Report On

Autopilot (Self-Driving Car)

Submitted in partial fulfilment of the requirements of the Mini project in Semester V of Third Year Computer Science and Engineering(Data Science)

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CERTIFICATE

This is to certify that the Mini Project entitled **“Autopilot (Self-Driving Car)”** is a bonafide work of **Harshkumar Devmurari (09), Gautham Kuckian (28), Prajjwal Vishwakarma (63)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of **“Bachelor of Engineering”** in Semester V of Third Year **“Computer Science and Engineering[Data Science]” .**

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Mini Project Approval

This Mini Project entitled "Autopilot(Self-Driving Car)**"** by **Harshkumar Devmurari (09), Gautham Kuckian (28), Prajjwal Vishwakarma (63),** is approved for the degree of **Bachelor of Engineering in** Semester V of Third Year **Computer Science and Engineering[Data Science] .**

Examiners

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Place

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Abstract

Autopilot system is designed with motive of fully self driving system. The autopilot system takes the video as input. It can be directly taken from webcam or a saved video of dashcam from internet. That video is then processed frame by frame. Each frame produces the result of both object detection and predicts drivable area on the lane. First the frame is passed on to yolov7 state-of-the-art rapid object detector released just a few months ago. The machine learning model is trained and validated from coco dataset. It is capable of identifying 80 different types of objects including car, trucks, motorcycles, pedestrians, animals, etc.
Each obstacle is identified and detected by making bounding box around them. These boxes also provide with probability of object which determines accuracy of the detector with minimum prediction of 75%. Lane line detection has many steps in pre-processing of image. Pre-processing includes converting to hls, Greyscale, thresh, canny edge detection and Gaussian blur. It is then transformed to bird-eye-view using perspective transform for prediction. These result are then passed on to inverse perspective transform and polygon is created for drivable space. Lane line is highlighted with a green colour polygon giving the sense of environment by producing the drivable area of lane. This plays critical role in decision making process for self driving without human intervention.

Acknowledgment:

At first, we would like to express our indebtedness to our mentor Prof. Krunali Vartak whose guidance helped us into making this project a success. We wish to express our sincere gratitude to, our Principal Dr. H.V. Vankudre who provided us all with necessary facilities. We take this opportunity to express our thanks to Dr. Vikas Gupta, Co-ordinator of the department of Computer Science Engineering (DS) for his valuable guidance and support to shape this program in a systematic way. We are extremely thankful for our respected lecturers for their keen interest and valuable suggestions in this program. In addition to this we would like to thank all the staff members of our Department for their suggestions and constructive critics. We also thank Prof. Maya Varghese who provided insight and expertise that greatly assisted the research. And finally we use this opportunity to express our sincere gratitude towards our parents and all our friends for their support and guidance.

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1. Introduction

1.1 Introduction

The fundamental idea behind the project is to develop an automated car that can sense its environment and move around it without human interventions. This project proposes driving automation, which will be accomplished by recognizing the roads, lane lines, and obstacles responding and making decisions. The biggest benefit of using a self-driving car is significantly fewer traffic accidents. Self-driving car process inputs and thinks of the optimal instructions that could be sent to actuators that control acceleration, braking, and steering.

1.2 Problem Statement & Objectives

Drivers have negative effects on their health due to long driving hours and harsh environments. They have to be focused every second when they are driving. In long term they lose clear vision followed by many mental health issues. Sometimes they become so tired and ignorant they lose consciousness and fall asleep. Due to this there are large number of vehicle accidents happening around the world. Also driver assistant systems which exist today are based on camera and sensors. Ultrasonic sensors and lidars are not that reliable as they are efficient on up to few meters and are costly for mass production so aren't feasible. This architecture developed is purely based on single monochromatic camera.

1.3 Scope

Scope of self-driving vehicles is increasing exponentially. The famous manufacturing companies like Tesla and TATA are also encouraging such technologies, even google is also leaned towards self-driving approach with its company named Waymo .All car manufacturing companies are now bending towards a self-driving approach. Many service-providing companies are also adapting and considering these systems for navigation also these technologies will help protect drivers and passengers from accidents.

2. Literature Survey

[1] Local Path Planning for Autonomous Vehicles Based on the Natural Behavior of the Biological Action-Perception Motion: Local path planning is a key task for the motion planners of autonomous vehicles since it commands the vehicle across its environment while avoiding any obstacles. To perform this task, the local path planner generates a trajectory and a velocity profile, which are then sent to the vehicle's actuators

Advantages:

Local path planning algorithm is implemented like behavior of living beings based on Attractor Dynamic Approach (ADA)

Disadvantages:

Doesn't change its path unless it senses some factor of risk in that path makes it less

[2] Path Planning for Autonomous Vehicles with Dynamic Lane Mapping and Obstacle Avoidance: Path planning is at the core of autonomous driving capabilities, and obstacle avoidance is a fundamental part of autonomous vehicles as it has a great effect on passenger safety. One of the challenges of path planning is building an accurate map that responds to changes in the drivable area.

Advantages:

Lane mapping is dynamic and can effectively avoid obstacles

Disadvantages:

Uses Lidar for its localization module which is less reliable and costly

[3] A review of research on object detection based on deep learning: In this paper, the representative algorithms of each stage are introduced in detail. Then the public and special datasets commonly used in target detection are introduced, and various representative algorithms are analyzed and compared in this field

Advantages:

Analyzed both single-stage detection algorithm and two-stage detection algorithm efficiently

Disadvantages:

Deep learning techniques have high dependency on dataset used and identification of small objects is not effective.

[4] Object detection in real time based on improved single shot multi-box detector algorithm:

This is about object detection techniques to detect objects in real time on any device running the proposed model in any environment. The accuracy in detecting the objects is checked by different parameters such as loss function, frames per second (FPS), mean average precision (mAP), and aspect ratio.

Advantages:

Uses multilayer convolutional neural networks which consists of multilayers to classify the given objects proved SSD algorithm with high accuracy

It enables to produce real-time object detection by using optimal values of aspect ratio.

Disadvantages:

Tried to improved less accuracy in detection of smaller object

[5] Microsoft COCO: Common Objects in Context: It introduce a new large-scale dataset that addresses three core research problems in scene understanding: detecting non-iconic views (or non-canonical perspectives [12]) of objects, contextual reasoning between objects and the precise 2D localization of objects

Advantages:

Free and open source dataset of around 328k images with instance segmentation

Disadvantages:

Traffic signs and road obstacles are not covered fully**.**

[6] Research on Detection Algorithm of Roadway Line on Structured Road Based on Vision:

In this paper it provide road lines and navigation signals for vehicles and finds the feature area by preprocessing the image, and then detects the lane line by Hough transform. The algorithm has high performance in highway environment

Advantages:

Improved version of Hough transformation is proposed and used which gives better results

Disadvantages:

Greyscale images are used so data quality is reduced and effect of lane line detection at road bends is not perfect.

[7] Recent progress in road and lane detection: a survey: In this paper the approaches and the algorithmic techniques devised for the various modalities over the last 5 years. It present a generic break down of the problem into its functional building blocks and elaborate the wide range of proposed methods within the scheme.

Advantages:

It improves the efficiency and driving safety of automatic driving

Disadvantages:

It is less accurate in lane and road appearance diversity, image clarity issues and poor visibility conditions.

[8] Real-Time Object Detection with Yolo: In this paper the task is to detect multiple objects from an image. The most common object to detect in this application is the car, motorcycle, and pedestrian. For locating the objects in the image they use Object Localization and have to locate more than one object in real-time systems.

Advantages:

Faster than traditional convolutional networks and faster-RCNN and comparatively good efficiency.

Disadvantages:

As based on anchor boxes so it can only detect few objects in perticular area so has a problem in detecting smaller groups of objects.

[9] Feature Pyramid Networks for Object Detection: Feature pyramids are a basic component in recognition systems for detecting objects at different scales. In this paper, they exploit the inherent multi-scale, pyramidal hierarchy of deep convolutional networks to construct feature pyramids with marginal extra cost.

Advantages:

This technique gives state of the art single models if ran in a faster-RCNN and is simple framework that can for feature pyramid networks (FPNs) inside convents.

Disadvantages:

This technique is avoided in deep learning object detectors because feature pyramid networks (FPNs) are memory and compute intensive

[10] Autonomous Vehicles: Levels, Technologies, Impacts and Concerns: In image sensing, a number of cameras are placed in the vehicle to generate images of the surrounding. Traffic lights and signs are easily interpreted. Image sensors are hard to use in fog, rain or night.

Advantages:

It is able to recognize animals and avoid it by steering away from it or stopping, depending on the conditions

Disadvantages:

There is a confusion in transmitting and receiving signals in case of radar and lidar.

Sensing around corners is very difficult and inability to track incoming traffic around the corner can be catastrophic.

3. Proposed System

3.1 Introduction

The autopilot system takes as input the video frame by frame. Each frame produces the result of both object detection and predicts drivable area in the lane. Each obstacle is identified and detected by making bounding box around them. These boxes also come up with probability of object which determines accuracy of the detector. Lane line is highlighted with a green colour giving the sense of environment.

3.2 Block Diagram

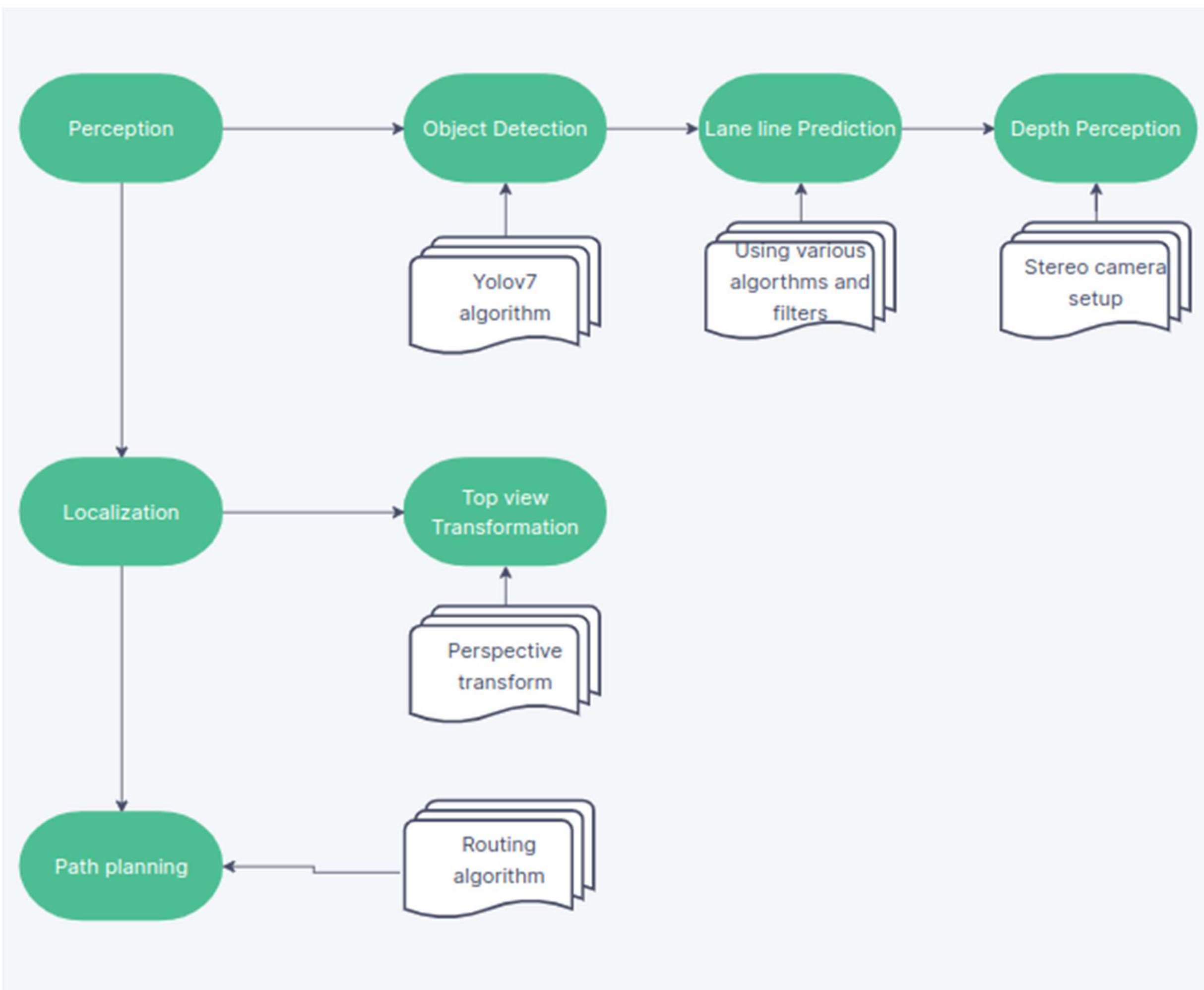

Fig 3.2.2 Autopilot Architecture

As mentioned in above figure 3.2.2, autopilot system has 3 phases. Initial stage of project performs rapid object detection and has a robust system of identifying up to 80 different types of normal everyday objects that include cars, trucks, motorbikes, and other similar obstacles. The detected frame is then acted upon through perspective transform to a birds-eye-view and passed on to filters greyscale, threshed, blurred, and canny edge detection algorithm in order to extract lane line markings in the selected area. This is then plotted back to the front-view frame using inverse perspective transform.

3.3 Process Design

Step 1) Raw video is collected from webcam and sent to backend.

Step 2) Resizing of video frames using opencv.

Step 3) Frames are send to yolov7 for object detection giving bounding boxes with probabilities using iou@0.75 that is accepted if iou is greater than 75%, then performing non max suppression to remove redundant bounding boxes.

Step 4) Collected frames are acted upon perspective transformation to get bird-eye-view.

Step 6) Bird-eye-view images are acted upon preprocessing techniques namely hls, greyscale, threshing, blur and canny edge detection.

Step 7) Lane line is predicted in bird-eye-view using general search.

Step 8) Bird eye view is then converted back to front view using inverse perspective transformation.

3.4 Details of Hardware & Software

1. **Hardware**: Processor: Any processor with good refresh rate
   RAM: 4Gb or above
   Camera device
   Input Device: Standard Keyboard, Mouse, and webcam
   Output Device: High-Resolution Monitor

2. **Software**: Droidcam Software
   Operating System: Windows XP or above
   Backend: Python 3.9, Yolo, PyTorch
   IDE: Visual Studio Code

3.5 Experiment and Results for Validation and Verification

- The below figure 4.1.1 shows the output of lane detection done using OpenCV

Fig 4.1.1 Isolated lane line detection

- The below figure 4.1.2 shows the object detection using YOLOv7 and also it shows the type of vehicle it detect.

Fig 4.1.2 Isolated Object Detection

➤ The below figure 4.1.3 shows the object detection of lane line marking.

Fig 4.1.3 Testing Feed from Real-time Camera

3.6 Analysis:

This project can be analysed by two modules, object detection and lane line prediction. Object detection gives us bounding box around obstacles that could be on roads like person, other vehicles like cars, trucks, motorcycles with percentage of accuracy meanwhile lane predict works by applying different filters like blurs and edge detectors and predicts the drivable area of lane.

3.7 Conclusion and Future work :

Conclusion:

The images used in the test were taken from straight roads, curves, and freeways under different road conditions. The system can adapt to a variety of luminous and weather conditions with good robustness and effectiveness but with small changes as it has to be configured with a camera angle for localization. Some typical scenes are selected from the video as samples to test the accuracy and robustness of autopilot. The model performs quite well in object detection but has to be improved in lane line marking to a few extent.

Future Work:

This model unlike now will also be able to perceive depth in the future using a depth perception mechanism. Depth perception can be implemented which can perceive depth via stereo camera setup helps in corner case scenarios. Effective routing algorithms like A* can be implemented and the decision-making process can be further done using a path planning module. Depth perception mechanism can fill up the current need for ultrasonic sensors and lidars securing the safety of the overall system. Control could be then sent to hardware components like a stepper motor for the steering wheel and a linear actuator for brakes.

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