CONTROL AND MONITORING OF AUTONOMOUS VEHICLE BY USING IMAGE PROCESSING

B.S. ELECTRONIC ENGINEERING, BATCH 2020

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for the degree

of Bachelor of Science

in Electronic Engineering

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RUBRICS FOR FYDP REPORT ASSESSMENT

Criteria No.	Criteria PLO (Percentage)	Excellent	Good	Fair	Poor
1	**Writing Mechanics PLO-10 Communication (10%)**	The report covers all required project details / chapters and maintain reader's interest with a logical coherent flow. The structure is clear and concise.	The report covers all required project details / chapters. The structure is clear and concise.	The report shows some gaps in coverage of required project details / chapters. The structure contains repetitions and redundancies.	The report shows insufficient content to show that required project details / chapters are met. Plain listing of information without regards to structure and/or flow.
2	**Literature Review and Problem statement PLO-2 Problem Statement (10%)**	Literature is well-written and structured as per standards and covered all relevant material to the project. Problem statement is stated and covered sufficient justification. New reader can clearly understand its value and context. References are cited properly using a standard format	Literature is well-written but not properly structured as per standards and covered most of the material relevant to the project. Problem statement is stated and covered necessary justification with reference. References are cited using a standard format	Literature is not properly written and structured as per standards, but covered most of the material relevant to the project. Problem statement is stated but lacks necessary justification. References are cited using a standard format	Literature is poorly written, poorly structured and does not cover the relevant material to the project. Problem statement is vaguely stated without any justification. References are cited using a standard format.

3	**Methodology PLO-3 Design/ Development of Solutions (10%)**	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are well-described with sufficient details and supporting diagrams.	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are well-described. However further explanation is required.	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are described but not in a convincing manner.	Some aspects of the solution are described briefly but much of the description is left out.
4	**Implementation and Testing PLO-5 Modern Tool Usage (20%)**	Both implementation and testing of a system, are precisely performed with accuracy and provide all necessary details for the reader.	Both implementation and testing of a system, are performed with the necessary details for the reader.	Implementation of a system are performed with the necessary details for the reader. But testing of a system is not properly performed.	Both implementation and testing of a system, are not properly performed with lack of details.
5	**Results & Conclusions PLO-4 Investigation (10%)**	Report includes all key results of the project. Appropriate graphs, figures and tables are included for effective interpretation and explanation of the results. All important aspects of the project are well-summarized with the sense of closure and demonstrates the major outcome(s) of the project.	Report includes most of the key results of the project. Graphs, figures and tables are included for effective interpretation and explanation of the results. Most of the important aspects of the project are well-summarized with the sense of closure and demonstrates the outcome(s) of the project.	Includes few key results of the project. Graphs, figures and tables are included with limited interpretation and explanation of the results. Few aspects of the project are summarized with the sense of closure and demonstrates the outcome(s) of the project.	Key results of the project are missing. Graphs, figures and tables are not included. Important aspects of the project are not clearly summarized with.

6	**Formatting Style and Similarity Index PLO- 8 Ethics (20%)**	Formatting style of chapters, table of contents, title page, references and appendices are proper and relevant with an acceptable similarity index.	Formatting style of chapters, table of contents, title page, references and appendices are proper with only minor impact on flow of reading with acceptable similarity index	Formatting style is proper but figures and tables don't follow standard practice (caption figure number etc.) with high but acceptable similarity index	The formatting of the chapters may need improvement with very high similarity index.
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FINAL YEAR DESIGN PROJECT MAPPING WITH SDG

Group No.	**Title of Project**	**SDGs Mapping**
07	CONTROL AND MONITORING OF AUTONOMOUS VEHICLE BY USING IMAGE PROCESSING	1) Industry, Innovation & Infrastructure. 2) Life on Land

DECLARATION

I hereby declare that this project report entitled "**CONTROL AND MONITORING OF AUTONOMOUS VEHICLE BY USING IMAGE PROCESSING**" is an original work carried out by Muhammad Farooq, Mohammad Mubeen, Muhammad Wasif Khan and Syed Zohaib Ali in partial fulfillment for the award of degree of Bachelor of Science in Electronic Engineering of Electronic Engineering Department, Sir Syed University of Engineering and Technology, Karachi, Pakistan during the year 2020 to 2024. The Project report has been approved as it satisfies the academic requirements in respect of project work prescribed for Bachelor of Science in Electronic Engineering.

I also declare that it has not been previously and concurrently submitted for any other degree or other institutions.

Internal Advisor: Prof Dr. Lubna Farhi

Date: 10-12-2023

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ABSTRACT

Autonomous vehicles are becoming increasingly common, and the demand for safe and reliable control and monitoring systems is growing. Image processing is a powerful tool that can be used to improve the safety and performance of autonomous vehicles. The purpose of this project is to implement sophisticated computer vision algorithms for real-time processing of camera data in autonomous vehicles, aiming to reduce computation time by leveraging hardware acceleration and efficient algorithms while ensuring accurate perception, edge detection for collision and decision making in real-time.

To achieve the goal, system will use a variety of image processing techniques, including sift algorithm for object and vehicle detection, and Textonboost algorithm for sign recognition, to ensure that the vehicle is safe and operating as intended. The system will also be able to monitor the environment around the vehicle and detect potential hazards.

The project will be implemented using a variety of tools and software, including OpenCV, c++, and ROS. The system will be tested in a simulated environment and on a real-world autonomous vehicle. The results of the project will be evaluated in terms of safety, performance, and scalability. In result, it Process camera data in real-time to continuously update the vehicle's perception and decision-making. Also will reduce computation time by leveraging hardware acceleration and implementing efficient algorithms for faster processing in autonomous vehicles.

Keywords: autonomous vehicles, image processing, ROS, OpenCV, control, monitoring, performance, sift, texton boost.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The rapid advancement in autonomous vehicle technology has indeed ushered in a revolutionary transformation in the automotive industry. Autonomous vehicles, commonly known as self-driving cars, have emerged as a groundbreaking innovation with the potential to redefine transportation systems and revolutionize urban mobility. Equipped with advanced sensing technologies and artificial intelligence, these vehicles can navigate and interact with the environment without direct human intervention, paving the way for safer, more efficient, and environmentally friendly transportation solutions. Central to the success of autonomous vehicles is their ability to perceive and interpret the surrounding environment accurately and in real-time. This crucial capability is achieved through image processing, a subfield of computer vision that plays a pivotal role in providing autonomous vehicles with essential visual perception.

Image processing algorithms analyze visual data from various sensors, including cameras and ultrasonic sensors, to extract valuable information, recognize objects, detect obstacles, and enable autonomous vehicles to make informed decisions. One of the primary applications of image processing in autonomous vehicles is object recognition and detection. Cameras mounted on self-driving cars capture images of the environment, which are then processed to identify and categorize objects such as pedestrians, vehicles, traffic signs, and road markings. By precisely identifying these objects, autonomous vehicles can understand their surroundings and anticipate potential hazards.Ultrasonic sensors, on the other hand, use high-frequency sound waves to measure the distance between the sensor and nearby objects. Image processing techniques are employed to analyze the data from these sensors and generate a detailed understanding of the vehicle's immediate surroundings. While ultrasonic sensors provide a more limited field of view compared to LiDAR, they are still valuable for detecting objects in close proximity to the vehicle.

Image processing also plays a crucial role in path planning and obstacle avoidance. Autonomous vehicles rely on data from their sensors, including ultrasonic sensors, to detect obstacles in real-time. By employing image processing algorithms, self-driving cars can anticipate potential collisions, adjust their trajectory, and safely navigate through complex traffic scenarios. This capability is a fundamental aspect of ensuring both passenger safety and the safety of other road users.

Furthermore, image processing enhances the perception of autonomous vehicles in challenging environmental conditions. Adverse weather conditions like rain, snow, and fog can obstruct sensors and cameras, reducing their effectiveness. Image processing techniques, such as image enhancement and sensor fusion, help mitigate these challenges by improving the visibility of the environment and combining data from multiple sensors, including ultrasonic sensors, to create a more comprehensive view.

1.2 MOTIVATION

The motivation behind this project stems from the pressing need to augment the capabilities of autonomous vehicles to handle complex real-world scenarios. We believe that image processing holds the key to unlocking new possibilities in the realm of self-driving technology. By harnessing the power of visual data from cameras installed on the vehicle, we can provide it with a more comprehensive and detailed understanding of the world it navigates.The project's inspiration also arises from the desire to enhance road safety and mitigate the human errors that contribute to a significant portion of traffic accidents. With millions of lives lost each year due to road accidents, the development of safer and more reliable autonomous vehicles becomes an ethical imperative. By integrating image processing into the control and monitoring systems of self-driving cars, project aims to reduce the potential for accidents and improve overall vehicles environment.

As autonomous vehicles inch closer to widespread adoption, concerns about public acceptance and trust become increasingly pertinent. By incorporating image processing-based perception capabilities, the system aims to instill greater confidence in autonomous vehicles, both among passengers and pedestrians. The ability of these cars to "see" their environment and make informed decisions based on visual cues can help dispel doubts about their reliability and safety.

1.3 PROBLEM STATEMENT

Developing autonomous vehicles that efficiently process real-time data, make rapid decisions, and optimize computation time is crucial for safe and reliable transportation. Current challenges include slow data processing, suboptimal decision-making, and computation delays, hindering the vehicles' responsiveness and safety. This research aims to overcome these obstacles by creating innovative image processing techniques, intelligent decision algorithms, and efficient computations to enhance the overall performance and adoption of autonomous vehicles.

1.4 OBJECTIVES

Implement sophisticated computer vision algorithms for accurate perception and analysis of the vehicle's environment: Develop and integrate advanced computer vision algorithms capable of accurately perceiving and analyzing the surrounding environment of the vehicle. These algorithms will leverage cutting-edge techniques in object detection, recognition, segmentation, and tracking to provide a detailed understanding of the surroundings, including other vehicles, pedestrians, road markings, traffic signs, and obstacles.

Process camera data in real-time to continuously update the vehicle's perception and decision-making: Develop a real-time data processing pipeline that efficiently handles camera inputs from multiple sensors installed on the vehicle. This pipeline will employ high-performance data processing techniques to continuously update the vehicle's perception of the environment as the camera data streams in. The updated perception will serve as the foundation for the vehicle's decision-making process, ensuring accurate and timely responses to dynamic changes in the surroundings. Reduce computation time by leveraging hardware acceleration and implementing efficient algorithms for faster processing in autonomous vehicles: Optimize the computation time of the computer vision algorithms by utilizing hardware acceleration techniques, such as GPUs or specialized AI chips. Additionally, employ efficient algorithm design and implementation practices to further reduce processing time without compromising the accuracy of the results. The objective is to achieve high-performance processing capabilities that meet the real-time demands of autonomous vehicles, ensuring swift and reliable decision-making on the road.

1.5 AUTONOMOUS VEHICLE

An autonomous vehicle or car, also known as a self-driving vehicle or car and driverless vehicle or car, is a vehicle that is capable of navigating and operating without human intervention. These vehicles use a combination of advanced sensors, cameras, radar, lidar (Light Detection and Ranging), GPS, and powerful onboard computers to perceive their surroundings, interpret the data, and make decisions accordingly.

The main objective of autonomous cars is to enhance road safety, increase efficiency, and provide more convenient transportation options. By removing the need for a human driver, autonomous cars aim to reduce human errors, which are a significant cause of accidents on the road.

Autonomous cars can operate in various levels of autonomy, as defined by the Society of Automotive Engineers (SAE) J3016 standard:

Level 0: No Automation: The driver is responsible for all aspects of driving, and the car provides no automated assistance.

Level 1: Driver Assistance: The vehicle can assist the driver with either steering or acceleration/deceleration but not both simultaneously.

Level 2: Partial Automation: The car can control both steering and acceleration/deceleration simultaneously under certain conditions. However, the driver must remain engaged and be ready to take over when needed.

Level 3: Conditional Automation: The car can manage most driving tasks under specific conditions but requires the driver to take over if requested by the system. The driver can disengage from driving but must be available to intervene if necessary.

Level 4: High Automation: The vehicle can perform all driving tasks and handle different road conditions without human intervention within specific operational design domains (ODD). However, there might be exceptional circumstances where a human driver may need to take control.

Level 5: Full Automation: The car is capable of completely autonomous driving under all conditions and does not require any human intervention. The steering wheel and pedals may not even be present in a level 5 autonomous car.

1.6 ARITIFICIAL INTELLIGENCE IN AUTONOMOUS VEHICLE

Autonomous cars use artificial intelligence to perceive their environment through sensors, cameras, and process this information using computer vision and machine learning algorithms. AI helps them plan routes, make real-time decisions, and improve performance over time. It ensures safety through redundancy and detects malfunctions. AI also enables natural interactions with passengers and facilitates over-the-air updates. The development involves rigorous testing and regulatory compliance for safe deployment on public roads. As AI technology advances, autonomous cars are expected to become safer, more efficient, and more common.

CHAPTER 2

LITERATURE REVIEW

2.1 THEORITICAL BACKGROUND

Theoretical background in autonomous vehicles using image processing is the foundation of the technology that enables vehicles to perceive and understand their surroundings through visual information. It involves applying computer vision algorithms to images captured by cameras mounted on the vehicle to extract meaningful data and make informed decisions. Here's an explanation of the theoretical background in autonomous vehicles using image processing:

2.1.1 Computer Vision:

Computer vision is a branch of artificial intelligence and computer science that focuses on enabling machines, such as autonomous vehicles, to interpret and understand visual information from the environment. It involves developing algorithms to process and analyze images to extract relevant features.

2.1.2 Image Acquisition:

The first step in the image processing pipeline is image acquisition, where cameras mounted on the vehicle capture real-time images of the surrounding environment. These images provide the vehicle with a visual representation of the world.

2.1.3 Preprocessing:

Preprocessing involves enhancing the captured images to improve their quality and reduce noise. Techniques such as image filtering, contrast adjustment, and image normalization are applied to make the subsequent analysis more effective.

2.1.4 Feature Extraction:

In the feature extraction stage, relevant information is extracted from the preprocessed images. This could include identifying edges, corners, contours, textures, and other distinct features that can help in object recognition and localization.

2.1.5 Object Detection and Recognition:

Object detection and recognition algorithms are used to identify and locate specific objects of interest within the images. These could include other vehicles, pedestrians, traffic signs, lanes, and obstacles. Deep learning techniques like convolutional neural networks (CNNs) have shown significant success in this area.

2.1.6 Semantic Segmentation:

Semantic segmentation is a process of classifying each pixel in the image to a specific object class or category. It helps the autonomous vehicle understand the different regions in the scene and assists in path planning and obstacle avoidance.

2.1.7 Instance Segmentation:

Instance segmentation is an extension of semantic segmentation that not only identifies object classes but also assigns a unique instance label to each individual object in the scene. This allows the vehicle to differentiate between multiple instances of the same object class.

2.1.8 Object Tracking:

Object tracking algorithms help the vehicle maintain the identity of detected objects over time. It is crucial for predicting object movement and making informed decisions in dynamic environments.

2.1.9 SLAM (Simultaneous Localization and Mapping):

SLAM is a technique used in autonomous vehicles to create a map of the environment while simultaneously localizing the vehicle within the map. It utilizes image features and sensor data to estimate the vehicle's position and update the map in real-time.

2.2 BRIEF HISTORY

The history of autonomous vehicles dates back several decades and has evolved significantly over time. The concept of self-driving cars can be traced back to the 1920s when the idea of "phantom auto" was first introduced. However, it wasn't until the 1980s that significant advancements were made, thanks to the development of computer vision and artificial intelligence.

In the 1980s and 1990s, research institutions and automotive companies started experimenting with autonomous vehicle technology, focusing on basic control and navigation systems. The 2000s saw the introduction of more sophisticated features like adaptive cruise control and lane-keeping assistance, laying the groundwork for fully autonomous vehicles.

Around the 2010s, companies like Google (now Waymo) and Tesla became pioneers in the autonomous vehicle space, testing their self-driving technologies on public roads. This led to increased interest from other automakers and tech giants, prompting substantial investment and research in the field.

Since then, autonomous vehicle technology has continued to progress rapidly, incorporating advanced sensors, machine learning algorithms, and vast amounts of real-world data to enhance safety and performance. Numerous companies have joined the race to develop self-driving cars, leading to pilot programs, regulatory discussions, and widespread testing across the globe. While there have been challenges and concerns, autonomous vehicles hold the promise of revolutionizing transportation by improving road safety, reducing congestion, and transforming mobility for people worldwide.

2.3 SELF DRIVING CARS IN ASIA

As of last update in September 2021, autonomous cars were gaining significant attention and development across Asia. Several countries in the region were actively working on implementing and testing autonomous vehicle technology. Here are some highlights of the autonomous car landscape in Asia at that time:

2.3.1 China: China was one of the leading countries in autonomous vehicle development. Companies like Baidu, Alibaba-backed AutoX, and Tencent were investing heavily in self-driving technology. Baidu's Apollo platform, an open-source autonomous driving platform, was gaining traction and attracting partnerships with various automakers.

2.3.2 Japan: Japan was also actively involved in autonomous vehicle research and development. Companies like Toyota, Honda, and Nissan were working on their autonomous driving technologies and conducting tests on public roads.

2.3.3 South Korea: South Korea was making strides in the autonomous vehicle sector, with companies like Hyundai and Kia investing in research and development. The government was also supportive of autonomous vehicle initiatives and was promoting policies to facilitate testing and deployment.

2.3.4 Singapore: Singapore was among the Asian countries at the forefront of testing autonomous vehicles on public roads. It had launched several pilot projects to explore various use cases and study the feasibility of integrating autonomous vehicles into urban transportation.

2.3.5 India: While not as advanced as some of the other countries, India was also showing interest in autonomous cars. Some startups were exploring self-driving technology, and the government was considering regulations to pave the way for testing and deployment.

2.3.6 Other Asian countries: Various other Asian countries, such as Taiwan and Malaysia, were also beginning to explore autonomous vehicle technology, with companies and research institutions working on prototypes and conducting trials.

2.4 SIMILAR STUDIES

In September 2021, there were numerous studies on autonomous vehicles that utilized image processing as a key component of their perception system. Image processing plays a crucial role in enabling autonomous vehicles to interpret and understand their surroundings from visual data captured by cameras. Below are some areas of research related to autonomous vehicles and image processing:

2.4.1 Object Detection and Recognition: Many studies focus on developing advanced computer vision algorithms for detecting and recognizing objects on the road, such as other vehicles, pedestrians, traffic signs, and obstacles. Techniques like convolutional neural networks (CNNs) and deep learning are commonly employed for this purpose.

2.4.2 Semantic Segmentation: Semantic segmentation involves labeling each pixel in an image with a corresponding class label, such as road, sidewalk, car, or tree. Autonomous vehicles leverage semantic segmentation to create a detailed understanding of the environment and to plan safe paths.

2.4.3 Visual SLAM (Simultaneous Localization and Mapping): Visual SLAM techniques use image data to simultaneously create a map of the environment and determine the vehicle's position within that map. This is particularly useful in situations where GPS signals might be unreliable, such as in urban canyons or tunnels.

2.4.4 Pedestrian Detection and Intent Prediction: Autonomous vehicles need to anticipate the behavior of pedestrians to ensure safe navigation. Image processing techniques are employed to not only detect pedestrians but also predict their intentions, such as crossing the road.

2.4.5 Anomaly Detection: Image processing can be utilized to identify unusual or unexpected situations on the road, such as debris or sudden changes in traffic patterns.

2.4.6 Preprocessing and Data Augmentation: Image processing is often used to preprocess the raw camera data, such as correcting for distortion, adjusting brightness, and removing noise. Data augmentation techniques may also be applied to increase the diversity of the training dataset.

CHAPTER 3

HARDWARE DESCRIPTION

3.1 HARDWARE DESCRIPTION

This chapter explains the hardware design of prototype "Control and Monitoring of Autonomous Vehicle by Using Image Processing," this hardware description section provide a comprehensive overview of the hardware components used in autonomous vehicle system. For making a prototype, an assembly of car has been used. The assembly has four DC gear motors, to control the wheel direction such as left, right front and back. All the other instruments are removed from the assembly and a motor driver is fitted to drive the DC gear motors along with Arduino for command functioning.

Some hardware components used in this project are as follows:

- Raspberry pi as Main Processor (Master Device)
- Arduino (Slave Device)
- Raspberry pi-cam
- GPS Module
- Ultrasonic Sensor
- Obstacle Sensor
- Gear Motor
- H-bridge Motor driver (L298)
- Battery (3.7 lithium)

3.2 RASPBERRY PI

The Raspberry Pi, introduced in 2012, is a compact computer with the size of a credit card. It was developed to make a significant impact on the computing landscape. Conceived at the University of Cambridge's Computer Laboratory and later released by The Raspberry Pi Foundation, the Pi has a clear mission to revolutionize computer interaction for people of all ages, especially children. The Pi operates on Linux in a user-friendly graphical environment and includes GPIO (general-purpose input/output) connectors, allowing easy connection of sensors and motors.

Figure: 3.1 Raspberry Pi 3 B+

3.2.1 Classification of Raspberry pi 3 B+:

	Raspberry Pi 3 Model B	Raspberry Pi Zero	Raspberry Pi 2 Model B	Raspberry Pi Model B+
Introduction Date	2/29/2016	11/25/2015	2/2/2015	7/14/2014
SoC	BCM2837	BCM2835	BCM2836	BCM2835
CPU	Quad Cortex A53 @ 1.2GHz	ARM11 @ 1GHz	Quad Cortex A7 @ 900MHz	ARM11 @ 700MHz
Instruction set	ARMv8-A	ARMv6	ARMv7-A	ARMv6
GPU	400MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV
RAM	1GB SDRAM	512 MB SDRAM	1GB SDRAM	512MB SDRAM
Storage	micro-SD	micro-SD	micro-SD	micro-SD
Ethernet	10/100	none	10/100	10/100
Wireless	802.11n / Bluetooth 4.0	none	none	none
Video Output	HDMI / Composite	HDMI / Composite	HDMI / Composite	HDMI / Composite
Audio Output	HDMI / Headphone	HDMI	HDMI / Headphone	HDMI / Headphone
GPIO	40	40	40	40
Price	$35	$5	$35	$35

Table: 3.1 Raspberry pi classification

3.3 ARDUINO UNO

Arduino is a widely used open-source platform for building and programming electronic devices. Its versatility allows it to communicate with various devices and even interact with the internet to control specific electronic components. The core of Arduino is the Arduino Uno circuit board, coupled with its programming language (Simplified C++), enabling users to program the board effectively.

Figure: 3.2 Arduino UNO

3.3.1 Classification of Arduino UNO:

Microcontroller	ATmega328
Clock Speed	16MHz
Operating Voltage	5V
Maximum supply Voltage (not recommended)	20V
Supply Voltage (recommended)	7-12V
Analog Input Pins	6
Digital Input/Output Pins	14
DC Current per Input/Output Pin	40mA
DC Current in 3.3V Pin	50mA
SRAM	2KB
EEPROM	1KB
Flash Memory	32KB of which 0.5KB used by boot loader

Table: 3.2 Arduino UNO classification

3.4 RASPBERRY PI CAMERA

The Raspberry Pi Camera Module 2 was introduced as an upgrade to the original Camera Module in April 2016. This camera module offers the capability to capture high-definition videos and still photographs. Its user-friendly design makes it suitable for beginners, while advanced users can explore its full potential for expanding their knowledge. Online examples demonstrate its versatility, showcasing time-lapse, slow-motion, and other creative video applications. Moreover, bundled libraries enable users to experiment with various effects.

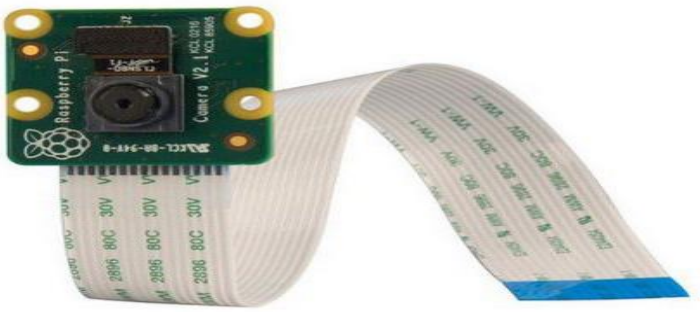

Figure: 3.3 Raspberry Pi Camera

3.4.1 Classification of Raspberry pi Camera:

Specification	Description
Size	Around 25 x 24 x 9 mm
Weight	3 g
Still Resolution	5 Megapixels
Video Modes	1080p30, 720p60 and 640 x 480p60/90
Linux Integration	V4L2 driver available
Sensor	OmniVision OV5647
Sensor Resolution	2592 x 1944 pixels
Sensor Image Area	3.76 x 2.74 mm
Pixel Size	1.4 m x 1.4 m
Optical Size	1/4
Full-frame SLR lens equivalent	35 mm
S/N Ratio	36 dB

Table: 3.3 Raspberry pi camera classification

3.4 GPS MODULE:

A GPS (Global Positioning System) module in an autonomous vehicle is a critical component responsible for providing precise and real-time positioning information. It plays a fundamental role in enabling the vehicle's navigation and localization, allowing it to determine its position and orientation accurately relative to the Earth's surface. Here's an explanation of the GPS module's importance and functionality in an autonomous vehicle:

Positioning and Localization:

The GPS module uses signals from a network of satellites in orbit to calculate the vehicle's precise geographic position (latitude, longitude, and altitude). This information is crucial for determining the vehicle's location on the Earth's surface.

Real-time GPS Data:

The GPS module continuously receives signals from multiple satellites to update the vehicle's position in real-time. It provides high-frequency updates, allowing the vehicle's control system to maintain an accurate and up-to-date position estimate.

Waypoint Navigation:

GPS data helps the autonomous vehicle navigate along predefined waypoints or routes. By using GPS coordinates and a navigation algorithm, the vehicle can follow a designated path, making it possible to drive autonomously along specific routes or to reach designated destinations.

Figure: 3.4 GPS module

3.5 ULTRASONIC SENSOR:

An ultrasonic sensor in an autonomous vehicle is a type of proximity sensor that uses sound waves to detect objects and measure distances. It plays a crucial role in the vehicle's perception and obstacle detection capabilities, helping the vehicle navigate safely and avoid collisions with obstacles in its environment. Here's an explanation of how ultrasonic sensors work and their importance in an autonomous vehicle:

Figure: 3.5 Ultrasonic Sensor

3.6 OBSTACLE SENSOR:

An obstacle sensor in an autonomous vehicle is a type of proximity sensor that detects and identifies obstacles, objects, or hazards in the vehicle's surroundings. The primary purpose of obstacle sensors is to provide crucial information to the autonomous vehicle's perception system, helping it navigate safely and avoid collisions with obstacles during its operation. Here's an explanation of how obstacle sensors work and their importance in an autonomous vehicle:

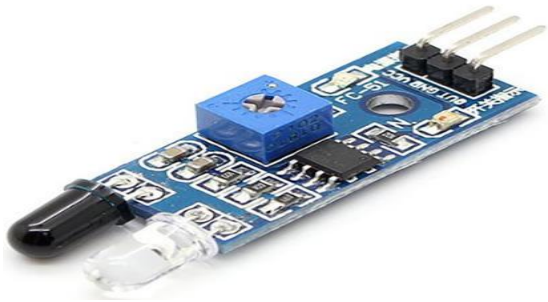

Figure: 3.6 Obstacle Sensor

3.7 GEAR MOTOR:

A DC gear motor is a type of electric motor that incorporates a gear reduction mechanism. It is commonly used in autonomous vehicles to drive the wheels and provide motion to the vehicle. DC gear motors offer several advantages, making them suitable for various applications, including autonomous vehicles. Here's an explanation of DC gear motors and their role in an autonomous vehicle:

Figure: 3.7 Gear Motor

3.8 H-BRIDGE MOTOR DRIVER:

An H-bridge motor driver is a type of electronic circuit used to control the direction and speed of a DC motor. It is a crucial component in an autonomous vehicle's drivetrain, as it allows the vehicle's control system to manage the movement of the wheels with precision. Here's an explanation of the H-bridge motor driver and its role in an autonomous vehicle:

Figure: 3.8 H-bridge Motor driver

3.10 BATTERY (3.7v lithium):

The 3.7v lithium battery is a lithium battery with a nominal voltage of 3.7v and a full-charge voltage of 4.2v. Its capacity ranges from several hundred to several thousand mAh. It is generally used in various instruments and meters, testing instruments, medical instruments, POS machines, notebook computers, and other products.

Figure: 3.9 BATTERY (3.7v lithium)

CHAPTER 4

SOFTWARE DESCRIPTION

4.1 SOFTWARE DESCRIPTION

This chapter explains the software design of prototype "Control and Monitoring of Autonomous Vehicle Using Image Processing," this software description section provide a comprehensive overview of the software components used in autonomous vehicle system.

Software is a set of instructions, data or programs used to operate computers and execute specific tasks. It is the opposite of hardware, which describes the physical aspects of a computer. Software is a generic term used to refer to applications, scripts and programs that run on a device.

Some hardware components used in this project are as follows:

- OpenCV
- Arduino IDE
- Raspberry Pi OS

4.2 OpenCV:

OpenCV (Open Source Computer Vision Library) is an open-source computer vision and machine learning software library. It is a popular and widely-used library for image and video processing tasks, providing a rich set of tools and algorithms for various computer vision applications. OpenCV is written in C++ and also provides interfaces for Python, Java, and other programming languages, making it accessible and versatile for developers.

Applications of OpenCV:

OpenCV is used in various industries and applications, including:

- Robotics and autonomous systems
- Computer vision research and development

- Augmented reality and virtual reality
- Image and video analysis for surveillance and security
- Medical imaging and healthcare applications
- Industrial automation and quality control
- Self-driving cars and autonomous vehicles

Figure: 4.1 OpenCV 4.0

4.3 ARDUINO IDE:

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus.

In the context of controlling and monitoring an autonomous vehicle using image processing, the Arduino software would typically play a specific role within the larger software ecosystem. While the primary image processing and decision-making tasks are often handled by more powerful processors or dedicated hardware, Arduino boards can be utilized for certain control and monitoring functions within the vehicle.

The Arduino programming language is used to program microcontroller boards such as the Arduino Uno to interact with sensors, actuators, and other devices connected to the board. In fact, the language is based on C++, and it is designed to be easy to use for beginners and non-programmers.

Features of Arduino Uno Board

- The operating voltage is 5V.
- The recommended input voltage will range from 7v to 12V.
- The input voltage ranges from 6v to 20V.
- Digital input/output pins are 14.
- Analog i/p pins are 6.
- DC Current for each input/output pin is 40 mA.
- DC Current for 3.3V Pin is 50 mA.
- Flash Memory is 32 KB.

Figure: 4.2 Arduino IDE

4.4 Raspberry pi OS:

The Raspberry Pi OS (ROS) can serve as a powerful and versatile platform for running various software components. Raspberry Pi, with its processing capabilities and support for camera modules, can handle image processing tasks and act as a central control unit for the vehicle. Here's how the Raspberry Pi software could be used in such a scenario:

4.4.1 Image Processing:

The Raspberry Pi can run image processing algorithms to analyze real-time images captured by cameras mounted on the vehicle.

4.4.2 Decision Making:

Based on the results of the image processing, the Raspberry Pi can make decisions on vehicle control, navigation, and interaction with the environment.

4.4.3 Path Planning and Navigation:

Raspberry Pi can execute path planning algorithms to determine the optimal trajectory for the vehicle to follow, considering obstacles, traffic rules, and the vehicle's dynamics.

4.4.4 Communication with Central Control:

In a multi-vehicle scenario or when operating within a larger autonomous system, the Raspberry Pi can communicate with a central control station to receive high-level commands or transmit data and status updates.

Figure: 4.3 Raspberry pi OS (ROS)

RESULT AND OUTCOMES:

The culmination of this project has resulted in a remarkable prototype, showcasing an autonomous vehicle equipped with an array of capabilities. Through meticulous development, the vehicle now demonstrates exceptional control over its speed, precise monitoring of distances, accurate edge detection, and the ability to navigate and circumvent obstacles seamlessly.

One of the most impactful achievements lies in the significant reduction of computation time. This was made possible by harnessing hardware acceleration and implementing highly efficient algorithms, enabling swift and real-time processing essential for autonomous vehicles' continuous decision-making.

The integration of a sophisticated parking system within the autonomous vehicle stands out as a pinnacle outcome of this endeavor. This addition is anticipated to bring about a myriad of benefits for both individuals and society at large. These benefits encompass heightened road safety measures, a substantial decrease in traffic congestion, and a remarkable reduction in the time spent searching for parking spots. This amalgamation of advancements promises a transformative shift in the way we perceive transportation, offering a future where safety, efficiency, and convenience converge harmoniously on our roads.