Internet Of Things Project

SEMESTER VI

BML MUNJAL UNIVERSITY™

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Self Driving Car

Abstract

In the 21st century, with the advent of machine learning and path breaking work in artificial intelligence, the vehicles are focused to be automated to give human driver relaxed driving. In the field of automobile various prospects have been considered which can automate a vehicle. Google, the biggest network has started working on it's own self-driving cars since 2010 and has been developing new changes to give a whole new level to the automated vehicles. In this project we have focused on certain applications of an automated car, in which the car detects the road in front and moves accordingly. The following vehicle will follow the track and lane automatically. The other application is automated driving during the heavy traffic jam, hence relaxing driver from continuously pushing brake, accelerator or clutch. Since taking intelligent decisions in the traffic is also an issue for the automated vehicle so this aspect has been also under consideration in this paper.

INTRODUCTION

Self driving car are autonomous vehicles that are intelligent enough to steer and maneuver themselves on the road and can reach the required destination. These cars are able to sense the environment around them and treat that as input to generate motor functions accordingly.
The car's intelligence is directed by a convolutional neural network that is trained to take the surrounding images as input and maneuver the car in the direction with least resistance relative to the surrounding.
The levels of autonomy of a car are a progression of self-driving features that automobile engineering experts SAE International have laid down. These levels range from non self-driving features at all to fully-autonomous driving. They are as follows:

- **Level 0: No automation**. These are cars equipped with regular cruise control. The ability to maintain a speed that the driver sets is not autonomous. It's still up to the driver to change speed if the car catches up to a slow-moving Prius hogging the left lane. These cars are primitive in self driving paradigm and almost all daily use cars fall under this category.
- **Level 1: Driver assistance required to drive.** Adaptive cruise control falls into this category. This Level detects the lane on which the car is travelling and the car steers itself

through lane detection model. Lane keeping assistance falls into this category as well, as the car will gently guide you back into your lane as you start to cross the line.

- **Level 2: Partial automation available.** This level of automation controls the speed of the car along with the lane and steering of the car. At this level the car is able to detect the vehicles along with the speed and is able to manipulate the speed and steering accordingly.

- **Level 3: Conditional Automation.** Audi claims that the new A8 is the first production car to achieve Level 3 autonomy, The car, rather than the driver, takes over actively monitoring the environment when the system is engaged. The Audi A1 traffic jam pilot can take over the tedious job of moving through highway traffic jams at speeds below thirty miles per hour. However, drivers must respond to a "request to intervene," interrupt that is generated. In other words, once the conditions under which Level 3 autonomous driving is possible no longer exist, such as traffic clearing and speeds exceeding a certain limit, the driver is supposed to take over. This is probably the stickiest level of autonomy, as drivers will be called to take over when they haven't been paying attention to the road for a while. This is also the difference between Level 3 and 4 that *Motor Trend* failed to grasp.
- **Level 4: High automation.** Self-driving cars will be able to handle most dynamic driving and is the closest that has been reached to human driving. In other words, a Level 4 car can handle most mundane driving tasks on its own, but will still require driver intervention from time to time, during poor weather conditions, for example, or other unusual environments. Level 4 cars will generally do the driving for you, but are still not trained enough to deal with unforeseen conditions. These cars are not able to handle high level of environmental noise.
- **Level 5: Full automation.** Humans are nothing but cargo that tell the car where to take them. The car can drive itself anytime, anywhere, under any conditions. Any human intervention in the driving at all is not Level 5. This Level of driving is an ideal condition and can be achieved only with a comprehensive artificial intelligence.

It's important to note that today, right now, the highest level of autonomy available to us is Level 3—not full autonomy.
Even the most famous fictional autonomous car of all time, KITT from *Knight Rider*, only achieved Level 4 autonomy. KITT had amazing driving capabilities, far beyond what most human drivers are capable of. But in the interest of good TV, even KITT had limitations that required Michael Knight to take the wheel on occasion. Any modern car claiming Level 4 or 5 autonomy is just as fictional as KITT himself.

Literature review

Jiajia Chen, University of Science and Technology, Hefei, China:

The research paper published by Jijia Chen describes autonomous vehicles as an important and upcoming technology that'll reduce the traffic accidents drastically. One of the important aspect of an autonomous vehicle is its capability to change lanes and passing the vehicle in its front without any collision. Two main factors that the vehicle must consider are:

1. Calculating the distance to the safe lane
2. Generate a path based on piecewise quadratic Bezier curve and the maximum curvature of the Bezier to verify if the path is safe for the vehicle or not.

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The paper mentioned another interesting approach for the autonomous vehicles to follow. It suggested that the vehicle should find a track and then track a desired route without an obvious consideration of the vehicle's stability. Stabilisation is then achieved by the construction systems build inside the vehicles. One major technology to achieve the stability while driving is an Electronic Constancy Control which constantly enhances the driving inputs from the car to ensure and manage stability. In a real life scenario, there can be cases when a vehicle needs to attempt a double lane change in an emergency. In such cases, the Constancy control needs to stop trying to deliver stability to the system. When in a state of emergency, the vehicle needs to use radar sensor to detect other vehicles that might be coming through.

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The mentioned paper states that an important capability that an autonomous vehicle must possess is to switch multiple operations when they need, such as escaping obstacles, scheduling to lead the vehicle from an starting point to an aim conformation and resolution building to select an optimum action policy. Also, the vehicle must act in different ways that are strong to sorts of uncertainties, such as sensors being affected by noise, wheel spin up, obstacle moving unpredictably, earthquake, heavy rain and many more.

IOT Architecture

Collaboration and Process

Once a system is developed, collaboration is must with groups so as to provide stability and other features to the car.

Application

The Image Recognition application currently run on the Pi itself, but it can be moved to a remote server.

Data Abstraction

The images being taken by the Raspberry Pi can be used to further make our model precise.

Data Accumulation

Data is stored in storage of Raspberry Pi and can be stored in cloud storage.

Edge Connectivity

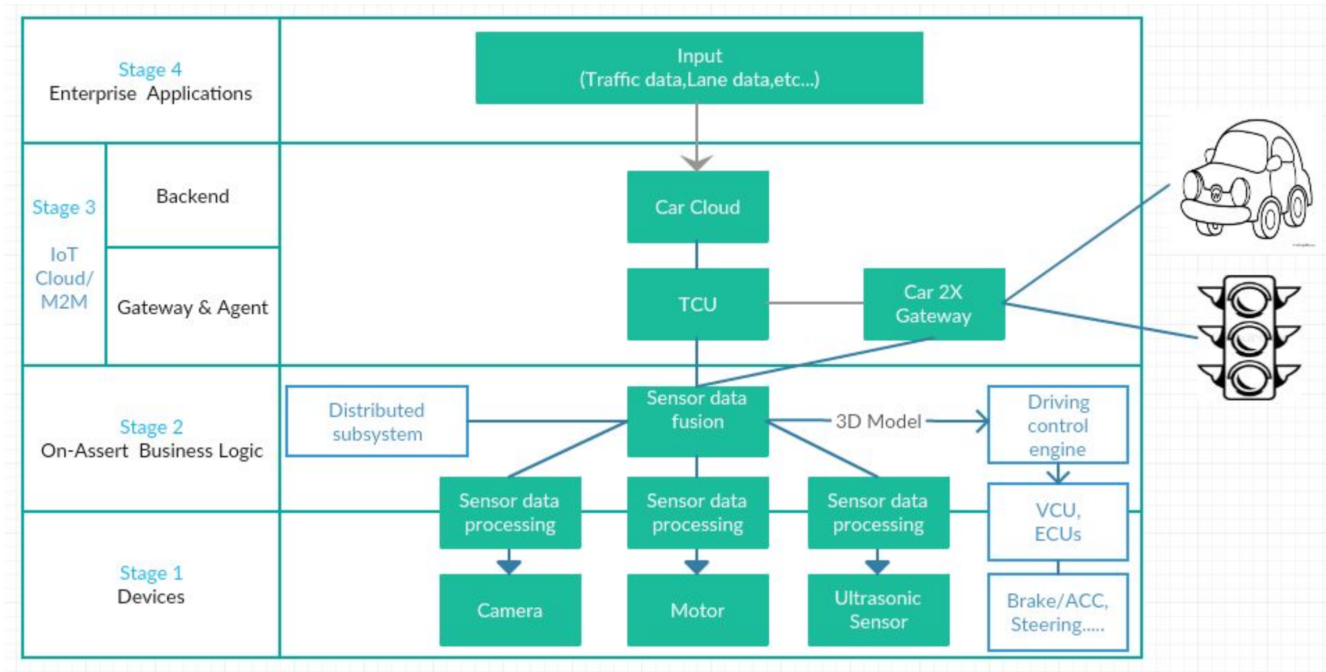
Noise in Image are removed to eliminate wrong/false result.

Connectivity

Data Bus, Wires, Wifi 802.11.4 n

Physical Devices

PiCamera, Motor, Ultrasonic Sensor, Power Source.



Proposed Algorithm

NEURAL NETWORK:

CNNs, like neural networks, are made up of neurons with learnable weights and biases. Each neuron receives several inputs, takes a weighted sum over them, pass it through an activation function and responds with an output. The whole network has a loss function and all the tips and tricks that we developed for neural networks still apply on CNNs.

The intelligence of neural networks is uncanny. While artificial neural networks were researched as early in 1960s by Rosenblatt, it was only in late 2000s when deep learning using neural networks took off. The key enabler was the scale of computation power and datasets with Google pioneering research into deep learning. In July 2012, researchers at Google exposed an advanced neural network to a series of unlabelled, static images sliced from YouTube videos. To their surprise, they discovered that the neural network learned a cat-detecting neuron on its own, supporting the popular assertion that “the internet is made of cats”.

LANE DETECTION:

Canny Edge detection algorithm: This algorithm is used to detect edge lines in any image. First we remove any noise in the image through gaussian blur then we find the intensity gradient of the image through which we find the edges where there is a change in gradient.

Hough Line Transform: Hough line transform is used to detect any shape. The shapes are represented as parametric lines with an inclination. So first it creates a 2D array or accumulator (to hold values of two parameters) and it is set to 0 initially. Let rows denote the ρ and columns denote the θ. Size of array depends on the accuracy you need. Suppose you want the accuracy of angles to be 1 degree, you need 180 columns. For ρ, the maximum distance possible is the diagonal length of the image. So taking one pixel accuracy, number of rows can be diagonal length of the image.

Experiment and Simulation Setup

Following components are being used :-

- Raspberry Pi
- Pi camera
- Motors
- Ultrasonic sensor

Specifications
Raspberry Pi 3 model B:

- SoC**:** Broadcom BCM2837
- CPU**:** 4× ARM Cortex-A53, 1.2GHz
- GPU**:** Broadcom VideoCore IV
- RAM**:** 1GB LPDDR2 (900 MHz)
- Networking**:** 10/100 Ethernet, 2.4GHz 802.11n wireless
- Bluetooth**:** Bluetooth 4.1 Classic, Bluetooth Low Energy
- Storage**:** microSD
- GPIO**:** 40-pin header, populated
- Ports: HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)

Pi Camera Module :

- Sony IMX219 8-megapixel sensor
- Camera specifications
    - CCD size : ¼ inch

    - Aperture (F) : 2.0
    - Focal Length : 3.04mm
    - Field of View : 73.8 degree
- 3280 × 2464 still picture resolution
- Support 1080p30, 720p60 and 640x480p90 video record
- Dimension: 25mm × 24mm × 9mm

Ultrasonic Sensor :

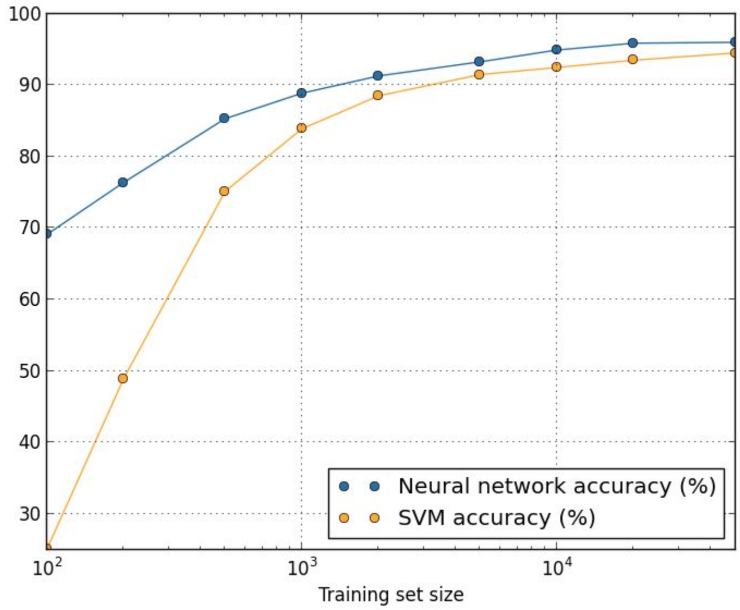
- Supply voltage: 5V
- Global Current Consumption: 15mA
- Ultrasonic Frequency: 40KHz
- Maximum Range: 400 cm
- Minimal range: 3 cm
- Resolution: 1 cm
- Trigger Pulse Width: 10 µs
- Outline Dimension: 43x20x15 mm

Configuration:
We have connected ultrasonic sensors, buzzer and camera module directly from Raspberry Pi. With the help of these sensors we are controlling actuators like motor which is also directly connected to pi.

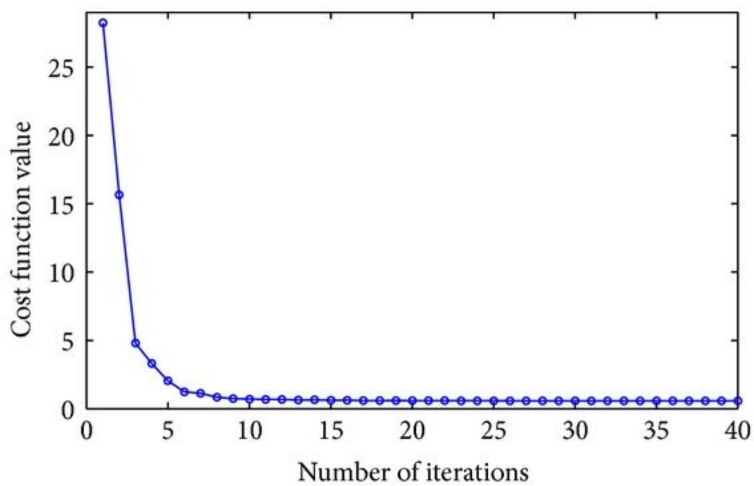
Result and Analysis

Our Current model is giving inaccurate result sometimes. The more time the car spends on the road the more data it collects to train its models. Thus, it can take more precise results with less error rate.

Currently, our model is trained with over 900 images. And the accuracy we are getting is quite dull. Once our model is trained with more than 5000 images and considering the track we are using for our prototype we are aiming to hit more than 90% accuracy rate.



Also, the cost function decreased with more iterations as expected. After performing 10 iterations on the training test, testing the model on the test data set resulted an exponential decrease in the cost function value.



But the problem we are facing is with the computation power and storage capacity of raspberry pi . We have trained models for Traffic light detection and Lane detection but the problem is the frame rate of camera module and computation power of raspberry pi are not working coherently. We have two solutions for this problem, either to overclock raspberry pi and increase the computation power or use cloud technology, storage and file sharing which requires a faster internet.

Conclusion and Future Scope

Self driving car can generate huge amount of data after proper implementation. Generated data can be used to train the car. The data can be generated based on various parameters such as traffic conditions, environmental conditions, quality of road etc. This generated data further can be used to make custom models for the cars so that they are able to plot a path between source to destination for the user taking the various factors into consideration.
Also, with enough self driving cars on road, we can easily predict the congestion and the means to avoid them better than the conventional congestion detection algorithms can provide.
Self Driving Cars are an interesting project to work upon and with ever improving microcontrollers and ever evolving algorithms, never seen before accuracy can be achieved.

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