CREATING A COST EFFECTIVE SCALE MODEL OF AUTONOMOUS VEHICLE TEST BED

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ABSTRACT

Autonomous vehicles are poised to become one of the most pervasive and impactful applications of Computer Vision, Machine and Deep Learning and Artificial Intelligence. However, difficult challenges still remain before their widespread deployment, many of which concern the system as a whole, rather than single components in isolation. Examples include the code sign of hardware components and algorithms, the coupled interactions between perception and control, the optimal allocation of finite computational resources to concurrent processes, and safe multi-agent behaviors.

I. INTRODUCTION

Today, the research community is facing a lot of challenges in studying the individual components, system-level interactions and processes involved in Autonomous Driving, due to the significant logistical issues associated current physical testbeds. Building a fleet of full-scale Autonomous Vehicle, Infrastructure mimicking real-world scenarios involves spending a lot of time and cost given the amount of complexity and resources needed. Not to mention the limitations in creating the scenarios which also significantly affects the flexibility in experimentation? this paper , will attempt to address such issues by introducing a scale model of Autonomous Vehicle Test Bed to study the Autonomous Driving behavior, without compromising on the breadth of processes involved.

First of all, people tend to be very bad drivers, so anything that would remove the human from control of the machine will improve the accident rate by a lot. And US drivers are worse than most, because they have almost no real training in driving before they get their license, and lose most of the training that they do have over the next several years. And then when drivers get old, and they tend to lose their focus on what they are doing, they get into even more accidents.

Secondly, driving stuff as a living is very expensive. So by having self driving vehicles (trucks, cars, buses, delivery vans, etc.) will reduce costs a lot and make for cheaper transportation.

Thirdly, because of so many accidents, insurance for drivers is expensive, and that creates a huge profitable industry to collect those funds and dole them out to the victims of accidents.

Finally, a large number of the victims coming to emergency wards in hospitals are there from the injuries received in accidents. Eliminating most of those accidents will reduce the load on our health care system, reducing costs for all. And in addition, the biggest cause of traffic jams is from the bad and illogical driving from human drivers. Automated vehicles will be consistent, safe, and avoid traffic jams and construction by knowing how to avoid those situations. And in doing so, traffic will move more smoothly, and we will all get to where we want to go more quickly, and with less aggravation. But of course, there will be some downsides to this, but I'll let others focus on that.

II. LITERATURE SURVEY

1. Duckietown: an Open, Inexpensive and Flexible Platform for Autonomy Education and Research.

2017 IEEE International Conference on Robotics and Automation (ICRA) Singapore May 29 - June 3, 2017

Duckietown is an open, inexpensive and flexible platform for autonomy education and research. The platform comprises small autonomous vehicles built from off-the-shelf components, and cities complete with roads, signage, traffic lights, obstacles, and citizens in need of transportation. The Duckietown platform offers a wide range of functionalities at a low cost. Duckiebots sense the world with only one monocular camera and perform all processing onboard with a Raspberry Pi 2, yet are able to: follow lanes while avoiding obstacles, pedestrians and other Duckiebots, localize within a global map, navigate a city, and coordinate with other Duckiebots to avoid collisions. Duckietown is a useful tool since educators and researchers can save money and time by not having to develop all of the necessary supporting infrastructure and capabilities. All materials are available as open source, and the hope is that others in the community will adopt the platform for education and research.

2. A Low-Cost Model Vehicle Testbed with Accurate Positioning for Autonomous Driving

Journal of Robotics Volume 2018, Article ID 4907536, link- https://doi.org/10.1155/2018/4907536

Accurate positioning is a requirement for many applications, including safety-critical autonomous vehicles. To reduce cost and at the same time improving accuracy for positioning of autonomous vehicles, new methods, tools, and research platforms are needed. We have created a low-cost testbed consisting of electronics and software that can be fitted on model vehicles allowing them to follow trajectories autonomously with a position accuracy of around 3 cm outdoors. The position of the vehicles is derived from sensor fusion between Real-Time Kinematic Satellite Navigation (RTK-SN), odometry, and inertial measurement and performs well within a 10 km radius from a base station. Trajectories to be followed can be edited with a custom GUI, where also several model vehicles can be controlled and visualized in real time. All software and Printed Circuit Boards (PCBs) for our testbed are available as open source to make customization and development possible. Our testbed can be used for research within autonomous driving, for carrying test equipment, and other applications where low cost and accurate positioning and navigation are required.

3.ASFAULT: Testing Self-Driving Car Software Using Search-based Procedural Content Generation.

2019 IEEE/ACM 41st International Conference on Software Engineering ICSECompanion link - https://youtu.be/lJ1sa42VLDw

Ensuring the safety of self-driving cars is important, but neither industry nor authorities have settled on a standard way to test them. Deploying self-driving cars for testing in regular traffic is a common, but costly and risky method, which has already caused fatalities. As a safer alternative, virtual tests, in which self-driving car software is tested in computer simulations, have been proposed. One cannot hope to sufficiently cover the huge number of possible driving situations self-driving cars must be tested for by manually creating such tests. Therefore, we developed ASFAULT, a tool for automatically generating virtual tests for systematically testing self-driving car software. We demonstrate ASFAULT by testing the lane keeping feature of artificial intelligence-based self-driving car software, for which ASFAULT generates scenarios that cause it to drive off the road.

4.Integration of Open Source Platform Duckietown and Gesture Recognition as an Interactive Interface for the Museum Robotic Guide.

The 27th Wireless and Optical Communications Conference (WOCC2018)

In recent years, population aging becomes a serious problem. To decrease the demand for labor when navigating visitors in museums, exhibitions, or libraries, this research designs an automatic museum robotic guide which integrates image and gesture recognition technologies to enhance the guided tour quality of visitors. The robot is a self-propelled vehicle developed by ROS (Robot Operating System), in which we achieve the automatic driving based on the function of lane following via image recognition. This enables the robot to lead guests to visit artworks following the preplanned route. In conjunction with the vocal service about each artwork, the robot can convey the detailed description of the artwork to the guest. We also design a simple wearable device to perform gesture recognition. Then, in the second phase (or recognition phase), we apply KNN (k-nearest neighboring) algorithm to recognize the hand gesture of users in real time. Experiments show that our method can work in real time and get better accuracy than other methods.

5.Improving Multisensor Positioning of Land Vehicles with Integrated Visual Odometry for Next-Generation Self-Driving Cars.

Journal of Advanced Transportation Volume 2018, Article ID 6513970 link- https://doi.org/10.1155/2018/6513970

For their complete realization, autonomous vehicles (AVs) fundamentally rely on the Global Navigation Satellite System (GNSS) to provide positioning and navigation information. However, in area such as urban cores, parking lots, and under dense foliage, which are all commonly frequented by AVs, GNSS signals suffer from blockage, interference, and multipath. These effects cause high levels of errors and long durations of service discontinuity that mar the performance of current systems. A scheme called Aided Visual Odometry (AVO) is developed and integrated with a high performance mechanization architecture utilizing vehicle motion and orientation sensors. The resulting solution exhibits improved state covariance convergence and navigation accuracy, while reducing computational complexity. Experimental verification of the proposed solution is illustrated through three real road trajectories, over two different land vehicles, and using two low-cost inertial measurement units (IMUs).

6.Traffic Light Detection and Recognition for Self Driving Cars using Deep Learning.

2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA)

Self-driving cars has the potential to revolutionize urban mobility by providing sustainable, safe, convenient and congestion free transportability. This vehicle autonomy as an application of AI has several challenges like infallibly recognizing traffic lights, signs, unclear lane markings, pedestrians, etc.In this paper, we propose a deep neural network based model for reliable detection and recognition of traffic lights using transfer learning. The method incorporates use of faster region based convolution network (R-CNN) Inception V2 model in Tensor Flow for transfer learning. The model was trained on dataset containing different images of traffic signals in accordance with Indian Traffic Signals which are distinguished in five types of classes. The model accomplishes its objective by detecting the traffic light with its correct class type.

7. A Hardware-in-the-Loop Scaled Platform for Testing Autonomous Vehicle Trajectory Tracking.

Journal of Advanced Transportation Volume 2017, Article ID 9203251, link-https://doi.org/10.1155/2017/9203251

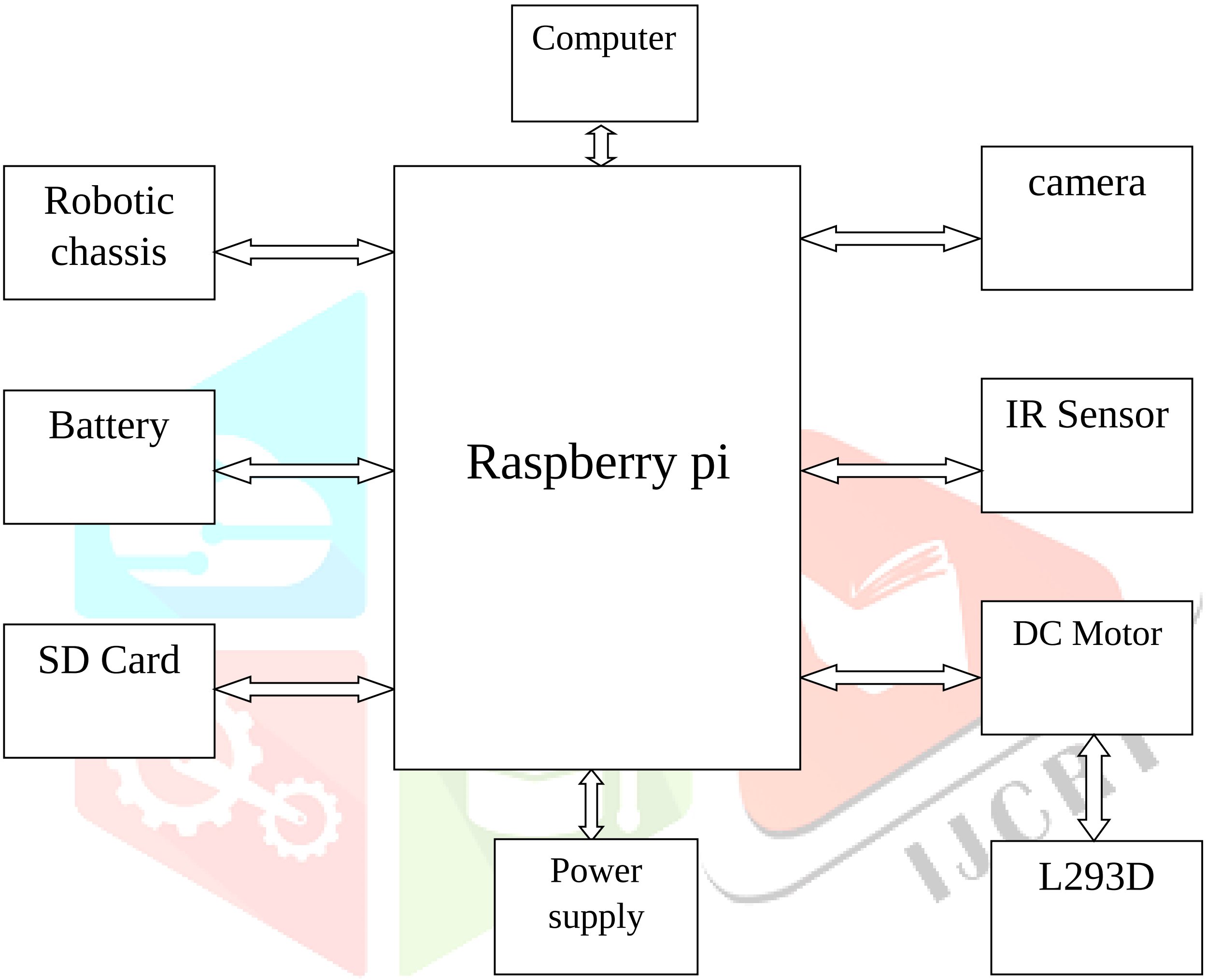
With the advent of autonomous vehicles, in particular its adaptability to harsh conditions, the research and development of autonomous vehicles attract significant attention by not only academia but also practitioners. Due to the high risk, high cost, and difficulty to test autonomous vehicles under harsh conditions, the hardware-in-the-loop (HIL) scaled platform has been proposed as it is a safe, inexpensive, and effective test method. This paper uses a case of the development process of tracking control for high-speed U-turn to build the tracking control function. The experiment results demonstrate the effectiveness of the HIL scaled platform.

8. Implementation of Lane Detection Algorithm for Self-Driving Car on Toll Road Cipularang using Python Language.

2017 4th International Conference on Electric Vehicular Technology (ICEVT) October 2-5, 2017. Bali, Indonesia.

Self-Driving Car research problem requires several sub-topics that need to be discussed more deeply. Such as Deep Learning, Computer Vision, Fusion Sensor, Localization, Control, until Path Planning. All of them are fusion of several fields of study. This paper discusses the results of implementation of lane detection algorithm on toll road Cipularang as parts of self driving car system. Image processing methods are a combination of methods of color region, line selection, canny edge detection, and Hough transform. The result shows this algorithm needed to be add some methods that can changing the parameters during day and night adaptively. Because constant parameters can only be used in the same lighting conditions. Overall the implementation method in Python Language can successfully detect the road lane with accuracy above 90 percent.

III. BLOCK DIAGRAM



Raspberry pi: The Raspberry Pi is credit card sized single board computer that plugs into a computer monitor and TV. Python is a programming language which is used to Interface raspberry pi. . The Raspberry Pi is the central computer of the Autonomous vehicle. AV use Model B (A 1.2GHz 64-bit quad-core ARMv8 CPU, 1GB RAM), a small but powerful computer.

Robotic chassis: Chassis is the main support structure of the vehicle which is also known as 'Frame'. The chassis pack includes 2 DC motors and wheels as well as the structural part.

Camera: The Camera is the main sensor of the Autonomous vehicle. It is used for lane following purpose.

Battery : Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. The battery provides power to the Autonomous vehicle.

IR sensor: An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment.

DC motor: A **DC motor** is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy.

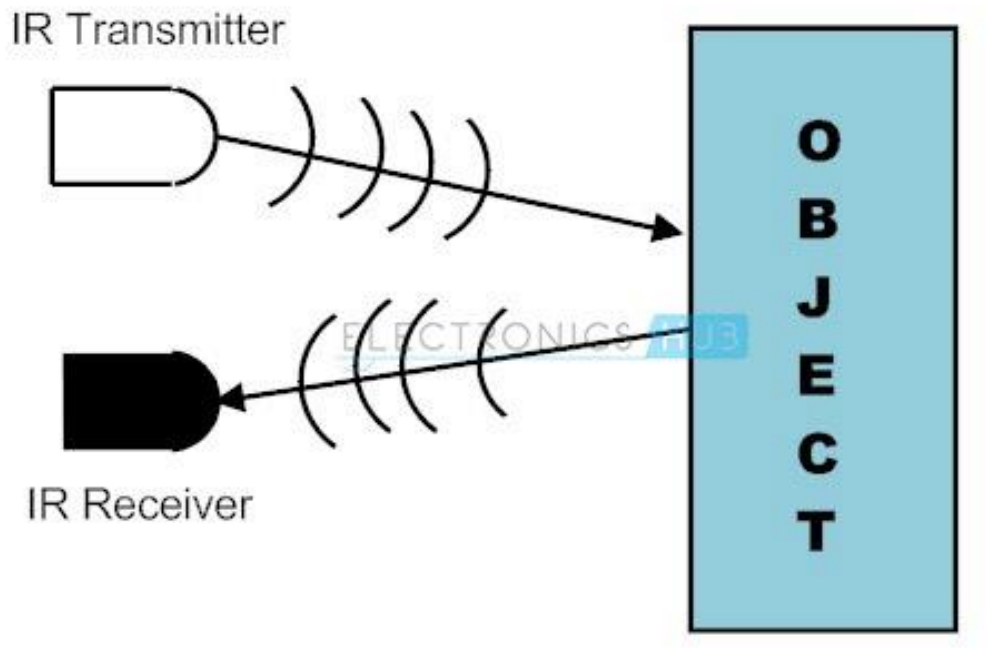
L293D driver: The L293D is a popular 16-Pin **Motor Driver IC**. As the name suggests it is mainly used to drive motors. A single **L293D IC** is capable of running two DC motors at the same time; also the direction of these two motors can be controlled independently.

Power supply: A **power supply** is an electrical device that supplies electric powerto an electrical load.

SD card : The Micro SD card is the hard disk of the Raspberry Pi. 16 GB of capacity are sufficient for the system image. SD card contains raspbian operating system.

METHODOLOGY

A) OBSTACLE DETECTION



The basic concept of an Infrared Sensor which is used as Obstacle detector is to transmit an infrared signal, this infrared signal bounces from the surface of an object and the signal is received at the infrared receiver.

The principle of an IR sensor working as an Object Detection Sensor can be explained using the following figure. An IR sensor consists of an IR LED and an IR Photodiode; together they are called as Photo – Coupler or Opto – Coupler.

Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations.

Infrared receivers are also called as infrared sensors as they detect the radiation from an IR transmitter. IR receivers come in the form of photodiodes and phototransistors.

When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined.

B) LANE FOLLOWING:

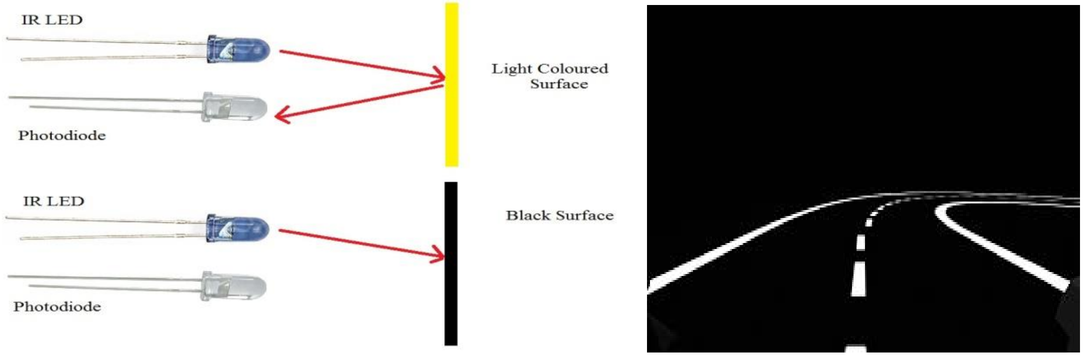


Fig 4.1.1.Lane following diagram

It is universal that black color absorbs the entire radiation incident on it and white color reflects the entire radiation incident on it. When the IR transmitter emits infrared radiation, since there is no direct line of contact between the transmitter and receiver, the emitted radiation must reflect back to the photodiode after hitting any object. The surface of the object can be divided into two types: reflective surface and non-reflective surface. If the surface of the object is reflective in nature i.e. it is white or other light color, most of the radiation incident on it will get reflected back and reaches the photodiode. Depending on the intensity of the radiation reflected back, current flows in the photodiode.

If the surface of the object is non-reflective in nature i.e. it is black or other dark color, it absorbs almost all the radiation incident on it. As there is no reflected radiation, there is no radiation incident on the photodiode and the resistance of the photodiode remains higher allowing no current to flow. This situation is similar to there being no object at all.

4.1.1. KEY TECHNOLOGIES AREAS

- **INTERNRT OF THINGS**

  The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
- **ARTIFICIAL INTELLIGENCE**

  Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions) and self-correction. In order for the AV to operate in a full range of environments with millions of changing aspects that will need to be accounted for, it will require AI, which will allow the base level software to be developed and tested with a self-learning capability.

- **MACHINE LEARNING**

  Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

- **DEEP LEARNING**

  Deep learning is a class of machine learning algorithms that uses multiple layers to progressively extract higher level features from the raw input. For example, in image processing, lower layers may identify edges, while higher layers may identify the concepts relevant to a human such as digits or letters or faces

- **GPS**

  These global positioning systems will be a critical link for AV to determine their location as they move. GPS, which stands for Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

4.2 HARDWARE REQUIREMENTS:

- **RASPBERRY PI**

Fig 4.2.1. Raspberry pi

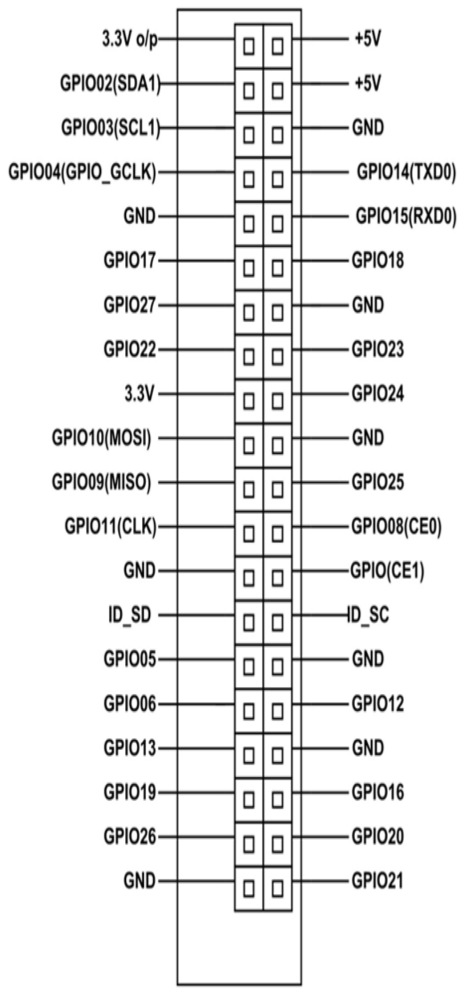


Fig4.2.2. Pin configuration of raspberry pi

RASPBERRY PI 3 is a development board in PI series. It can be considered as a single board computer that works on LINUX operating system. The board not only has tons of features it also has terrific processing speed making it suitable for advanced applications. The Raspberry Pi is the central computer of the Autonomous vehicle. AV use Model B (A 1.2GHz 64-bit quad-core ARMv8 CPU, 1GB RAM), a small but powerful computer.

Raspberry Pi 3 Technical Specifications

Microprocessor	Broadcom BCM2837 64bit Quad Core Processor
Processor Operating Voltage	3.3V
Maximum total current drawn from all I/O pins	54Ma
Flash Memory (Operating System)	16Gbytes SSD memory card
Internal RAM	1Gbytes DDR2
Clock Frequency	1.2GHz
Ethernet	10/100 Ethernet
Wireless Connectivity	BCM43143 (802.11 b/g/n Wireless LAN and Bluetooth 4.1)
Operating Temperature	-40ºC to +85ºC
Camera connector	15 pin mipi camera serial interface

Table 4.2.1.raspberry pi technical specifications

Raspberry pi 3 pin configuration:

PIN GROUP	**PIN NAME**	**DESCRIPTION**
POWER SOURCE	+5V, +3.3V, GND and Vin	+5V -power output +3.3V -power output GND – GROUND pin
COMMUNICATION INTERFACE	UART Interface(RXD, TXD) [(GPIO15,GPIO14)]	UART (Universal Asynchronous Receiver Transmitter) used for interfacing sensors and other devices.
	SPI Interface(MOSI, MISO, CLK,CE) x 2 [SPI0-(GPIO10 ,GPIO9, GPIO11 ,GPIO8)] [SPI1--(GPIO20 ,GPIO19, GPIO21 ,GPIO7)]	SPI (Serial Peripheral Interface) used for communicating with other boards or peripherals.
	TWI Interface(SDA, SCL) x 2 [(GPIO2, GPIO3)] [(ID_SD,ID_SC)]	TWI (Two Wire Interface) Interface can be used to connect peripherals.
INPUT OUTPUT PINS	26 I/O	Although these some pins have multiple functions they can be considered as I/O pins.

Table 4.2.2 Raspberry pi 3 pin configuration

- **CHASSIS**

Fig4.2.3. Chassis

Chassis is the main support structure of the vehicle which is also known as 'Frame'. It bears all the stresses on the vehicle in both static and dynamic conditions. In a vehicle, it is analogous to the skeleton in living organisms. The origin of the word Chassis lies in the French language. Every vehicle whether it is a two-wheeler or a car or a truck has a chassis-frame. However, its form obviously varies with the vehicle type. The chassis pack includes 2 DC motors and wheels as well as the structural part, in addition to a screwdriver and several necessary mechanical bits (standoffs, screws and nuts).

The Chassis has the following functions. It

1. Supports or bears the load of the vehicle body
2. Provide the space and mounting location for various aggregates of vehicle
3. Supports the weight of various systems of the vehicle such as engine, transmission etc.
4. Supports a load of passengers as well as the luggage
5. Withstands the stresses arising due to bad road conditions
6. Withstands stresses during braking and acceleration of the vehicle

- **CAMERA**

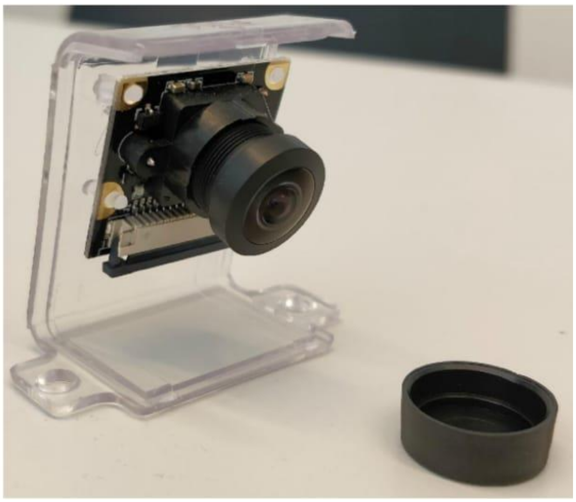


Fig 4.2.4. Fish eye lens camera

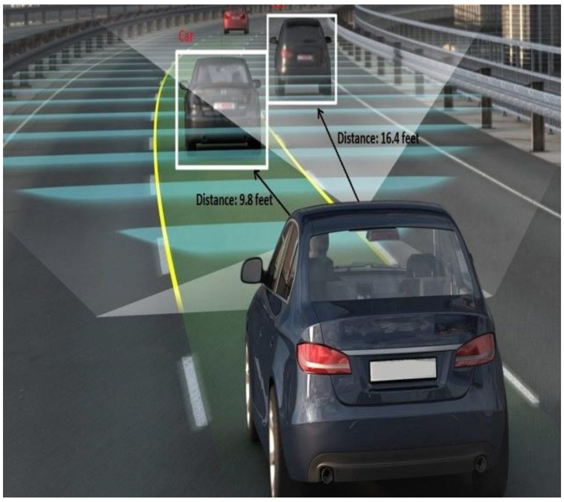


Fig4.2.5. Image captured by camera

The Camera is the main sensor of the Autonomous vehicle. All versions equip a 5 Mega Pixels 1080p camera with wide field of view (160) fisheye lens.A fisheye lens is an ultra wide-angle lens that produces strong visual distortion intended to create a wide panoramic or hemispherical image. Fisheye lenses achieve extremely wide angles of view. Instead of producing images with straight lines of perspective (rectilinear images), fisheye lenses use a special mapping (for example: equisolid angle), which gives images a characteristic convex non-rectilinear appearance. There are two main types of fisheye lenses, circular and full-frame. Each produces a very different effect For cameras with a 35mm sensor or film, a typical circular fisheye lens might have a focal length of 8mm to 10mm. Full-frame lenses have slightly longer focal lengths, usually 15mm to 16mm.. The focal length is determined by the angular coverage, the specific mapping function used, and the required dimensions of the final image.

- **DC MOTOR**

Fig4.2.6. Dc motor

A **DC motor** is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Parameter	Value
Power	3.0kW
Max rated Voltage	220V
Max rated Current	18.1A
Speed	1500rpm
Moment of Inertia (J)	0.0607 kg-m^2
Armature Resistance (R_a)	0.65Ω
Armature Inductance (L_a)	0.008H
Back EMF Constant(K_m)	1.25V/rad/sec

Table4.2.3. Specifications OD dc motor

- **L293D MOTOR CONTROLLER**

Fig4.2.7. L293D motor controller

The **L293D** is a popular 16-Pin **Motor Driver** IC. As the name suggests it is mainly used to drive **motors**. A single **L293D** IC is capable of running two DC **motors** at the same time; also the direction of these two **motors** can be controlled independently.

Features

- Can be used to run Two DC motors with the same IC.
- Speed and Direction control is possible
- Motor voltage Vcc2 (Vs): 4.5V to 36V
- Maximum Peak motor current: 1.2A
- Maximum Continuous Motor Current: 600mA
- Supply Voltage to Vcc1(vss): 4.5V to 7V

- **SD CARD**

Fig4.2.8. SD card

The MicroSD card is the hard disk of the Raspberry Pi. 16 GB of capacity are sufficient for the system image. Secure Digital (SD) is a non-volatile memory card format for use in portable devices. It was derived from an earlier effort called the Multimedia card which is a flash memory card standard. While these devices are called memory cards technically they are really Solid State Disk drives since they are generally accessed like disk drives and are formatted to emulate a disk drive. **MicroSD** is a type of removable flash memory card used for storing information. SD is an abbreviation of Secure Digital, and microSD cards are sometimes referred to as µSD or uSD. The cards are used in mobile phones and other mobile devices.

- **HEAT SINK**

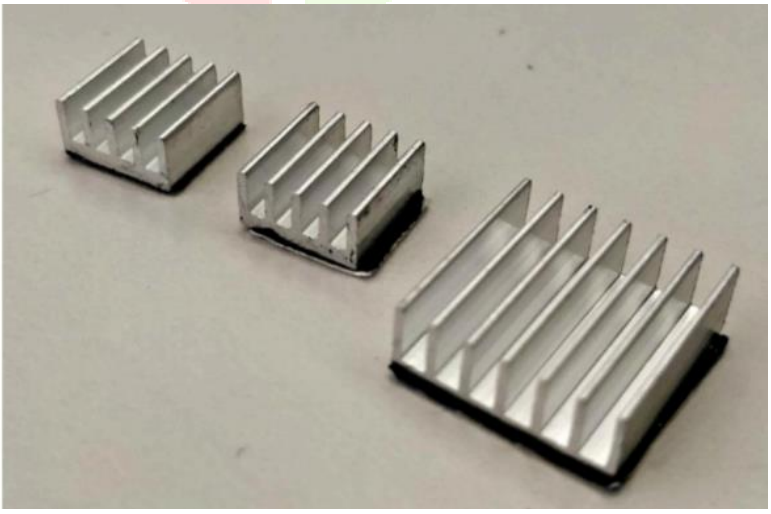


Fig4.2.9.Heat sink

A heat sink is a thermal conductive metal device designed to absorb and disperse heat away from a high temperature object such as a computer processor. Usually heat sinks are outfitted with built-in fans to help keep both the CPU and the heat sink at an appropriate temperature. Heat sinks are made out of metal, such as a copper or aluminum alloy, and are attached to the processor. Most heat sinks have fins, thin slices of metal connected to the base of the heat sink, which help spread heat over a large area. A heat sink (also commonly spelled heatsink) is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature at optimal levels. In computers, heat sinks are used to cool CPUs, GPUs, and some chipsets and RAM modules. Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronics such as lasers and light emitting diodes (LEDs), where the heat dissipation ability of the component itself is insufficient to moderate its temperature. The Raspberry Pi will heat up significantly during use. It is warmly recommended to add heat sinks, as in Figure 3.8. Since we will be stacking HATs on top of the Raspberry Pi with 15 mm standoffs, the maximum height of the heat sinks should be well below 15 mm. The chip dimensions are 15x15mm and 10x10mm.

- **BATTERY**

Fig4.2.10. Battery

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the '-' side), a cathode (the '+' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode).When the anode and cathode of a battery is connected to a circuit, a chemical reaction takes place between the anode and the electrolyte. This reaction causes electrons to flow through the circuit and back into the cathode where another chemical reaction takes place. When the material in the cathode or anode is consumed or no longer able to be used in the reaction, the battery is unable to produce electricity. At that point, your battery is "dead."Batteries that must be thrown away after use are known as primary batteries. Batteries that can be recharged are called secondary batteries.

The battery provides power to the Autonomous vehicle. We choose this battery because it has a good combination of size (to fit in the lower deck of the Magician Chassis), high output amperage (2.4A and 2.1A at 5V DC) over two USB outputs, a good capacity (10400 mAh) at an affordable price.

4.3 SOFTWARE REQUIREMENTS

- **Python**

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed. We require python 3.6.

CONCLUSION

In this paper , a testbed for research and development within the areas of autonomous driving, we are able to achieve cost effective autonomous vehicle testbed. It is difficult to test real autonomous vehicle under harsh Conditions, using test scaled autonomous vehicle becomes an apparent alternative. We have leveraged precise specification and resource management in developing the system to enable a sliding scale of realism. We have targeted an autonomous driving application here, this model, with augmented capabilities; can be extended to autonomy in other less structured domains, such as air, sea, and perhaps space robotics.

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