Developing Autonomous Vehicle Systems Using Machine Learning Techniques and Comparison of SVC and Naive Bayes Algorithms

D.Vineela Chandra, J. K. R Sastry

Abstract: Autonomous vehicles are very famous now a days. To increase the comfort and to save time, Machine learning concepts are used to achieve autonomous driving. We initially train the vehicle manually through remote access using internet. During this training, we obtain data from sensors regarding object distance around the vehicle at every instance of time and current direction of the vehicle. Later we feed this data into machine learning algorithms and develop a classifier which predicts the directions for new sensor data using previous experience. In this paper, the effect of different algorithms on the vehicle and accuracy comparisons between those algorithms is presented.

Index Terms: Autonomous vehicles, Machine learning, Ultra sonar, Object distance

I. INTRODUCTION

Autonomous vehicle is a known concept today in the industry. Autonomous vehicles drive autonomously without any assistance from the driver. This technology saves a lot of time to the driver. An average human spend 1 year of their life span in driving. By saving this time a lot of productive work can be done. Autonomous vehicles are combination of field of study of navigation, data science, and embedded systems. Historically autonomous vehicles are derived from auto pilot implemented to flight technologies. The concept of autonomous vehicle is first presented by Google in Google I/O 2013, later which was developed into Google self-driving vehicle. Now-a-days companies like Tesla, Uber, and Volvo are investing millions of dollars in research and development of self-driving vehicles. Autonomous vehicles are classified into 6 levels based on Autonomous level by SAE International. One of which falls under the category of "No Automation" which means that the performance of the vehicle is fully dependent on human driver, even when the driver is assisted through warning or intervention systems, The next type is "Driver Alert Assisted" Vehicle systems that assist the driver through provision alerts that help the driver to drive the vehicle most appropriately. In the case of Partial Automation type, the driver is assisted with some of the semi- automated sub-systems that deal with steering, acceleration etc., in addition to the assistance provided by alerting systems.

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The "driving mode-specific execution" models are designed and built with assistance systems that help the driver to navigate the cars efficiently. The assistance system may be related to any of the sub-system of the vehicle.

The "Conditional Automation, High Automation and Full Automation" based systems are fully automated and no driver is involved in running such vehicles

Many companies built prototypes of their research and trained them around the globe. The training time and distance data achieved by some of the companies are shown in Table 1.

Table 1- Training and distance data – Training the Vehicles

Maker	2018	
	Distance between disengagements	Distance
Delphi Automotive Systems	14.9 miles (24.0 km)	2,658 miles (4,278 km)
Tesla	2.9 miles (4.7 km)	550 miles (890 km)
Ford	196.6 miles (316.4 km)	590 miles (950 km)
Nissan	263.3 miles (423.7 km)	6,056 miles (9,746 km)
Waymo	5,127.9 miles (8,252.6 km)	635,868 miles (1,023,330 km)
BMW	638 miles (1,027 km)	638 miles (1,027 km)
Mercedes Benz	2 miles (3.2 km)	673 miles (1,083 km)
General Motors	54.7 miles (88.0 km)	8,156 miles (13,126 km)
Bosch	0.68 miles (1.09 km)	983 Miles (1,582 km)

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Machine learning and Artificial Intelligence are sub branches of data sciences and analytics. Both ML and AI use statistics and probability theory to predict the output. Machine learning algorithms need huge amount of data to train. Based on the type of learning Machine learning is classified into 3 types. They are characterized by supervised learning, unsupervised learning and Reinforcement Learning

II. LITERATURE SURVEY

Vehicles today are becoming autonomous with the use of sensors.Bing shun lim *et al.*, [1] focused on the mostly used ultra sonic sensor for autonomous vehicles. They provided in-depth assessment of vulnerabilities of sensor to prevent from occurring of life threatening incidents.

Ayesha Iqbal *et al.*, [2] implemented a multi-functional autonomous car which has features that help following a track avoid obstacles, take turns, stop the car in traffic signals accordingly.

P.K.Sinha *et al., [3]* developed a methodology for particular application in the navigation of mobile robot in the unstructured environment keeping the design targets as scalability, sensitivity to moving objects and noise immunity.

Ms. C. Suganya *et al., [4]* proposed a method of using "c" programmed into MATLAB to brake automatically when the traffic light is red, to avoid obstacles etc.

D. D. Jadhav *et al., [5]* proposed a driverless vehicle that has onboard GSM and GPS with features like starting the vehicle only when authorized person send message on external SIM, Sending current location to predefined mobile number and obstacle detection using Ultra sonic, infrared sensors.

Geetinder kaur *et al., [6] explored* the impact of driving driverless vehicles with sensors. With the advancement in technologies, the burden on human is decreasing and burden on sensors is increasing. So the impact is studied here.

Gurjashan sing pannu *et al., [7]* have built a monocular vision autonomous car prototype using Raspberry pi as a processing chip. Here along with ultra-sonic sensor, HD camera is also used to get real time data. Many algorithms like lane detection, obstacle detection etc., are combined and designed.

Wenhao Zhang *et al.*, [8] proposed a practical framework of hardware and software with external configuration and internal mechanism of an autonomous vehicle. They have presented advantages and disadvantages of using 3 sensor platforms and they have presented software architecture showing the working of the system.

Although autonomous vehicles are providing safety, comfort the initial price of them would be too high. Neda Mosoud et al., [9] assessed the potential for circumventing this barrier by shared owner ship program in which households form clusters share the ownership and ridership so that utilization ratio of vehicles would be increased.

The alternative of ultra sonic sensor used in autonomous vehicles is LiDar.To overcome the issues with camera and ultra-sonic sensor Bijun Lee A et al., [10] proposed automatic parking based on self-driving car using HDL-32E LiDar.Here cloud data is processed and minimum size of parking space required is obtained from RRT algorithm. Fuzzy logic controller is used to brake and accelerate for speed control.

A number of machine learning approaches have been presented in the literature for making the vehicles to learn and use the learning for automating the Vehicles[11][12][13][14][15][16][17][18][19][20]. The issue of looking at the different characteristics of the vehicles systems and road built sensing and navigations systems have not been much addressed especially using support vector systems.

From the survey, we can see that research towards using machine learning techniques is very less. This concept if integrated with autonomous cars would be an added advantage by reducing the efforts. In this paper a classifier has been presented that can be used to predicts the direction of the vehicles using the for data acquired through newly built sensor and the data is processed through ML algorithms either for training the vehicles or predicting the movement of the vehicles.

III. PROPOSED MODEL

Many fields of expertise have to be used for building autonomous vehicle system that can be categorized into Data Science (Machine Learning. Artificial neural networks, Data visualization), Computations and Algorithms (python), Mechanical design (Rover bogie technology), Electronics and Electrical development (Sensors, Drivers, Actuators, Power supplies)

An algorithm has been developed that takes into account both training and prediction of vehicle movement. The flow chart that depicts the algorithm is shown in Figure 1.

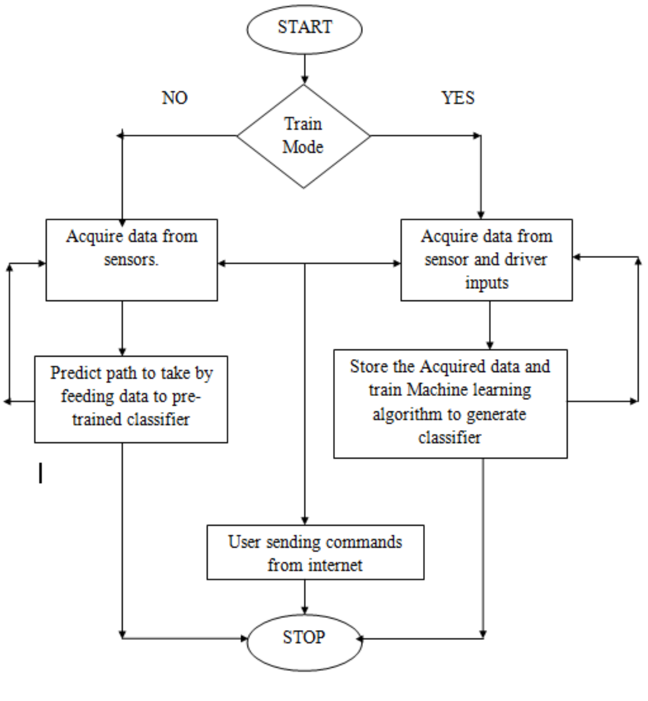

Figure 1: Training and predicting the vehicle movement.

3.1 Algorithm

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1. Begin all physical system and proceed to boot sequence.
2. Prompt for the user input to set the mode into
   a. Training
   b. Prediction
3. If the input is Training
   i. Get all sensors data with respective to driver inputs in the real time environment or get commands from remote control through internet.
   ii. Store the data for processing and develop a classifier by feeding data to machine learning algorithm.
4. If the input is prediction
   a. Get all sensors data from the physical system or get commands from remote control through internet.
   b. Feed that data to pre trained classifier and predict the direction or angle the physical system should follow.

In this prototype we are using two communication methods.

3.2 Communication between Raspberry pi and Remote Server:

This is based on Internet and IP. Both Raspberry pi and Remote server has IP address to communicate with one another. We use a wireless router from JIO network which was connected to the raspberry pi using Wi-Fi protocol. Every router has DHCP which allocates IP's to the connected devices in random order. So, to eliminate DHCP we need to configure a static IP address based on MAC (media access control). To access router from outside networks we also need to eliminate Network Address Translation (NAT). To eliminate NAT we need to write rules to forward incoming Packets to our static IP address on desired port.

3.3 Communication between Raspberry Pi and Arduino:

This Communication is based on Serial protocol which is famous inter device communication. In serial communication we have RX and TX pins of one device connected TX and RX pins of other device respectively. Both devices communicate with the basis of baud rate or bit rate.

3.4 Software Architecture

The software architecture of the classier and predictive system is shown in the Figure 2.0

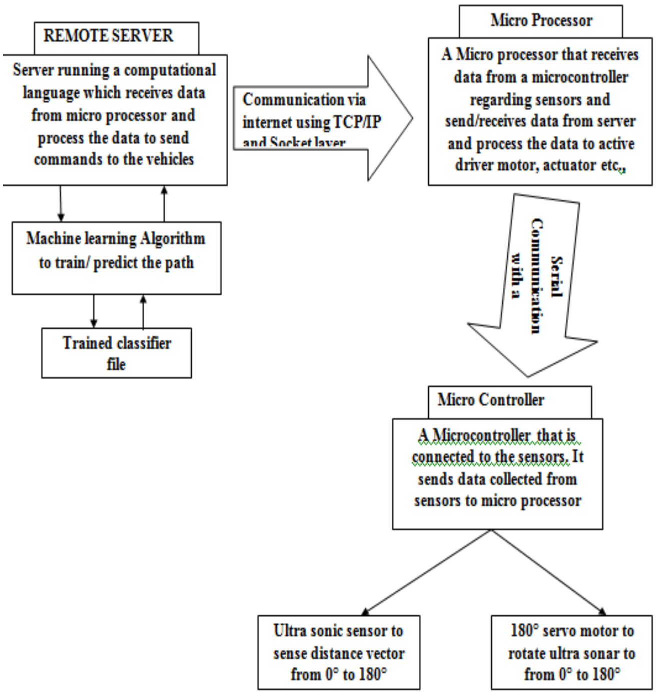

Figure 2: Software Architecture

3.5 File system and description

The details of Python files used in the development of the system are placed below**:**

ULV_pi.py

This file creates intercommunication between raspberry pi and cloud system. This file acts as server file where we connect our cloud system as client.

ULV_getdata.py

This file is used to get training data from the vehicle by using A, S, D, W keyboard keys of remote server.

ULV_train.py

This file is used to train and create the classifier on the data from the file rawdata.pkl you obtained from ULV_getdata.py

ULV_move.py

This file is used to run the vehicle autonomously by using the classifier generated from ULV_train.py

The linking of the python files is shown in the figure 3

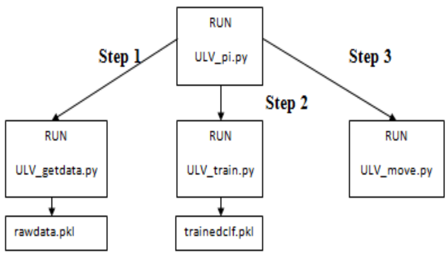

Figure 3: File execution sequence

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IV SYSTEM IMPLEMENTATION

We have discussed the process of acquiring data from the vehicle using ULV_getdata.py file. In this chapter we train the vehicle to take right turn whenever it comes up with an obstacle. Let's consider 4 decisions that machine learning algorithm have to take while driving the rover.

Decision 1: Forward
Decision 2: Reverse
Decision 3: Right
Decision 4: Left

So, the work of the algorithm is to classify the data into forward, reverse and right, left. So, we need to use any one of the classification algorithm in machine learning.

In a typical situation there can be 4 classes' 1,2,3,4 representing forward, reverse and right, left motions of the vehicle. The sensor data is the input to the algorithm and direction of the vehicle is required output. Since the vehicle is manually driven, while in training mode one can get current direction (forward, reverse, right, and left) of the vehicle corresponding to sensor data. Thus both input and output to the classification algorithm can be obtained which means that one can use "supervised learning "method for learning the system.

A classification algorithm that implements as supervised learning system needs to be used. The supervised learning systems requires Vehicle lookups, vehicle guidance based processed output or based on predictive outputs. In either vase input lookups are required. There are only two classification methods that meets these requirements that include Linear SVC (Support Vector Machine), Naive Bayes (Probability Theory). There is however a necessity to find the best.

The accuracy of prediction with each of these algorithms needs to be assessed. A comparison of training time and prediction time needs to be assessed considering both the algorithms. The prediction must be done in real time which should be very less and training time can be more as only training is done once. The algorithm that meets both the issues of prediction and training undertaken in less time is the most appropriate algorithm that can be chosen for implementation of Vehicle autonomous systems

Understanding data from sensor: -

The major data we are using is distance vectors. This is the data of Ultra sonar distance sensor at every 30° while rotating from 0° to 180°.

[0°, 30°, 60°, 90°, 120°, 150°, 180°, 180°, 150°, 120°, 90°, 60°, 30°, 0° , direction]

The above data is an array of distances at represented angles. At the end of every sample, the direction of the vehicle at that instance can be obtained. Since servo motor rotates form left to right and right to left, the angle of rotation form 0° to 180° (servo motor clock wise sweep) and 180° to 0° (servo motor anti-clock wise sweep) can be achieved.

Feature : [0°, 30°, 60°, 90°, 120°, 150°, 180°, 180°, 150°, 120°, 90°, 60°, 30°, 0°], Class: direction (1 or 2 or 3 or 4)

Data can be reduced through reducing dimensionality of the data. T-distributed stochastic neighbor embedded method has been used for reducing the size of the data. Figure 4 shows the how the size of the data can be reduced by using only two dimensions considering both clockwise and anti-clockwise rotation.

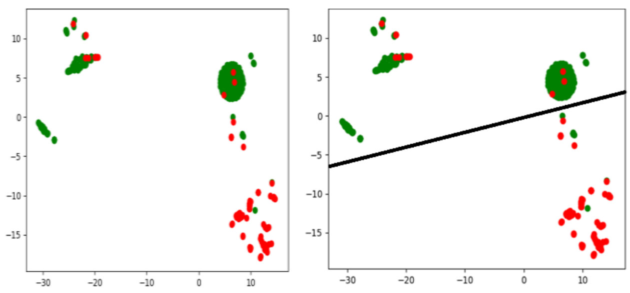

Figure 4: 2D reduction of data and analysis

The classification of 2D data shown in Figure 4 and 3D data is shown in Figure 5. All green points are class 1 (forward movement) points and all the red points are class 2 (Right turn). One can carefully observe the data so that the data can be split into two half based on data type with a line. By observing the data we can easily say that both classes are separable

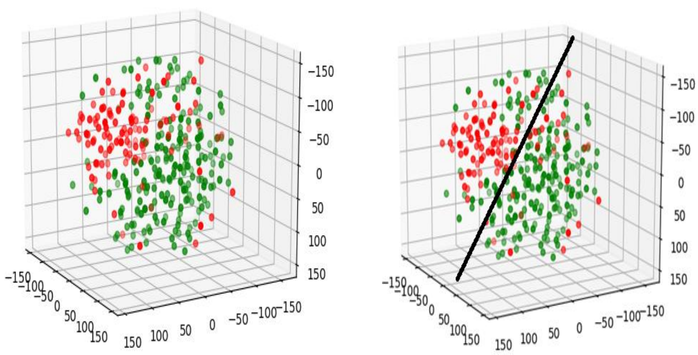

Figure 5: Classification of the rotational data

IV. RESULTS

After data visualization if the data is linearly separable and contains enough data points start training by feeding distance vectors and corresponding classes to the sklearn SVC or naive bayes by running ULV_train.py.

Both SVC and naive bayes have almost same training (fitting) time and predicting time. But we can't tell which one is better without discussing about accuracy of the prediction.

The accuracy increases with the increase in data. As we only have moderate dataset. The acceptable accuracy is about 80%. Every time we run the algorithm we randomly shuffle the input feature and classes. So, we get different accuracies each time we run. In this situation for better result we run the algorithm for n time and average the accuracies. We also consider highest accuracy in n times. Training and prediction with SVC is shown in Table 2

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Table 2 Training and Predicting through SVC

Sample number	Parameter value	Measurement
1	Length of training Set	294
	Length of testing set	15
	Average Accuracy	93.33
	Fitting Time	0.0539
	Predicting Time	0.01199
	Highest Accuracy	100.00
2	Length of training Set	263
	Length of testing set	46
	Average Accuracy	93.69
	Fitting Time	0.04020
	Predicting Time	0.034
	Highest Accuracy	97.82
3	Length of training Set	155
	Length of testing set	154
	Average Accuracy	90.714
	Fitting Time	0.0199
	Predicting Time	0.1029
	Highest Accuracy	94.15

Training and prediction with Naïve Bayes is shown in Table 3

Table 3 Training and Predicting through Naïve Byes

Sample number	Parameter value	Measurement
1	Length of training Set	294
	Length of testing set	15
	Average Accuracy	95.33
	Fitting Time	0.0099
	Predicting Time	0.0150
	Highest Accuracy	100.00
2	Length of training Set	263
	Length of testing set	46
	Average Accuracy	94.78
	Fitting Time	0.0099
	Predicting Time	0.0479
	Highest Accuracy	100.00
3	Length of training Set	155
	Length of testing set	154
	Average Accuracy	93.63
	Fitting Time	0.0069
	Predicting Time	0.1500
	Highest Accuracy	95.4545

V. CONCLUSIONS

Machine learning algorithms can be effectively employed for modelling and developing autonomous vehicle systems. SVC and Naïve Bayes algorithms have been found to be quite suitable for modelling autonomous vehicle systems. Naïve byes algorithm has been proved to be the nest choice due to increased accuracy, less prediction time and training time.

The processing power required for powering the microprocessor or on board to be accomplished by the model can be quite reduced by using a remote server.

Dimensionality based reduction reduces the quantum of 2D and 3D data to be processed to the large extent.

The proposed method yields an accuracy of nearly 93.30 % when compared 80.00% accuracy that can be achieved by any of the machine Learning based algorithms that exists in the literature,

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