Project Presentation

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Title

Real Time Control Using Convolution Neural Network for Self-Driving Cars

References

1. A.G.Howard, M.Zhu, B.Chen, W.Wang and T.Weyand(2017). Mobilenets:Efficient convolutional neural networks for mobile vision applications.
2. C.C.J.Kuo,(2016).Understanding convolutional neural networks with a mathematical model.
3. K.He, X.Zhang ,S.Ren and J.Sun,(2015). Delving deep into rectifiers:Surpassing human-level performance on imagenet classification.

Abstract

- In this paper,we perform an Autonomous deep learning robot using an end-to-end system.
- The deep learning robot used Convolution Neural Network(CNN).CNN model learns from images and steering angles collected while driving and has accuracy upto 85.03%.
- The system operates as the the controller for navigating and driving automatically.
- The results showed that the CNN is able to learn the diversified tasks of lanes and roads with or without lane marking.
- CNN can replace the conventional PID controller.

Definitions

- Deep learning: A type of machine learning and artificial intelligence that imitates the way humans gain certain types of knowledge.It is important element of data science.
- Neural network: It is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way human brain operates.
- CNN: A type of artificial neural network used in image recognition and processing that is specially designed to process pixel data.
- MobileNet: A streamlined architecture that uses depthwise seperable convolutions to construct lightweight deep CNN.

Introduction

- Recent theoretical developments revealed that CNN was in diversified tasks pattern recognition is the major function of self-driving car task.
- One primary problem to adopting CNN for predict the steering control is the regression method.
- We can deal with above problem using Gaussian area concept to predict steering angle.
- Though the prediction method changed.But the concept such as using the convolution kernel to scan entire images still remains.

Collecting data

Training data is collected by car in form of images and steering angle.

1. Images
   The image was collected and then converted color space from BGR to RGB and resizing the image from 1280×720 pixels to 160×160 pixels.Overall process focuses on reducing size of the image corresponding to the frame rate of self-driving car system.

2. Steering angle
   It is transformed into 5 classes are left,midleft,forward,right and midright.Each class is divided into intervals of 30 degrees per class in Fig.steering angle.

CNN architecture

CNN description

- The model is designed for resolution 160×160 pixels.
- Mobilenet performs feature extraction.
- We can customize prediction layer by using Softmax activation function which predicts the probability class.
- The prediction layer had 5 nodes with softmax function.
- Training process compiled with learning rate 0.001 and categorial cross entropy loss function.

CNN architecture

Mobilenet
Input layer
Convolutional layer
Depthwise n Convolution layer
Batch Normalization
ReLU
(n = 1,2,3,...,13 layers)
Global Average Pooling layer
Reshape layer
Dropout layer
ReLU layer
Reshape layer
Softmax layer
Reshape layer
Output

Figure: CNN Architecture

Self-driving control architecture

Controller

- CNN's can be used in place of conventional controllers(CC).
- As, CC's may lead to poor handling performances because they need to set up with specific features and hardware parameters.
- CNN is able to go beyond pattern recognition.It learns the entire processing pipeline needed to steer an automobile.
- CNN block diagram below is applied to replace the CC's.
- Furthermore,the CNN can apply on real time processing with or without lane marking.

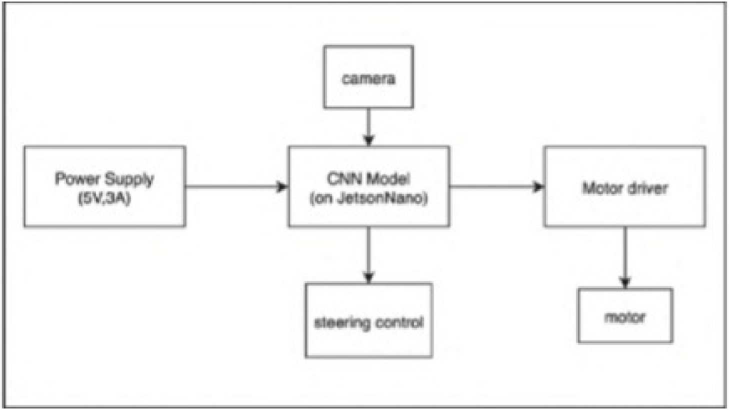

Figure: CNN block diagram

Hardware optimization

A processor with high processing speed and high performance to communicate and respond rapidly is needed in self-driving car(SDC) for driving and steering motor control.

1. The processor for the self-driving car is the Jetson Nano.It is used to compute CNN models .
2. The controller selected for building SDC is STM32, the main function of controller is communication between the motor drive system and Jetson Nano.
3. The motor driver chip for building the SDC is L293D.Using this chip can typically power up to 36 volts.
4. The power supply for SDC is an 11.4 volts 2200mAh Lipo battery. all systems in SDC requires power.

Methods and Experiments

Experiment Setup

- First, Lipo battery is applied to SDC and set-up an alarm to detect when voltage in each battery cell was lower than threshold.
- The steering angle is initially started at 0 degree.

Data collection

- A data set,captured image and steering angle is collected while controlling the car through a joystick.
- Thousands of images are saved into JetsonNano that runs on Ubuntu 14.0 operating system.
- The range of servo motor angle is between -70 to 70 degrees.

Output data for classification

1. The steering angles collected from a joystick are in between -75 to 75 degrees.
2. We will segment the steering angle corresponding with image data into five classes.
3. Below there is fig regarding interval of angles and classes.

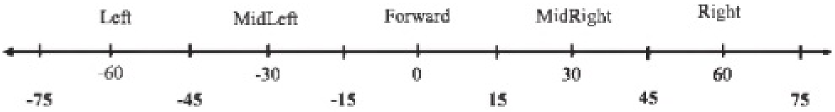

Figure: Relation between steering angle and classes

Image processing

The CNN was designed with 160×160 pixels for pushing the higher frame rate as fast as possible. The image normalization has been done before applied to the model.

Data pre processing

We shuffled data from CSV file that contains the image path and steering angle. The data is divided into training and testing set with ratio of 80% and 20% respectively.

Training model

1. When an entire dataset is passed forward or backward through neural network is one epoch.
2. We train the network about 128 epochs.
3. Accuracy of the training dataset is 94.09% and the accuracy of the testing dataset is 85.03%.

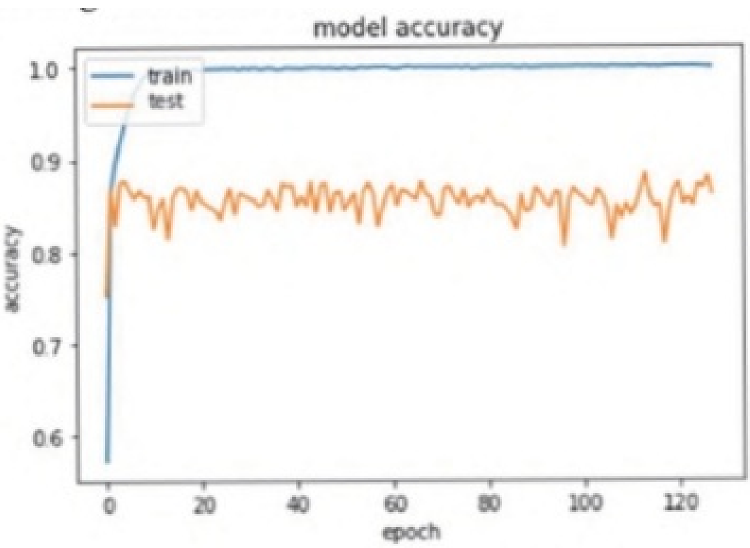

Figure: Output accuracy of 128 epochs diagram

Experimental Results

- We test the experiments in 2 phases,software simulation and on road testing.
- The CNN model has softmax activation function,the purpose of this activation function is used to predict probability of each classes(P_i).
- In first phase, the images are applied to CNN in order to obtain P_i corresponding to steering class angle.
- The prediction angle from each class is calculated by equation (1).

$$Angle(degree) = \sum_{i=0}^{4} P_i \times W_i \tag{1}$$

  where W_i is degrees corresponding to Table 1.
- This equation is used to compute output steering angle.

Class(Probability)	Meaning	Degrees(W_i)
Class 0	Left	-60
Class 1	MidLeft	-30
Class 2	Forward	0
Class 3	Right	30
Class 4	MidRight	60

Table: 1:class meaning and gain for mapping to predicted angle

Experimental results

- In second phase,the trained model from the first phase is embedded into car.
- The accuracies were calculated from training and phase which are 94.05% and 85.03% respectively.

Conclusions

Conclusions

1. This paper used CNN as a controller.There is no theoretical comparing between using conventional controllers and CNN in SDC.
2. The conventional ones obtain the errors from measured data while errors in CNN are not directly fed back from output errors.
3. CNN is able to learn the the diversified tasks of lanes and the roads following with or without lane marking,direction planning and automatically control.

Thank you!