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Implementation of Autonomous Vehicles based on Vision, Localization, and Control Approaches.

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ABSTRACT: Over decades technology keeps evolving and one of the highly emerging applications in Automobile Industry is Autonomous Vehicles. The Demand for Electrical vehicles has been increasing from several years and use of Autonomous capabilities to build smart vehicles came into popularity. This paper discusses about Vision, Deep Learning, Sensor Fusion, Localization, and control of Autonomous vehicles, trying different filters and controller during implementation, testing navigation, working under several conditions, and simulating them using Robot Operating System(ROS).

Key Words: Robots, Mobile Robots, Computer Vision, Deep Learning, Sensor Fusion, Path Planning, Navigation, Motion Planning, Control.

1. INTRODUCTION

Autonomous Vehicles have the potential to improve transportation facilities and mobility and by providing safe and convenient mode to travel. The demand for Electric vehicles has been increasing to promote and reduce pollution. Many Universities and technological firms started showing interest in funding to test autonomous capabilities of Autonomous vehicles during emerging sales of Electric vehicles in market. These Self Driving cars usually work under a combination of multiple sensors like LIDAR, RADAR, SONAR, ODOMETRY and GPS. Several features in this Automated Driving System include speed control, Lane Detection, Obstacle Avoidance, Emergency Braking System require human control to operate even under these smart abilities of the vehicles. The implementation of Advanced control system integrated with multiple sensors feed the surrounding data to the system and control the movement of the vehicles autonomously. Research on autonomous vehicles involves in several problems based on Computer Vision, Deep learning, Sensor Fusion, Path Planning, Localization, mapping, and Control. This paper discusses the implementation of Self Driving Car Features and Capabilities tested in simulated world using ROS.

2. LITERATURE SURVEY

Autonomous vehicles are competent enough to learning from the surrounding data and process information to computational system without human involvement also known as Autopilot Technology to guide through the route. This usually involves vision, localization, control, planning approaches to test the functionalities of this Autonomous vehicles.[4]

Development of these vehicles can be classified into several categories:

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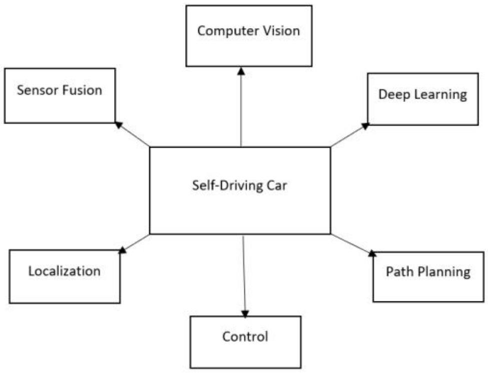

Figure 1 Block Diagram of Self Driving Car

❖ Computer Vision

Computer Vision is field of Computer Science involves in Machine learning techniques that provides the systems the ability to sense data from images, videos, or visual information to take necessary actions and send responses of data to compute the process.[1]

Computer vision involves usually in vital technologies named as Deep learning and Convolutional neural network(CNN). Several applications include:

1. Image Classification
2. Object Detection
3. Object tracking
4. Image retrieval based on content

Usually, Computer Vision involves in methods like acquiring the data , processing the date from the image, and analyzing to train the model to produce accurate required information to find a solution.[2]

❖ Deep Leaning

Deep learning is a type of technology involves in study of Machine learning and Artificial Intelligence that imitates the learning process of humans to gain knowledge and train the model. This is an important aspect of Data Science field of study and inspired by working and replicating function of brain called as Artificial Neural Networks(ANN).[5]

Recent developments and advancements in the field of AI are due to data science. During this implementation Deep learning is used to train Behavior cloning of real cars from the real time data acquired from cars.

❖ Sensor Fusion

Sensor Fusion is the capability of the computational system to bring input data from multiple sensors like LIDAR,RADAR and camera to a single module acquired from surrounding of vehicle. This results in producing accurate data to help in continuation of the vehicle mobility This can be classified into two categories:

1. Direct Fusion
2. Indirect Fusion

In Direct Fusion, data is obtained from homogeneous and heterogeneous sensors and is based on historical values of the sensors indicative of the surrounding. While Indirect fusion is independent of previous data.

❖ Localization

Localization is a process of obtaining the exact location of the robot with correspondence to its surroundings. It is a fundamental concept of a n autonomous s robot to know its location to be able navigate through the location coordinates produced during mapping of the surrounding data variables produced from sensors during sensor fusion in this model. In this model we use particle filter localization which is effective in providing a guess of the location of the robot and represented as position and orientation.[6]

❖ Control

Control of the vehicle is based on data retrieved from Localization which presents position of the environment and Planning system to make responses and create path during navigation. Control is based on acceleration and angle of steering to form trajectory and contains a sequence of checkpoints containing variable like position, angle, and yaw.[7]

The algorithm can be called as controller, and this usually initiates instructions for the vehicles to accelerate and steer along the path created. The controller used in this model is PID(Proportional Integral Derivative).

❖ Path Planning

Path Planning is the main computation module of the autonomous vehicles used to replicate human thinking and decision process accumulated from Deep Learning techniques and processing them using data provided by sensors during sensor fusion techniques.[3]

Path Planning usually involves creating a geographical path estimated from data to assist in navigation from initial point to endpoint. Path Planning consists of maneuvering and trajectory variables used to process in this module.

3. IMPLEMENTATION

ROS nodes are declared to initialize the implementation process of testing self-driving car capabilities. These Nodes include Traffic light detection and Classification, Obstacle avoidance, Waypoint detection, Acceleration and Maneuvering Control.

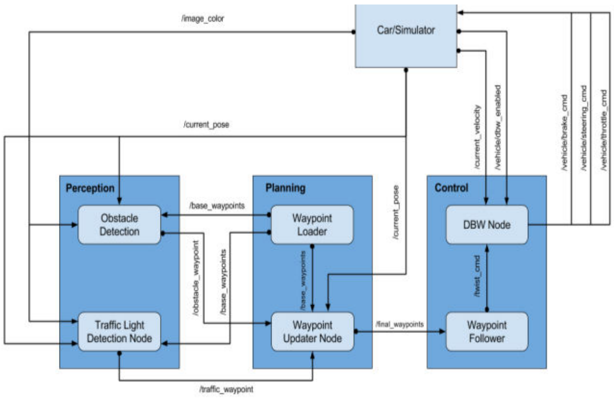

Figure 2 ROS Nodes

The Implementation is done in a three-step process in a simulated workspace designed for self-driving cars environment.

A. Perception

During this process the use of sensor fusion methods are implemented to acquired perceptual data from the surroundings using LIDAR and Camera Sensor and later these meaningful data with accurate variables is processed to Machine learning and Deep Learning processing module system to detect and classify the state of Traffic light signals. LIDAR is used for obstacle detection and avoidance, whereas the Camera module sends the light and Sign Images to process unit which helps in acceleration and deceleration.[8]

B. Planner

Waypoints are coordinates used to process in the planner module to a form of high-definition map. They are pre-loaded and are in the form of continuous points.[13] The planner unit uses the perception data to initialize the acceleration needed to maintain target velocity starting from initial to endpoint. Later during progress of vehicle there is a need of updating target velocity from the feedback keeps receiving from perception unit system. This Planner unit is responsible for all mobility actions of vehicle to complete the projected trajectory till the end waypoint.

C. Control

In this unit, the data received from the planner module is used for controlling the speed required and direction to travel of the vehicle. Control unit in this node is responsible for brake, throttle and Steering of the vehicle.[10] The Proportional Integral Derivative Controller is accustomed to prevent from causing any deviation until it reaches the end point. If there are any discrepancies in current and target velocities of the vehicle they are monitored, and correction is done to maintain accuracy.

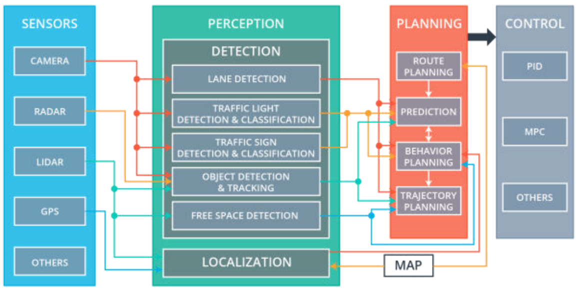

Figure 3 Execution Flow

4. RESULTS

An Autonomous vehicle has the capability to observe, authorize and respond accordingly to the surroundings. The first step of AV is detecting lanes on the road to let the vehicle follow rules of road transportation.

Figure 4 Lane Detection

The next application involves in extending the process to Advanced Lane finding which increases the precision of vehicle driving path. Use of Color Transforms and gradient to find the curvature of the lane.

Figure 5 Advance Lane Detection

The next step involves in Traffic Sign Detection and Classification. OPENCV is used to implement this application of autonomous vehicle. For training a data set is required.

Figure 6 Traffic Sign Dataset

Sensor fusion is used to collect data from LIDAR as it provides higher spatial resolution than RADAR.[11] Extended Kalman filter algorithm is used because updating of extended Kalman filter is not applicable to no-linear distribution along with RADAR data.

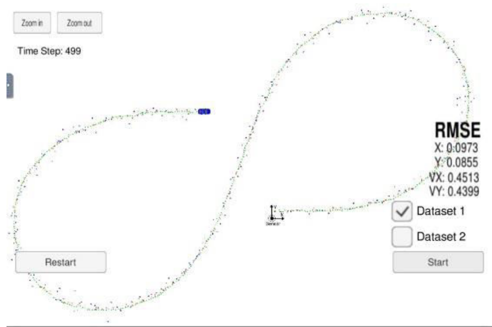

Figure 7 LIDAR Mapping

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Next the simulated vehicle in the ROS workspace is used for training the driving behavior to vehicle using direction keys. Behavior cloning is used to imitate human vehicle driving making it more accurate for training the model.

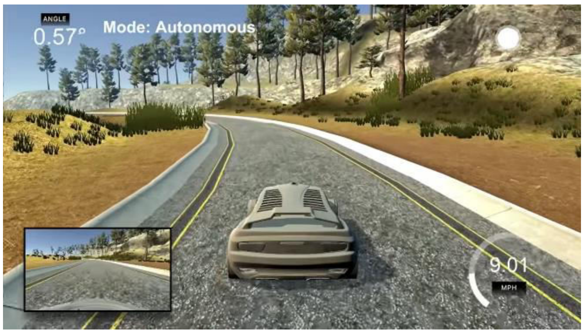

Figure 8 Behaviour Cloning

This is implemented using KERAS and camera on the bumper of simulated car during training.

Localization is the next process involved in autonomous vehicles. The data acquired from sensor fusion contains variables of waypoints to and coordinates of map to create trajectory involving in path planning sequence.[14]

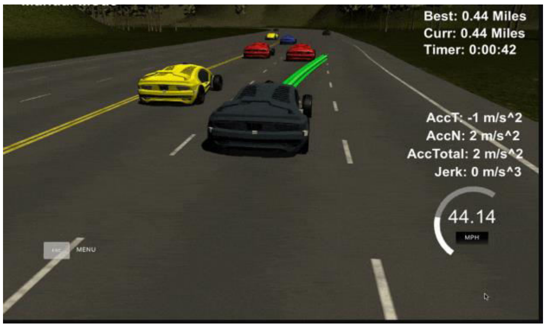

Figure 9 Autonomous Driving

5. CONCLUSION

To Summarize, this research work is a cumulative study of applications and challenges involved in implementation and working of autonomous vehicle. This mainly summarizes and explains how a self-driving vehicle acquires, assess, and produces required decision for the movement and takes precautionary steps to avoid collisions. Use of LIDAR increased the accuracy of obstacle detection which is the crucial part of this process. The Future enhancements includes implementation of these algorithms and model in real time using a real car to test more functionalities like Automatic parking, pick up after parking, sudden braking system, automatic speed maintaining according to lane shifting and advancements in sensors to provide accurate data which helps the car to work adaptively.

REFERENCES

[1] A. Dixit, R. Kumar Chidambaram, and Z. Allam, "Safety and Risk Analysis of Autonomous Vehicles Using Computer Vision and Neural Networks", *Vehicles*, vol. 3, no. 3, pp. 595-617, 2021. Available: 10.3390/vehicles3030036.

[2] Z. Jia, A. Balasuriya and S. Challa, "Vision based data fusion for autonomous vehicles target tracking using interacting multiple dynamic models", *Computer Vision and Image Understanding*, vol. 109, no. 1, pp. 1-21, 2008. Available: 10.1016/j.cviu.2006.12.001.

[3] T. Teja, "Autonomous robot motion path planning using shortest path planning algorithms", *IOSR Journal of Engineering*, vol. 3, no. 01, pp. 65-69, 2013. Available: 10.9790/3021-03116569.

[4]"Self-Driving Car Engineer", *Udacity.com*, 2021. [Online]. Available: https://www.udacity.com/course/self-driving-car-engineer-nanodegree--nd0013. [Accessed: 10- Nov- 2021].

[5] K. Sonwane, "Simulating Self Driving Car Using Deep Learning", *International Journal for Research in Applied Science and Engineering Technology*, vol. 9, no., pp. 738-743, 2021.

Available: 10.22214/ijraset.2021.36454.

[6] Y. YI and D. LIU, "Robot Simultaneous Localization and Mapping Based on Path Planning in Dynamic Environments", *ROBOT*, vol. 32, no. 1, pp. 83-90, 2010. Available: 10.3724/sp.j.1218.2010.00083.

[7] "Mobile Robot Simulation and Navigation in ROS and Gazebo", *International Journal of Mathematics and Computers in Simulation*, vol. 14, 2020. Available: 10.46300/9102.2020.14.6.

[8] C. Liu, C. Zhou, W. Cao, F. Li and P. Jia, "A Novel Design and Implementation of Autonomous Robotic Car Based on ROS in Indoor Scenario", *Robotics*, vol. 9, no. 1, p. 19, 2020. Available: 10.3390/robotics9010019.

[9] "Robot Vision Image Processing and Path Planning", *International Journal of Recent Trends in Engineering and Research*, vol. 4, no. 10, pp. 55-58, 2018. Available: 10.23883/ijrter.2018.4401.v8isv.

[10] G. Khekare and S. Sheikh, "Autonomous Navigation Using Deep Reinforcement Learning in ROS", *International Journal of Artificial Intelligence and Machine Learning*, vol. 11, no. 2, pp. 63-70, 2021. Available: 10.4018/ijaiml.20210701.oa4.

[11] Y. CHEN, X. ZHAO and J. HAN, "Review of 3D Path Planning Methods for Mobile Robot", *ROBOT*, vol. 32, no. 4, pp. 568-576, 2010. Available: 10.3724/sp.j.1218.2010.00568.

[12] S. Pramod Thale, M. Mangesh Prabhu, P. Vinod Thakur and P. Kadam, "ROS based SLAM implementation for Autonomous navigation using Turtlebot", *ITM Web of Conferences*, vol. 32, p. 01011, 2020. Available: 10.1051/itmconf/20203201011.

[13] A. Housein and G. Xingyu, "Simultaneous Localization and Mapping using differential drive mobile robot under ROS", *Journal of Physics: Conference Series*, vol. 1820, no. 1, p. 012015, 2021. Available: 10.1088/1742-6596/1820/1/012015.

[14] G. Khekare and S. Sheikh, "Autonomous Navigation Using Deep Reinforcement Learning in ROS", *International Journal of Artificial Intelligence and Machine Learning*, vol. 11, no. 2, pp. 63-70, 2021. Available: 10.4018/ijaiml.20210701.oa4.

[15] A. Ganiev and K. Hee Lee, "A Study of Autonomous Navigation of a Robot Model based on SLAM, ROS, and Kinect", *International Journal of Engineering & Technology*, vol. 7, no. 333, p. 28, 2018. Available: 10.14419/ijet.v7i3.33.18517.