Self-Driving Cars

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Abstract

With the development of machine learning and artificial intelligence operators especially self-sustained devices and autonomous machines are undeniably going to play a vast role in our daily lives. Therefore it is essential for people to start adapting to ongoing innovations. For my case, as a high school student, 5 months into of learning programming, I started working with a sensor called "vision sensor". The sensor is a camera used to create input to microcontrollers and with appropriate coding it can be configured as an image processor, by interpreting and analyzing data and considering all its possible outcomes. Furthermore, when I realized that this sensor could be the actual basis of a self-driving car, I started to consider, "How will a driverless car respond to different road conditions?". Hence, I conducted some experiments to replicate this system. At first, I wrote a code for the sensor which could determine the location of a white tape. Therefore, the camera made it possible for the robot to follow the tape while staying centered on the "road". Later on, decided to try it on some other surfaces with different frictions, road conditions and color codes applied, to see if it affected my results. For example, I tried on a glass and on a slightly rocky surface to better grasp the consequences in every situation, just like driverless cars themselves. Thus, this experiment can be considered as an attempt for solving futuristic problems.

Keywords: *Self-driving cars, Programming, Sensors, Artificial Intelligence, Engineering Education*.

Introduction

A brave new world is ahead of us and all the developments made in technology over the last decade are driving humanity upto a new stage. An era of self-sustainability. With these rapid changes, the combination of mechanical devices and automation is becoming an inevitable fact. Although many people are not aware of these ongoing improvements regarding computerized gadgets, they are already in our lives, even in our pockets. For instance Amazon has released an intelligent echo-speaker called Alexa, which has a voice recognition system inside and is capable of understanding the given command in order to perform tasks accordingly [5].

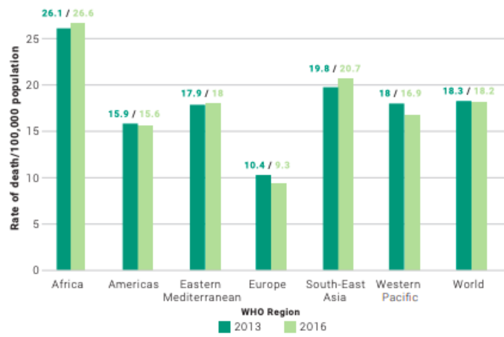
Positive Impacts of Automation

Many intellectuals, politicians and journalists are depicting doomsday scenarios for our automated future[6]. However, according to a significant number of scientists, and entrepreneurs, automation will lead us to bright new future[6]. American company "HelpSystems" states that, a recent study by a leading trade journal asked the question, "What do you see as the most important benefits of an automated or unattended computer center?"[1] and the primary results attributed into 5 categories, "Cost Reduction, productivity, availability, reliability and performance". These 5 attributes brought by our machine companions will drive us even further and allow more innovative technologies to emerge.

Self-Driving Cars

With these fundamental advancements, a new invention, Artificial Intelligence, has come to light. One of the recent, and still developing uses of A.I. is self-driving cars. Many big companies like Ford, Daimler, and Toyota, have taken actions in order to structure their own fully autonomous cars[2][8]. For instance, Ford has created a self driving division including ArgoAI [8]. Daimler, who was the early leader of self-driving technology, and is partnered with Bosch. Toyota, chose a different path and invested 500 billion USD to UBER. Valuations of these companies and their investments, have reached colossal numbers. Bloomberg reports that private investments in self-driving car companies in the second quarter of 2018 is more than the total private investment in this sector in the prior 4 years combined [2].

As the pursuit for a completely autonomous car is still in its infancy, there are some applications of the technology in the form of driver assistance. For example the new Drive Wise package from Kia, offers features such as lane keeping assist, auto cruise and collision prevention systems [7]. This package also costs an extra 2,000$ on top of the price. Additionally, some customers don't think it's worth the price. However, in the US alone 37,000 people die each year in car crashes, with nearly 10,000 of them being younger than age 20 [4]. Therefore, when considering damage done to people because of human errors(Figure 1), the new price tag appears to be worth it.



(Fig.1. Rate of road traffic death per 100,000 population per continent by WHO)

Procedure

How Do Self-Driving Cars Work?

At the moment almost every self-driving car company take a similar approach whilst manufacturing their products. Fundamentally, a fully autonomous car needs to be able to perform 3 tasks in order to replace and work as efficient as a human driver. These tasks are: to perceive, to think and to act, and they are made possible by a combination of high technology cameras, radars, computers and LIDAR sensors (Figure 2).

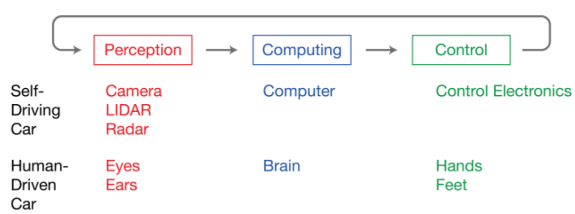


Fig.2. Like a human drivers, self-driving cars also executes a cycle consists of seeing, analyzing and acting accordingly to the situation. As seen in the figure high tech devices take over these tasks. [3]

First the environment has to be scanned by high end cameras or LIDAR technology. Then the real innovation comes in, "thinking" or computing step. By using neural networks and advanced image recognition algorithms, cars are able to warn drivers of hazards on the road or follow the lanes freely with minimal intervention by the driver.

Creating a prototype

The experiments ran at our school focused mostly on the lower end of the technology to assess how they could be used to achieve a higher safety standard, and how they may be limited in comparison to high end technology such as the LIDAR. Trying to find a way to use the cheaper solution to make the technology more accessible, and to reduce accidents. For this, the experiments tested

- Clear (control),
- Uneven,

- Curled terrain

conditions to see how well the camera method coped, and analyzed the problems to find a possible solution.

The test rig was a simple chassis with a camera in the front, located in the middle, along with necessary electronics and the VEX brain used to process the camera feed. It is important to note that the chassis used one motor for each wheel, acting like a 4x4 vehicle.

VEX Brain

The brain can contain up to 8 programs inside, simultaneously. Furthermore, the system is capable of troubleshooting and with its smart motor ports it can give important feedback such as the torque, velocity, revolutions and degrees of a motor, in-real time.

Vision Sensor

A vision sensor is a camera which is used to create input to microcontrollers and with appropriate coding it can be configured as an image processor, by interpreting and analyzing given data and considering its possible outcomes. Therefore this sensor was considered to be the most beneficial sensor whilst performing this experiment.

Fig.3. Identical VEX brain and vision sensor used in the experiment. [9]

Fig.4. The configuration of vision sensor and datas intake from the tape

Testing the prototype

Clear Terrain

The control setup used a simple set up of tape to simulate the lanes on a traditional highway road. The camera was used to follow the tape and keep the entire vehicle centered according to the data taken from the sensor. The experiment was repeated with different colors of tape to see if it would have an effect, but under constant light the findings did not vary.

```
if((centerXX - offsetX)<=  VisionSensor.largestObject.centerX &&
   VisionSensor.largestObject.centerX<=(centerXX + offsetX)){

    Brain.Screen.clearScreen(color::green);
    vex::task::sleep(50);
    RightMotor1.spin(directionType::fwd, 20, velocityUnits::pct);
    RightMotor2.spin(directionType::fwd, 20, velocityUnits::pct);
    LeftMotor1.spin(directionType::fwd, 20, velocityUnits::pct);
    LeftMotor2.spin(directionType::fwd, 20, velocityUnits::pct);
```

Fig.5. The code works by interpreting data from the sensor (the center X value of the largest identified object). If the taken data is in between pre-set constants (centerXX and offsetX which are specifically arranged for the robot to align with the tape) the brain gives motors a drive forward command at a %20 speed.

Uneven terrain

This experiment used small rocks and styrofoams sticked to the surface to create an uneven terrain and a shaky road to pose greater challenge for the robot. Particularly to simulate any cracks, or wear that may be found on the road. Also the experiment tested whether the camera would be able to keep the test rig centered while overcoming the uneven terrain. The same process with the different color codes were also repeated on this setup. Additionally, the identical sensor and code was used.

Curved terrain

This experiment structure used the identical tape utilized in the first controlled setup - Clear Terrain. For this case the tape was bent and tilted to form a curved pathway. Especially for replicating a curvy mountain road or a sharp turn. The aim of this experiment was to observe whether the robot was protecting its position at the center of the road or continuously hitting the wall. Furthermore, the same process with the different color codes, the identical sensor and code were also repeated on this setup. Fortunately, the experiment succeeded and as expected the robot kept its position at the center.

```
else{
    VisionSensor.takeSnapshot(SIG_WHITE);

    int measured = centerXX - VisionSensor.largestObject.centerX;

    int variable;
    Brain.Screen.clearScreen(color::purple);
    vex::task::sleep(50);

    if(measured > 0){
        variable = 1;
```

```
if(measured < 0){
    variable = -1;
}

RightMotor1.spin(directionType::fwd, yildiz*20, velocityUnits::pct);
RightMotor2.spin(directionType::fwd, yildiz*20, velocityUnits::pct);
LeftMotor1.spin(directionType::rev, yildiz*20, velocityUnits::pct);
LeftMotor2.spin(directionType::rev, yildiz*20, velocityUnits::pct);
vex::task::sleep(10);
VisionSensor.takeSnapshot(SIG_WHITE);
```

Figures.6.& 7. The code sımply identifies two variables called ‘measured’ and ‘variable’, then it gives the “measured” variable a value of the pre-set constant minus the analyzed data. According to the result of that operation “variable” gets assigned with either -1 or 1. Finally, as the speed is multiplied with “variable” the robot decides whether to turn right or left.

Analysis

As a result all the experiments considering different variables succeeded according to the pre-justified hypotheses on all setups. The uneven terrain gave similar results with the control terrain, showing that the camera is sufficient in balancing the vehicle in the event of uneven driving conditions. It should be noted here that the 4x4 drive style of the vehicle may have had some part in the similar results as it allows for greater mobility and control.

Conclusion

To conclude the represented experiment, several suggestions can be made in order to improve the research and its outcomes. A further research, can provide affordable models of self-driving cars therefore, they can be beneficial regarding expenses while testing out their responses to environmental difficulties. These improvements can be made by:

- Adding a system which can detect any obstacle around the environment or on the road
- Adding another camera to avoid any adhesion to lanes
- Adding a distance sensor to slow down and at some point stop the vehicle when it senses an obstacle nearby, to avoid any collision
- Storing the data of commonly traveled directions with using machine learning technology, therefore by analyzing driver habits the system will provide a true driving experience to the passenger.

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