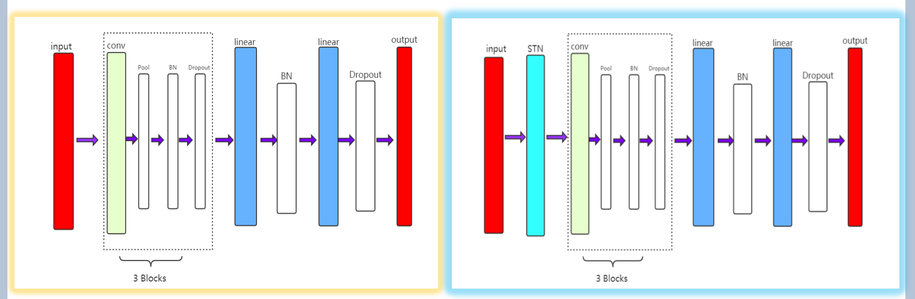

Fig.4 Network Design without / with STN

Experiment

Experiment Setting	Value
Test Dataset Size	12630 Pictures
GPU	Nvidia 2080TI

Hyper Parameter	Value
Batch Size	64
Drop Out	0.5
Learning Rate	1E-4
Epoch	100
Early Stopping Patience	10

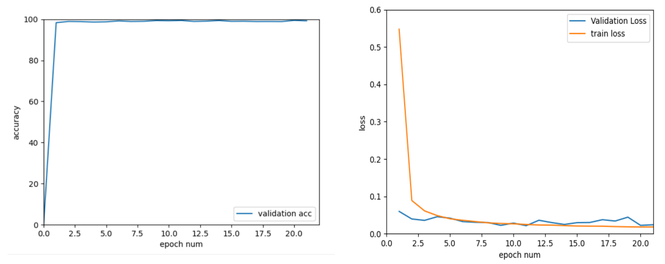

Fig.5 model accuracy and loss curves

Conclusion

In this project, our team proposed a novel network design to tackle with the road sign recognition problem. The model reaches an accuracy about 99%. However, this neural network could be too complex to be deployed on edge-devices with low computing power and limited storage place, it would be meaningful to explore how to compress the size of the network while maintaining a high recognition accuracy.

Challenges we met in this project come majorly from two parts:
1. We heard PyTorch is also a popular machine learning framework used in industry and we took time to learn it and used it to complete this project.
2. We adopted two approaches to optimize our original network design, which was elaborated in Section.2 Network Design.

Reference

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