DEVELOPMENT OF GAS SENSOR AND CAMERA VISION IN UNMANNED GROUND VEHICLE FOR AUTOMOTIVE APPLICATION

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ABSTRAK

Rover adalah peranti robotik yang mengintegrasikan sistem asas yang bersama-sama melaksanakan komponen elektrik dan mekanikal. Dalam penyelidikan ini, rover menggunakan komponen mekanikal terdiri daripada lengan robot, cengkaman sendi dan mekanikal, casis tulang belakang, dan pergerakan, sementara komponen elektrik merangkumi motor servo, servo pengawal, pemancar dan penerima untuk sistem penglihatan dan tanpa wayar pengawal sistem kawalannya dicadangkan. Selain itu, sebagai platform sensor bergerak, ia juga harus dilengkapi dengan sensor gas yang dapat menunjukkan jumlah gas ambang berbahaya kepada pengguna. Projek ini bertujuan untuk tujuan kawalan dan keselamatan. Selanjutnya, objektif utama projek ini adalah untuk membuat robot rover sederhana yang mudah dan menjimatkan kos untuk dikembangkan dan dihasilkan. Ia dilengkapi dengan lengan robot dan integrasi kamera penglihatan masa nyata untuk menambahkan lebih banyak kesesuaian pada rover ini. Rover ini dilengkapi dengan kamera FPV (First Person View), kamera bersepadu pada rover akan memberikan penglihatan dan arah yang baik kepada juruterbang rover. Tesis ini akan menggambarkan perlunya teknologi yang mencukupi dan boleh dipercayai serta alternatif robot rover yang disesuaikan dengan baik untuk keadaan setempat, yang dapat meningkatkan keselamatan pekerja dengan ketara. Oleh itu, dalam pelbagai misi, termasuk pengesanan korban, pengenalan bencana, pencarian dan penyelamatan, pengawasan dan pengintaian, dan penilaian risiko, teknologi rover yang dicadangkan juga dapat digunakan. Untuk hasilnya, sistem pengesan gas dan penglihatan robot berjaya dibangun menggunakan sensor gas MQ-2 dan sistem FPV khas yang kini tersedia di pasaran. Sensor gas MQ menggunakan pemanas kecil dengan sensor elektrokimia di dalamnya. Mereka sensitif terhadap gas. Setiap kali kepekatan gas meningkat, rintangan akan menurun (tetapi arus akan meningkat). Ia menyebabkan perubahan voltan dan dibaca pada pin output analog. Gambar yang diambil dihantar ke stesen darat, yang merangkumi monitor yang disambungkan ke modul penerima. Frekuensi gambar yang dihantar ditetapkan ke 5.8GHz, dan banyak saluran dapat dipilih. Unit pemprosesan gambar dapat memberikan gambar digital dari objek yang ditangkap oleh kamera. Sistem FPV dapat ditingkatkan lebih jauh, dengan radius yang lebih besar, resolusi lebih tinggi, dan kemampuan pengenalan dan pengenalan objek. Pada masa yang sama, kemajuan dalam penglihatan komputer dan pembelajaran mesin juga bergerak menuju sistem yang lebih kompleks yang dapat digunakan.

ABSTRACT

Rover is a robotic device that integrates a basic system that jointly implements electrical and mechanical components. In this research, a rover using mechanical components consists of a robotic arm, a joint and mechanical grip, a spine chassis, and locomotion, while electrical components include a servo motor, a servo controller, a transmitter and a receiver for vision system and wireless controller its control system is proposed. Besides, as a mobile sensor platform, it should also be fitted with a gas sensor that can show users the number of hazardous threshold gases. This project is intended for control and safety purposes. Furthermore, the main objective of this project is to make a simple robotic rover that is both easy and cost-effective to develop and produce. It is fitted with a robotic arm and real-time vision camera integration to add more versatility to this rover. This rover is fitted with an FPV camera (First Person View), an integrated camera on the rover will provide the pilot of the rover with good vision and direction. This thesis would illustrate the need for adequate, reliable technologies and a well-adapted robotic rover alternative for the local situation, which can significantly improve the safety of workers. Therefore, in various missions, including victim detection, disaster recognition, search and rescue, surveillance and reconnaissance, and risk assessment, the proposed rover technologies can also be used. As for the result, the gas detector and robot vision system were successfully constructed using the MQ-2 gas sensor and the typical FPV system currently available on the market. The MQ gas sensor uses a small heater with an electrochemical sensor inside. They are sensitive to gas. Whenever the gas concentration increases, the resistance will decrease (but the current will increase). It causes a voltage change and is read on the analog output pin. The captured image is sent to the ground station, which includes a monitor connected to the receiver module. The transmitted image frequency is set to 5.8GHz, and many channels can be selected. The image processing unit can give a digital image of the object captured by the camera. The FPV system can be further upgraded, with a larger radius, higher resolution, and object recognition and recognition capabilities. At the same time, advances in computer vision and machine learning are also moving towards more complex systems that can be deployed.

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LIST OF SYMBOLS

kg	Mass
kgm2	Moment of inertia
mm or ◦	The resolution of each axis movement
N	Thrust
Nm	Torque

LIST OF ABBREVIATIONS

CL	Closed Loop
CRASAR	Center for Robot-Assisted Search and Rescue
DOF	Degrees of freedom
EOD	Explosive Ordnance Disposal
FEMA	Federal Emergency Management Agency
FLIR	Forward-looking infrared
FPV	First Person View
HAZMAT	Hazardous Materials Management
HD	High dimension
ICARUS	Integrated Computer Application for Recognizing User Service
IGS	International GNSS Service
JPL	Jet Propulsion Laboratory
Kd	Derivative Gain
Ki	Integral Gain
Kp	Proportional Gain
LQR	Linear Quadratic Regulator
LUGV	Large Unmanned Ground Vehicle
OCU	Operator Control Unit
OL	Open Loop
PAEK	Polyaryletherketone
PID	Proportional Integral Derivative
PPM	Parts per million
RF	Radio Frequency
SUGV	Small Unmanned Ground Vehicle
UGV	Unmanned Ground Vehicle
WMR	Wheel Mobile Robot

CHAPTER 1

INTRODUCTION

1.1 Project Background

An unmanned ground vehicle (UGV) can be defined as a vehicle that moves on the ground and can be used without supervision. It can lift equipment and equipment (Fofilos, 2014). In many risky military operations, such as handling explosives, dispersing bombs, and frontline reconnaissance, it is used as a human substitute. Robots including UGV, have numerous important ascribes that will help and supplement fighters in the war zone. They are appropriate to perform standard and exhausting errands. They are valiant and energetic. They do redundant undertakings with speed and exactness. They can be intended to keep away from or withstand adversary deadly implements and to perform explicit military capacities. Above all, robots can lessen setbacks by expanding the battle viability of officers in the combat zone.

Hence, this thesis is a sort of UGV named automated rover that can move under troublesome territory conditions. Besides, the rover comprises a movement framework coordinated with sensors, PCs, programming, and extra highlights dependent on the motivation behind the vehicle (Habib and Baudoin, 2010). Robot parts, for example, arms and grippers are added to this rover and have wide applications in the virtual world. It is utilized in science, spatial examination, wellbeing, and military design. In hazardous and risky circumstances, it will, in general, diminish or dispose of dangers just as to dodge dangers to life or passing's for staff (Janai et al., 2017; R. Welch and G. Edmonds, 1994).

DRDO Daksh robot is one of automated ground vehicle robot innovations joined into one unit and make it work adequately, which is constrained by far off in finding the dangerous articles securely and decimating them. This is accomplished by the X-beam machine to find metals and LED. It is likewise utilized for climbing flights of stairs and filter vehicles for explosives. Daksh is a battery-worked far off controlled robot on wheels that was made with an essential capacity of bomb recuperation. Created by Defence Research and Development Organization, it is completely computerized. It can explore flights of stairs, arrange steep slants, explore restricted hallways and two vehicles to arrive at risky materials. Utilizing its robotized arm, it can lift a speculate item and output it utilizing its versatile X-Ray gadget. If the thing is a bomb, Daksh can defuse it with its water fly disrupter. It has a shotgun, which can tear open bolted entryways, and it can examine vehicles for explosives. With an expert control station (MCS), it very well may be distantly controlled over a scope of 500 m in view or inside structures. 90% of the robot's segments are native. The Army has likewise submitted restricted arrangement creation requests for 20 Dakshs. The principal clump of five units was given over to General Combat Engineers, on 19 December 2011 (Prasad Kulkarni, 2008).

Figure 1.1 DRDO Daksh ROV, Source (Prasad Kulkarni, TNN, Nov 28, 2008)

Locomotion is a vital mechanical component to be concentrated since it will viably supplement UGV movement. Plus, kinematic and dynamic components that are steady, contact surface qualities, and the sort of climate that the robot needs to be conveyed were additionally thought of. In portable robots, four types of movement are utilized for legs, wheels, tracks and hybrid movement. The idea of exploration work is to make a rocker-bogie drive framework dependent on those of NASA. NASA built up the rocker-bogie suspension framework for their rovers and was actualized in the Mars Pathfinder's Sojourner rover. The rocker-bogie suspension framework inactively keeps each of the six wheels on the robot in contact with the ground even on lopsided surfaces. It likewise can be utilized for different purposes to work in unpleasant streets and to climb the means.

A UGV prototype was developed following these principles, operating on electrical power and receiving commands from a computer via remote control software, featuring an IP surveillance camera. It is based on a 6 DOF Robotic Arm and is powered by an automobile battery with a high capacity, which provides ample power for several hours of use. An electric motor drives the vehicle quietly and efficiently, while a small onboard laptop is connected to the vehicle motion controller. The combination of a typical 12 Volt battery and an electric motor offers a reliable and relatively low-cost solution to the problem of UGV mobility, reducing maintenance requirements.

This prototype is suggested as a base for further development. The architecture was purposely kept as simple as possible, allowing for potential improvements and keeping the cost of construction low.

1.2 Problem Statement

Generally, robotic rover systems are expensive. The robotic rover is heavy, bulky, and requires a lot of storage space. In addition, standard rover components are specifically produced and manufactured for specific tasks, thus reducing the versatility and scope of system adjustments.

Some researchers report that the UGV robot used for nuclear detection still has several problems to be solved. They are too slow because it is bulky and heavy and difficult to move around, especially on stairs and uneven surfaces (Wehe et al., 1989). It shows that according to the requirements of the competent authority, this kind of mobile station needs to have a special design to enable it to climb the stairs at a higher speed. Issues to explain which is the speed is too loaned because it is substantial and huge, in this manner making it hard to move around particularly steps and lopsided surfaces.

It may usually be used during dangerous and threatening situations such as spilled chemical and gas leakage to collect data. To recover gas detection, Rover should use a gas sensor to obtain data, and the rover must simultaneously demonstrate the vision and evaluation results of the camera. Besides, because the distance from the consumer is too limited and unpredictable can occur, the limitation of the reach can put officials at high risk. Moreover, in corrosive gas environments, the rover has to be deployed so that it also needs material that can withstand high thermal conditions.

The complexity of robot tasks is getting higher and higher, so it is necessary to design and analyse intelligent, robust, computer-simple, and easy-to-implement controllers to optimize and maximize the performance of industrial robots.

Experimenting with the actions and mechanisms of real robots can damage the robot and require a lot of cash. Robot modeling and computer simulation to reduce the cost and time required to research robotic systems.

In managing the complete system to do surveillance has given, this problem can be mitigated used threatening situations such as spilled chemical and gas leakage to collect data to recover gas detection.

1.3 Objectives

The purpose of this study is to model and develop a controller for an industrial robot. The industrial robot should be able to perform a pick and place task and simulate it include:

i. To develop an embedded system such as a gas sensor and vision system for the robotic rover

ii. To develop a functional gas sensor prototype of the rover.

iii. To integrate a wireless vision system with the rover.

1.4 Scope of Project

This project will aim to build a robotic rover that will allow users to freely select the maximum number of customizable features installed on the rover. An example is the installed functionality, such as remote control, wireless HD camera, thermal camera, and gas sensor. Besides, there are a few conditions that allow the rover, such as before any accident occurs, to be deployed for the monitoring process and gas detection.

1.5 Organisation of Thesis

In addition to this chapter, it also includes the following chapters. Chapter 2 provides a literature review on the introduction of the rover and describes how to construct this type of robotic rover. In addition, as far as electrical and mechanical components are concerned, the similarities between the previous rover and the developed rover will prove a research gap in the robotic rover. However, the realization in the real world will be announced at the end of the project to create this great project.

Chapter 3 introduces the recommended methods that are used to create the details of the flowchart study on how to make a robotic rover. The parameters also need to be checked, because all calculations will affect the performance of the robotic rover. This chapter will also briefly explain how the robot rover control system integrates other features.

The important content of the thesis is results will be covered in chapter 4 in the way the final finding of the proposed methodologies before. That will show the strength and the limitation of the product that developed. So that, future work can propose to improve the qualities of the product in the ecosystem of the innovation technology world to maximise human potential for societal good.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In different instances of contact with the surrounding world, human beings have continuously tried to locate alternatives that can imitate their actions based on the course of centuries. Robotics has profound cultural roots and as a science dealing with the intelligent movement of various robot mechanisms which can be classified in the following four groups: robot manipulators, robot vehicles, man-robot systems, and biologically inspired robots, (Matjaž Mihelj et al, 2019).

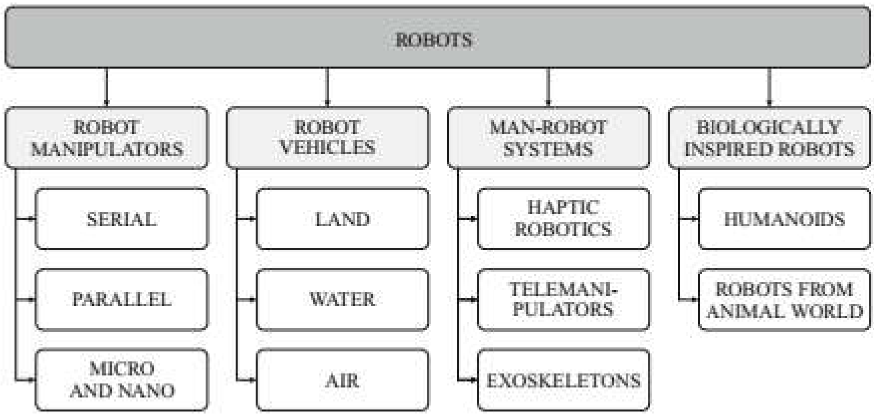


Figure 2.1 Classification of robots, Source: (Matjaž Mihelj et al, 2019)

Serial robot mechanisms are the most commonly encountered robot manipulators. One of the areas of interest in manufacturing, educational and medical applications is the industrial robot manipulator market. Study into the control of industrial robot motivation and movement. According to Webster, a robot is "An automatic device that performs functions normally ascribed to humans or a machine in the form of a human".

2.2 Unmanned Ground Vehicle

This section discusses the characteristics and implementations of two types of UGV, Large UGV and Large UGV. UGV types can be classified based on their load-lifting capabilities. Besides, because of their distinct role and position to be deployed, the nature of UGV differs.

2.2.1 Large Unmanned Ground Vehicle (LUGV)

Large Unmanned Ground Vehicle (LUGV) is a chain drive vehicle that was originally developed as part of the Integrated Computer Application for Identifying User Services (ICARUS) project, which performs search and rescue operations (Gert De Cubber, etc.) People, 2013). Usually, because it is equipped with multiple sensors such as cameras and gas sensors, it can assist in collecting data about hazardous areas and sending them directly to the final security personnel. Besides, LUGV also has external features such as a high-capacity gripper to lift payloads (Armbrust, De Cubber, & Berns, 2014).

The production of rover designs is usually based on the specifications and standards required by the authorities. Table 2.1 lists several examples of LUGV with general requirements in the nuclear field.

Table 2.1 Examples of LUGV in the nuclear industry

Robot	Payload Capacity	Operating Area	Functions	Total weight	Year
AMOOTY	10 kg	Nuclear power plant	Dig in hole Climb stairs	360 kg	1985
Dry Ice Blast Decontamination Device	-	Reactor building	Decontaminate dry ice blast	730 kg	2014

Source: (Iqbal, Tahir, Islam, & Riaz un, 2012) and (Saito et al., 2016)

In 1985, scientists at the University of Tokyo created a robot called AMOOTY, which was named after six robotic researchers (Iqbal et al., 2012). Figure 2.1 shows the structure of the robot. It looks like the trunk of an elephant and can go upstairs. Robotic researchers studied the concept of nuclear reactor maintenance and created a robotic locomotive device and nine degrees of freedom (DOF). The paper was a huge success. At the time, there was still no robotic arm. The robot still faces some challenges. Because it is heavy and wide, the pace is too slow to rise and pass on rough surfaces (Wehe et al., 1989).

Figure 2.2 AMOOTY, Source: (Armbrust et al., 2014)

Besides, LUGV has been used for search and rescue activities as well. Several examples of LUGVs with their general requirements in Hazardous Materials Management (HAZMAT) search and rescue operations are described in Table 2.2. The robotic rovers, for the most part, are massive, bulky, and take up a lot of storage space. Hazardous Materials Management (HAZMAT) agencies, for instance, face numerous hazardous hurdles when carrying out their life-saving responsibilities. In places where people are afraid to step on, the robot rover presents the most terrifying danger during the initial entry and repair steps.

Table 2.2 Examples of LUGV in HAZMAT Department

Robot	Operating Area	Year
ANDROS	Nuclear power plant	1991
HAZBOT II	Dangerous situation	1992

Source: (Welch, 1994; R. V. Welch & G. O. Edmonds, 1994)

HAZMAT personnel's first entrance is especially risky because the nature of materials used could be undisclosed. A robotic rover system may be applied to evaluate, decrease or minimize the risk to resolve this risky situation. Via this, every life-threatening or death threat to individuals that lurk in any wrong move can be avoided. Therefore, the key purpose of the Jet Propulsion Laboratory (JPL) Emergency Response The robotics project aims to develop remote-controlled mobile robots that the HAZMAT team can quickly deploy. In October 1991, the prototype was constructed and the robot was renamed Remote Andros Mark V-A (Welch, 1994).

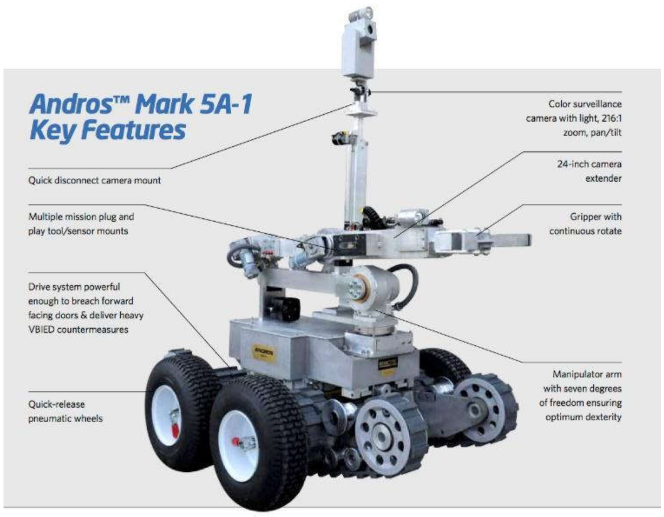


Figure 2.3 Remoted Andros Mark V-A, Source: (R. Welch & G. Edmonds, 1994)

In 1991, another rover was built by the Jet Propulsion Laboratory under the Emergency Response Robotics project. This rover, as seen in Figure 2.3, is a remote mobile robot named Andros for HAZMAT squad deployment (R. Welch & G. Edmonds, 1994). In order for the HAZMAT team to determine other requirements for the effective use of this robot, the team conducted various tests and trainings on the robot.

The Andros robot was redesigned by incorporating other specifications, such as track changes and advanced key instruments. The route was adjusted by clarifying the front and back of the stair climbing robot. Then developed a special key instrument to open the door of the robot. In opening doors, a winch mechanism has also been added as an aid to the robot. The robot was renamed HAZBOT II based on these modifications created by the HAZMAT team (Stone & Edmonds, 1992). Figure 2.4 shows that HAZBOT is a type of UGV used only in emergency situations, also known as ground emergency vehicles.

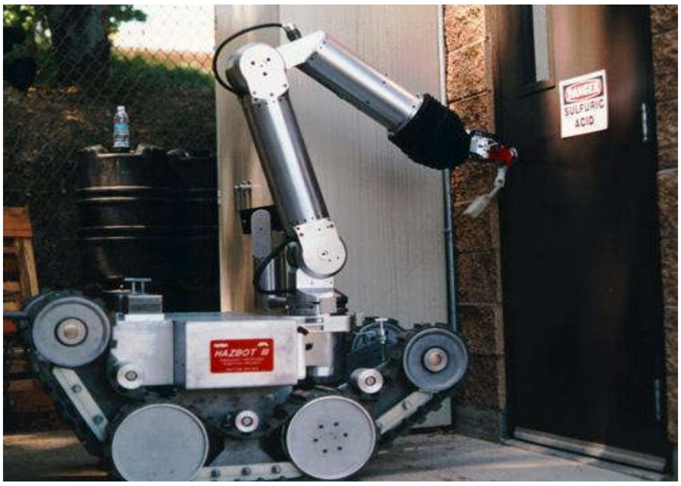


Figure 2.4 HAZBOT II, Source : (Matthies et al., 2002)

However, the researchers found that the design of HAZBOT II has many inconveniences, for example, they rely on the currency manipulation of the manipulator on the operator control panel. Therefore, they agreed to modify and upgrade the robot to operate in a potential fuel environment (Matthies et al., 2002). In order to reduce pollution, if it is used to manage chemical gases, the smooth contour must be redesigned. In addition, researchers have considered increasing the speed of the robot and the flexibility of the manipulator.

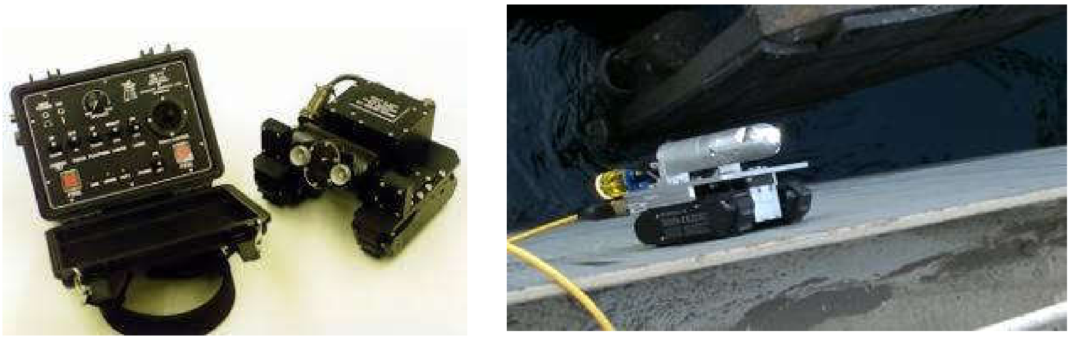
2.2.2 Small Unmanned Ground Vehicle (SUGV)

A UGV that can lift loads less than 90 kg can be called SUGV. As shown in Table 2.3, this section discusses and examines several examples of SUGV in search and rescue operations. The Federal Emergency Management Agency (FEMA) has proposed the robot specifications to the Robot-Assisted Search and Rescue Center based on the following table (CRASAR). Finally, due to the smallest size, they decided to choose the Inuktun mini-track VGTV. However, in certain situations that require time constraints, they can usually use Solem robots. The explanation is that the Solem robot is three times more dexterous than Inuktun and has greater potential to scale more irregular rubles (R. R. Murphy, 2004).

Table 2.3 Examples of SUGV in search and rescue operation

Robot	**Year**
Inuktun micro-Tracs VGTV	1989
Micro-Tracks	1989
Foster-Miller Solem	2001
Talon	2001

Source: (Liu & Nejat, 2013),(R. R. Murphy, 2004)



(a) MicroTracs (b) VGTV

Figure 2.5 Examples of SUGV (a) MicroTracs and (b) VGTV, Source: (Liu & Nejat, 2013)

Owing to their small size and basic control unit, the MicroTracs and VGTV were chosen over the other robots. They both have the most common modern technologies for data and search equipment. Also, due to their ability to provide video that can be controlled remotely, these two robots are called "cameras with wheels" as the most obvious feature. In comparison, the operator's time consumption is just in the range of 1.5 minutes. Typically, before starting their mission on the rubber mound, the specialist rescuers selected the tiny robot to be used.

Foster-Miller was holding two robots. Solem and Talon. Talon can travel on all terrains and by using two-way radio frequency, users can control (RF). By viewing the image transmission at 1.6 km, the Operator Control Unit (OCU) will normally provide accurate feedback. Besides, due to its velocity, the robot has high dexterity that can exceed 6.6 kni/h. Also, while Talon was classified as SUGV, it is capacity for lifting payload is higher than 90 kg. In addition, special vision systems such as FLIR, night vision, microphones and zoom cameras are installed.

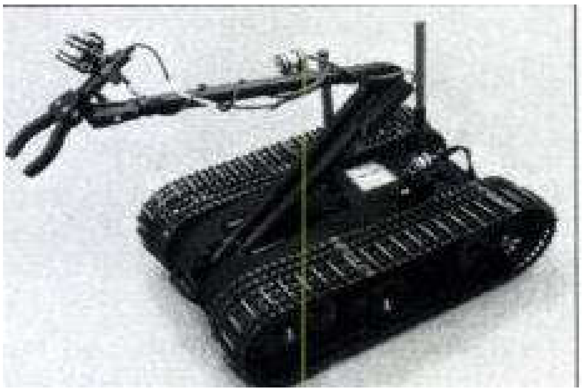


Figure 2.6 Talon robot, Source: (R. R. Murphy, 2004)

2.3 Tools of Architectural

Unmanned vehicle systems are large collections of modules for perception, planning, and control (Martial Hebert, Charles E. Thorpe, Anthony Stentz, et al, 1997). Modules interact at various rates, require various bandwidths, and they have distinct goals. It is important to be able to assemble such a diverse set of modules into cohesive, integrated systems for complex missions. Therefore, providing a structured architecture is a structure that merges individual components into a cohesive integrated system, which is the key to creating a successful autonomous system.

The main characteristic of this strategy is its versatility. For instance, before their introduction into a larger system, behaviors may be independently developed and evaluated. Conversely, without impacting the rest of the scheme, the algorithms used within a specific action may be changed. Finally, since new habits can be added without changing the current system, it is encouraged to gradually improve the navigation system.

Three types of tools have been built to implement this method: a communication toolkit, which includes all the functions required for communication between software modules; an arbitration framework, which will create steering, speed, and Sensor direction commands are incorporated into actual vehicle controller commands; as well as mission planning and control environment.

2.4 Mechanical Aspects in Development of Rovers

Its mechanical structure is the key characteristic of a robot. The method of embedded features on the rovers is discussed in this section.

2.4.1 Robot Mechanical Structure

The robot manipulator classification is classified by types of coordination systems. Robot manipulators are typically categorized according to the configuration of their arm geometry or kinematics. In one of these five configurations, the majority of these manipulators break.

To have a sufficient number to perform a given task, the degrees of freedom (DOF) should be correctly distributed along with the mechanical structure. Six DOFs are required in the most general case of a task consisting of arbitrarily placing and orienting an object in three-dimensional (3D) space, three for positioning a point on the object. Concerning a reference coordinate frame, and three for orienting the target. The manipulator is said to be redundant from a kinematic point of view if more DOFs are available than task variables (Bruno Siciliano et al, 2010).

Until considering the industrial robot's efficiency and requirements manipulator. The basic typical mechanical structure must define the degree of freedom of the coordinate frame-dependent robot manipulator to be understood.

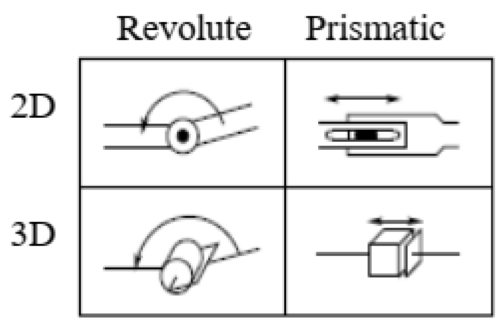
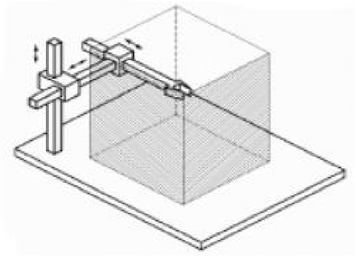
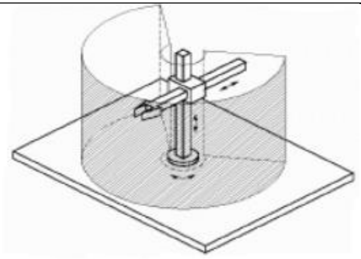
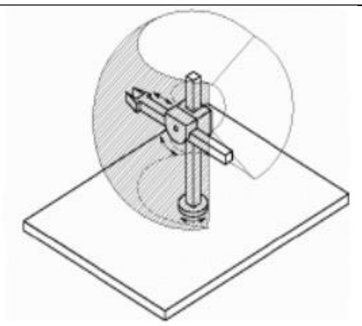
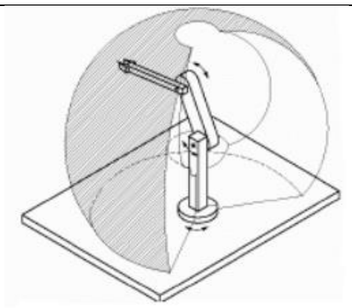
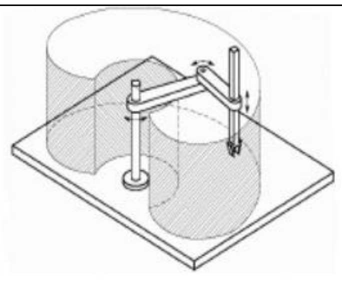


Figure 2.7 Representation of robot joints, Source: (Mark W. Spong et al 2005)

Table 2.4 Classification of robot manipulators, Source: (Bruno Siciliano et al, 2010 and Matjaž Mihelj et al, 2019)

Type	Workspace	Types of Joint	Symbol	Application
Cartesian		• Three prismatic joints • A cartesian degree of freedom	PPP	• Assembly • Pick and place
Cylinder		• One revolute joint and two prismatic joints • Cylinder configuration	RPP	• Machine tool • Spot welding
Spherical		• Two revolute joints and one prismatic joint • Spherical configuration	RRP	• Gas and arc welding
Articulated		• Three revolute joints • Most hand structure	RRR	• Welding • Spray painting
SCARA		• Two revolute joints and one prismatic joint • Selective Compliance Assembly Robot Arm	RRP	• Assembly

The robot data must be accompanied by the characteristic loading parameters, such as mass (kg), torque (Nm), the moment of inertia (kgm2), and thrust (N). The maximal velocity must be given at a constant rate when there is no acceleration or deceleration. The maximal velocities for particular robot axes must be given with the load applied to the end-effector. The resolution of each axis movement (mm or ◦), description of the control system, and the programming methods must also be presented (Matjaž Mihelj et al, 2019).

2.4.2 Locomotion

Locomotion is a very important mechanical feature to be studied since it will effectively complement UGV maneuverability. Besides, kinematic and dynamic elements that are stable, contact surface characteristics, and the type of environment that the robot requires to be deployed were also considered. In mobile robots, four forms of motion are used for legs, wheels, tracks and hybrid motion (Siegwart, Nourbakhsh, & Scaramuzza, 2011).

Leg locomotives are the first category. The number of points on the contact surface connecting the robot to the ground is specified. You can divide leg movements into one leg, biped leg, quadruped leg and hexapod leg. Each of them has its own special function, according to their robot application, the researcher only needs to choose. For example, a single-legged robot only needs a series of single touch points to enable it to travel on uneven terrain. However, the disadvantage of this design is that it affects stability, so the robot needs to change its gravity core or transfer pressure correctly to maintain stability.

Wheeled locomotives are the second type. Various fields and technologies have been used, such as Wheeled Mobile Robots (WMR) in the medical industry (A.E.-S.B.J.J. J. Ibrahim, 2016). By using this movement method, all wheels are automatically suspended, especially when the robot is moving on uneven terrain and more than three wheels are used to maintain ground contact. Instead of the issue of stability, this method of locomotion would also appear to focus on traction power, ability to move, and control mechanism. Moreover, the benefit of using wheeled locomotion is that it is possible to eliminate the risk of the robot slipping (Hamid, Nazih, Ashraf, Abdulbaky, & Khamis, 2016).

Tracking motion is the third type. Compared with wheeled motion, this idea uses a different principle because the design implements a double pedaling mechanism, which can be controlled by a mobile robot when using differential drive conditions. This movement is widely used in security agencies, such as reconnaissance, military and explosive ordnance disposal (EOD) surveillance exploration (Schempf, 2003).

Hybrid locomotion is the last type. The benefits of both prior locomotion, legged and wheeled locomotion, are incorporated through this definition. This means that by using the legged locomotives concept, hybrid vehicles can face challenges and drive on rugged terrain. At the same time, they can use the wheeled sports concept to move at high speeds on hard surfaces (Siegwart et al., 2011).

2.5 Electrical & Electronic Aspects in UGV Developments

This section reviews the types of control systems and vision systems traditionally used in rover stations. By pointing out the types of communication and vision systems commonly used by rover, it will further explain how to monitor the movement of the rover.

2.5.1 Control System

The control system is a mechanism that controls the behavior of all subsystems. It allows various parts of the robot to move and move, while allowing them to perform a specific set of movements and forces. Generally, the control system is divided into two kinds of open loop (OL) and closed loop (CL) system technologies. The controller sends the signal to the motor in the OL control system, but the output signal will not return or provide feedback because there is no parameter to calculate the current motor status. On the other hand, the output signal will be returned by the CL control device as input to explain the current state of the motor. The CL controller provides a certain benefit over the OL controller. However, many types of control systems, such as proportional integral derivative (PID) control, linear quadratic regulator (LQR) and international GNSS service control, have been widely used to control robots (IGS).

A robotic mechanical system consists of a few subsystems, namely (a) a mechanical subsystem consisting of both rigid and deformable bodies in turn, although only the former is the systems we will analyse here; (b) a sensing subsystem; (c) an actuation subsystem; (d) a controller; and (e) a subsystem for information processing. Besides, these subsystems communicate with each other through interfaces, the purpose of which is essential to decoding the transmitted information from one medium to another (Khalil and Dombre, 2002).

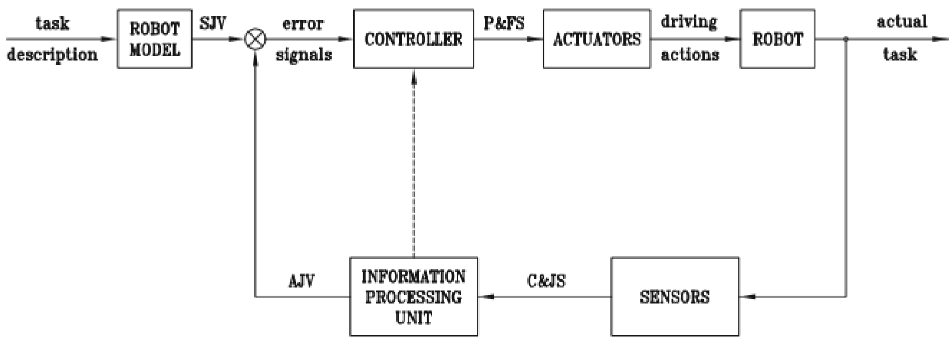


Figure 2.8 General architecture of a robotic mechanical system, Source: (Jorge Angeles et al, 2015)

The controller seeks to decrease the error to zero between the fixed point and the feedback signal. However, if the input signal and feedback signal are not equal, the position signal will be corrected by the controller until zero is the difference between the two signals. Because of nonlinearity, several systems can be unstable at all times, so a good control system must generate control output to track the desired response. This confirms that ensuring that the complex response of the closed-loop systems is stable is an essential problem when developing a control system.

To achieve reliability, monitoring, and parameter robustness, the PID regulator activates the controller. In addition, the control system is an indispensable regulator or controller, and it implements PID regulators in almost all controllers in almost every industry. The PID control equation shows equation 2.1. We only need to know 3 knobs. The first is the proportional gain Kp. Ki is the integral gain, the other is Kd, and then the differential gain Kd. The results of these gains prove the stability of the equation. In a sense, it makes the method impossible to guarantee. But the system is helping to make it more stable. In addition, because the speed of the system is not super-fast in practical applications, it pushes the device to value, which is called medium rate reactivity. The response speed depends on a function of how high Kp is. Unfortunately, to achieve tracking, this type of device was usually not appropriate. However, the I is good for tracking and if the system is stable, it is enough to have the I component to ensure tracking in almost all cases.

$$u = Kp^{e} + K_i \int_0^t \quad edt + Kd\frac{d}{dt}e \tag{2.1}$$

One of the limitations of using PID control techniques is that due to the nonlinearity of the robot manipulator due to unpredictable conditions, they are not enough to obtain the desired tracking control output. A great deal of time is therefore needed to change PID parameters (G.U.V.Ravi Kumar and Mr.Ch.V.N.Raja et al 2014).

PID controller transfer function takes one of the two formats the first format is given such as;

$$G_{PID}(s) = K_p + K_I/s + K_D s \tag{2.2}$$

With K_P , K_I , and K_D are the proportional, integral, and derivative gains respectively. The second format is

$$G_{PID}(s) = K_P(1 + {}^{1}/_{T_I s} + T_D s) \tag{2.3}$$

With $T_I = K_P/K_I$ and $TD = K_D/K_P$ are known as integral and derivative time constant respectively.

If the input is positive large, the proportional gain K_P must be large, the integral term K_I small 'and the derivative term K_D small; thus speeding the performance of the device and if the input is very small, the PID parameters K_P should be smaller, K_I larger, and K_D larger; thus, the output would have reduced overshoot and faster response (G.U.V. Ravi Kumar and Mr.Ch.V.N.Raja et al 2014).

2.5.2 Gas Sensing

The use of sensors is of crucial importance for efficient and accurate robot operation. Robot sensors can be generally divided into proprioceptive sensors assessing the internal states of the robot mechanism (positions, velocities, and torques in the robot joints); and exteroceptive sensors delivering to the controller the information about the robot environment (force, tactile, proximity, and distance sensors, robot vision), (Matjaž Mihelj et al, 2019).

In general, sensors convert the measured physical variable into an electrical signal which can be in a digital form assessed by the computer. In robotics, we are predominantly interested in the following variables: position, velocity, force, and torque. By the use of special transducers these variables can be converted into electrical signals, such as voltage, current, resistance, capacity, or inductivity, (Matjaž Mihelj et al, 2019).

The main reason for needing robots to assist rescuers is that robots can be used in dirty and dangerous environments and can perform boring tasks at the same time. For example, it's like entering a space smaller than anyone can enter and entering a dangerous place exposed to fire or oxygen consumption. Figure 2 shows an example of a blank where rescuers cannot enter (Liu & Nejat, 2013).

Figure 2.9 Void on Fire, Source: (Micire & Murphy, 2002)

Generally, a gas sensor is a sensor composed of sensors that sense gas molecules. It sends an electrical signal as an output proportional to the gas concentration. The gas sensor did not sense a specific gas. Therefore, they must tend to use analytical techniques to identify specific gases. However, these analysis methods have many shortcomings of skilled operators, especially the shortcomings of the designed PC and slow response time, and the proposed system does not have these shortcomings. The proposed system is automatic but needs to be reset every time an emergency occurs.

It is an ideal sensor for detecting dangerous LPG leaks in homes, service stations, storage tank environments, and even vehicles that use LPG gas as fuel. The unit can be easily integrated into an alarm circuit/unit to sound an alarm or provide a visual indication of LPG concentration. The sensor has excellent sensitivity and fast response time. When the target combustible gas is present, the conductivity of the sensor will increase as the gas concentration increases. Figure 2-1 below shows an example of an MQ-2 gas sensor.

Figure 2.10 MQ-2 gas sensor

The sensitive material of MQ-2 gas sensor is SnO2, which has low conductivity in clean air. When the target combustible gas exists, as the gas concentration increases, the conductivity of the sensor will be higher. Use a simple electronic circuit to convert the conductivity change into its corresponding gas concentration output signal. MQ-2 gas sensor is shown in Figure 2.1, it is sensitive to propane, butane and natural gas. The sensor can be used to detect different combustible gases, especially methane. This is a low-cost sensor suitable for different applications.

According to previous research, the most important person in the rescue operation is the rescuers themselves, because 135 rescuers died in Mexico City and 65 rescuers died in the exclusion zone. It used to be a terrible history when lack of skilled rescuers wanted to risk their lives to save others. Eventually, some of them were injured, and unfortunately, rescuers died when they could not avoid being injured by dangerous surrounding obstacles. area.

2.5.3 The camera visions

A camera visions is essentially an imaging sensor that can be installed in the world reference frame at any position and orientation. It uses actual pixels to construct an artificial image imaged by a real camera, and then projects it onto the world model. By knowing the location of the real and virtual cameras, and assuming a flat world model, an accurate image reconstruction can be generated from the location of the virtual camera, called a virtual image.

The three principles upon which detection and navigation systems for roads and intersections should be centered are;

a) Image-guided should be identification and navigation.

b) Detection is signaled by the existence of characteristics.

c) Road junctions should be actively tracked by the branch of the road or intersection.

For the vehicle, a camera is created; the structure does not match the time of the intersection, but a location before the intersection. The system does not process "now we are at an intersection, so we need to find its branch", but processes information such as "start looking for a lane of road". The location of each virtual camera and the network associated with it depends on the type of road that should be found. If there is a path or intersection to be recognized, the virtual camera will image it in a way that is important to the system's neural network. The device will continuously monitor the network trust of each virtual camera to determine when there is a road or intersection.

Many UAVs, ROVs, or other remote-controlled vehicles use a radio frequency configuration that links the antenna to a digital-analog converter module. Radiofrequency enables video and other data to be monitored and exchanged remotely. Video transmitters normally run at a power level of 200mW to 1500mW. 900 MHz, 1.2 GHz, 2.4 GHz, and 5.8 GHz are the most common frequencies used for video transmission.

2.5.4 Communication System

There are many standard types that can be used to describe communication systems as information and data, or they can be transferred from one computer system to another through a geographic area. This information uses different methods, such as electric waves and electromagnetic fields transmitted through conductors, and finally light waves through optical fibers.

A wireless network is a collection of networks that uses radio signal frequencies to communicate between computers and other network devices. Therefore, the topology is the configuration of a geometric network, and a typical topology is composed of a star topology, a bus topology and a ring topology. However, many computer networks used for data transmission and resource transmission often require data. There are two types of wireless networks: local area network (LAN) and wide area network (WAN) (Rossi, Wang and Zuo, 1997), but today's networks are also used in the form of low-power wide area networks (LPWAN). (Jebril, Sali, Ismail and Rasid), 2018).

2.6 Summary

This chapter outlines the important information of the source, but synthesis is the reorganization or reorganization of that information. It can make new interpretations of old materials, or combine new materials with old interpretations. Or it can trace the progress of knowledge in the field, including major debates. And, depending on the situation, the literature review may evaluate the source and advise the reader on the most relevant or relevant content.

CHAPTER 3

METHODOLOGY

3.1 Introduction

When it is discovered that the problem is that the existing robotic rover is large and requires more space and cannot be deployed in a limited space, the rover development phase begins. The purpose of deploying robotic rover is to help security agencies conduct dangerous search and rescue operations. Then a literature review was conducted to examine the use of UGV and the method of building a robotic rover.

Finally, the rover will install other functions on the chassis, such as gas sensors and wireless cameras, to achieve stable UGV deployment. In addition, the rover must also be tested indoors and outdoors to enable it to be used under actual hazardous conditions. The results and reviews of the rover will be collected, enhancements will continue, and the process will stop when it can provide users with high efficiency.

3.2 Design of features

Figure 3.1 displays the flow diagram of the fabrication flowchart. This flowchart is proposed to design with other features such as gas sensors and vision systems. The flow map of our Integrated Concept Project Flow is shown in Figure 3.1. The first thing we need to do, based on the flow chart, is to define the problem based on the title given. After having researched the title of the design and development of a robotic rover under hazard conditions. The suggested design after researching the title and selected the design that wants to continue based on the screening principle that shows the score of each design based on the selection criteria want. To get some advice and opinion, the concept suggested was referred to our supervisor.

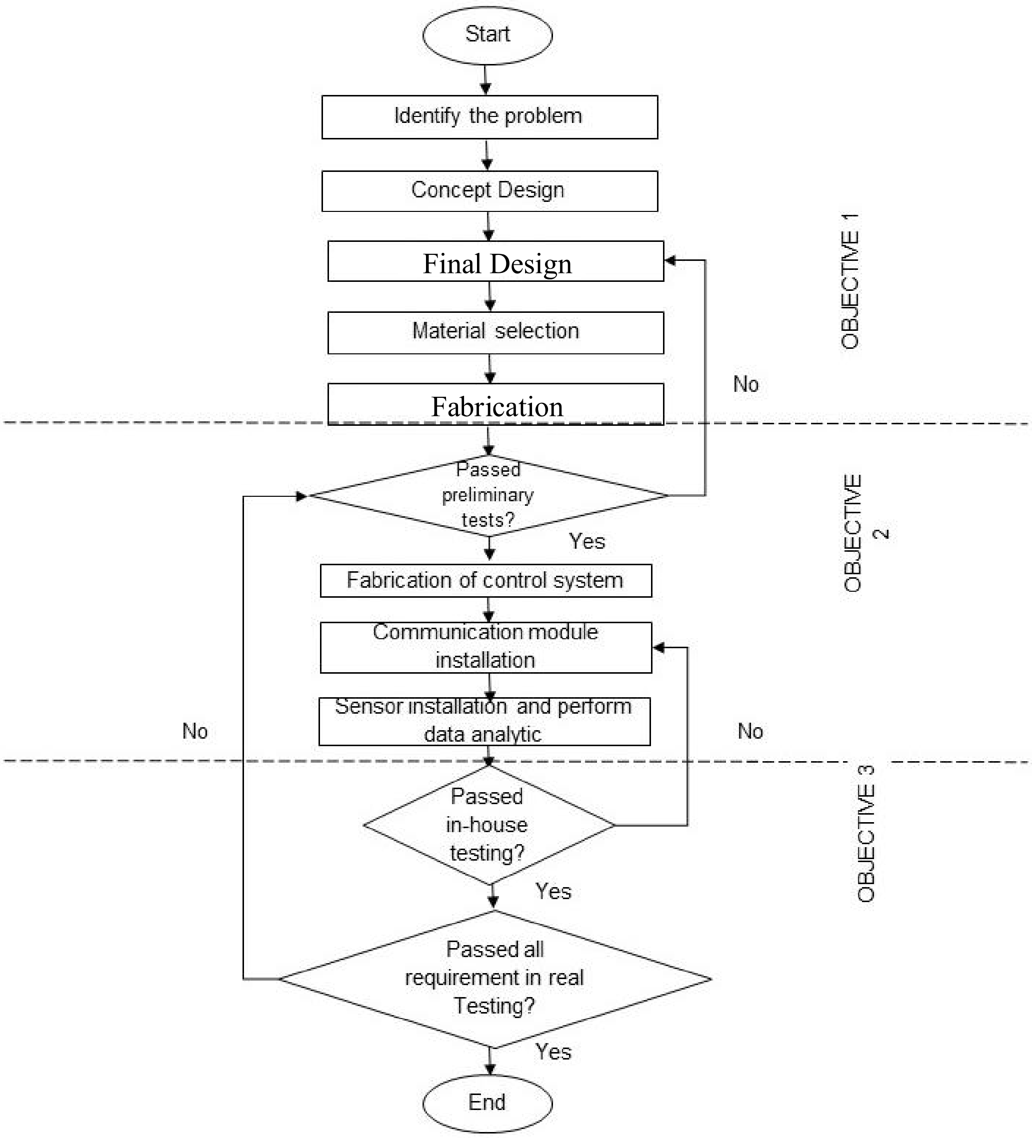


Figure 3.1 Fabrication Flowchart

It is proposed to build the suggested UGV with rocker boogie as its locomotion. Besides, the robotic arm, gripper, gas sensor, vision system, and controller were part of the UGV. Mechanical design involves selecting the appropriate motor for the rover application, selecting materials for the frame and robotic arm, and positioning the motor in the appropriate location within the rover.

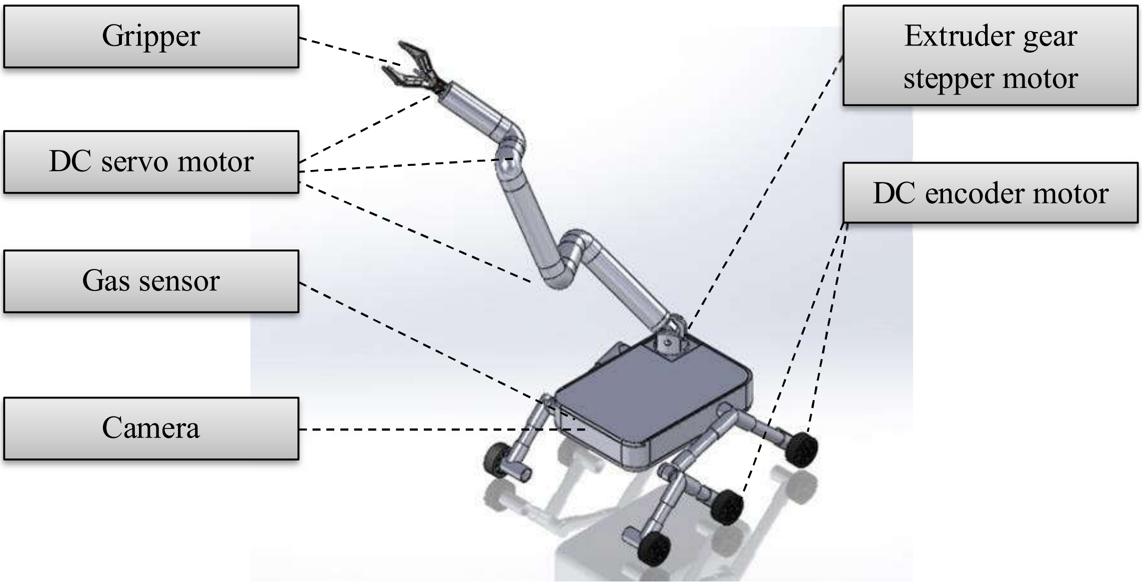


Figure 3.2 Proposed UGV

The main factor of aluminum is the low density of the metal and its corrosion resistance due to passivation. For the aerospace industry, structural components made of aluminum and its alloys are critical, and also critical for other transportation and structural materials fields. At least in terms of weight, the most useful aluminum compounds are oxides and sulphates.

In short, aluminum is almost always alloyed, which greatly improves its mechanical properties, especially after tempering. For example, alloys with an aluminum content of 92% to 99% are standard aluminum films and beverage cans. The main alloy agents (e.g., duralumin) are copper, zinc, magnesium, manganese, and silicone and the weight ranges differ by a few percent for the other metals.

3.3 Architectural System

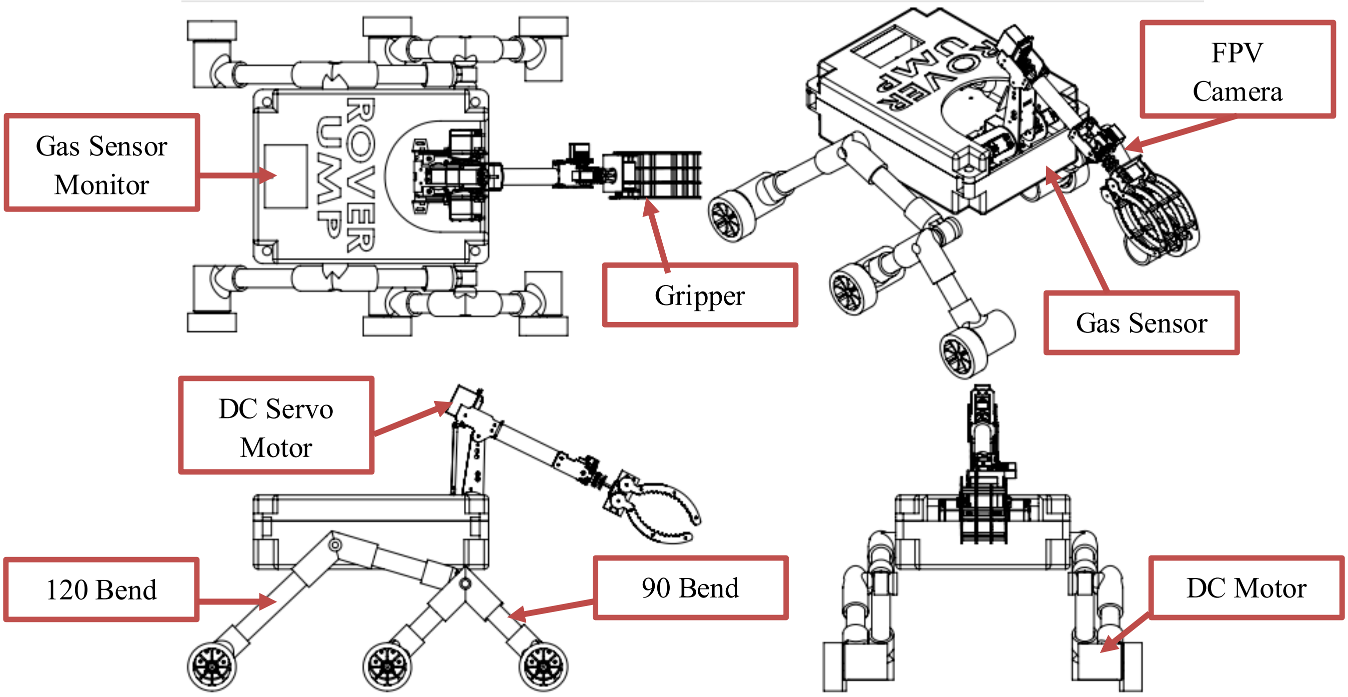


Figure 3.3 Mechanical Drawing of Rover

For the robotic rover, a multifunctional track is suggested to ease its mobility on all surfaces. Besides, to aid authorities, the built chassis robotic rover needs to climb the stairs. The design was modified to a rocker boogie design based on the purpose, which is explicitly constructed according to the research findings on the general size of stairs in architecture. Also, due to rotating the wheel, the rocker boogie would use six DC motors.

By using the rocker boogie mechanism, Figure 3.3 illustrates locomotion. Due to its suspension mechanism, this design is suitable for rovers, particularly when doing exploration activities. Besides, by changing the suspension ties and joints, users can alter the rocker boogie configuration. Therefore, it helps the rovers to change the center of mass and increase their stability while traveling. Also, the purpose of this design is to ensure that the rovers slip away when crossing sloppy terrain (Tarokh, 2016).

Usage of the Control Loop will also control this UGV. If the UGV wants to turn left or right, the control loop system will regulate the wheel motion. By following the correct angle, the motor will also be coded. This implies that it did not only counteract the motor driver but also required a feedback system with sensor implementation. Thus, the speed engine value can be specified when the encoder has been mounted.

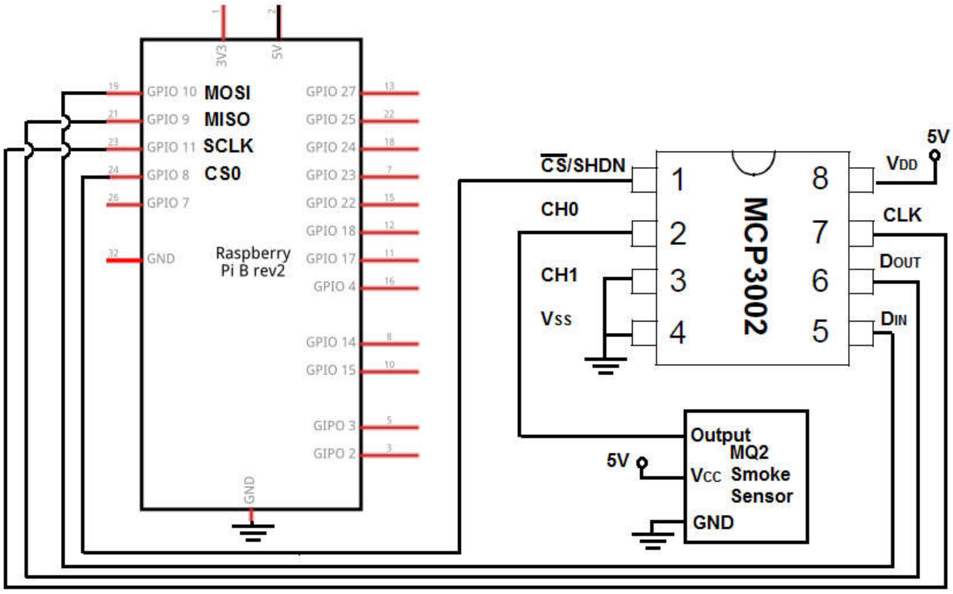


Figure 3.4 MQ-2 Smoke Sensor Circuit with Raspberry Pi Schematic

It is recommended to install a Grove-Gas sensor (MQ2) module on the UGV to detect gas leaks (home and industry). It can be used to detect H2, LPG, CH4, CO, flue gas, alcohol and propane and other gases. The technical data of the MQ2 gas library can be found in Appendix A. Due to its high sensitivity and fast response time, it can be measured as quickly as possible. The potentiometer can change the sensitivity of the sensor. The integration between the Raspberry Pi and the gas sensor (MQ-2) works well in the intelligent robotic rover shown in Figure 3.4.

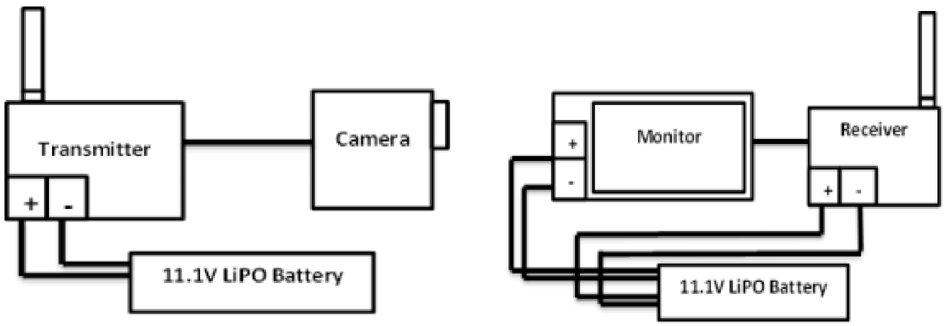


Figure 3.5 Transmitter & Receiver System of Camera Vision

An image sensor or also called a visual sensor is a device that detects and transmits information from the image composition. The way to process images is to convert the attenuation of light waves into signals. These waves can be light or other electromagnetic radiation.

A small camera is mounted on the top of the arm fixture to enable the first-person view (FPV) feature. Then, a monitor with a receiver converts the transmitter signal into an image so that the user can view real-time monitoring of the safety rover. Figure 3.5 Using the display transmitter and receiver system in the rover.

3.4 Gas sensor

It is recommended to install a Grove-Gas sensor (MQ2) module on the UGV to detect gas leaks (home and industry). It can be used to detect H2, LPG, CH4, CO, flue gas, alcohol and propane and other gases. The technical data of the MQ2 gas library can be found in Appendix A. Due to its high sensitivity and fast response time, measurements can be made as quickly as possible. The potentiometer can change the sensitivity of the sensor. The integration between the Raspberry Pi and the gas sensor (MQ-2) works well in the intelligent robotic rover shown in Figure 3.6.

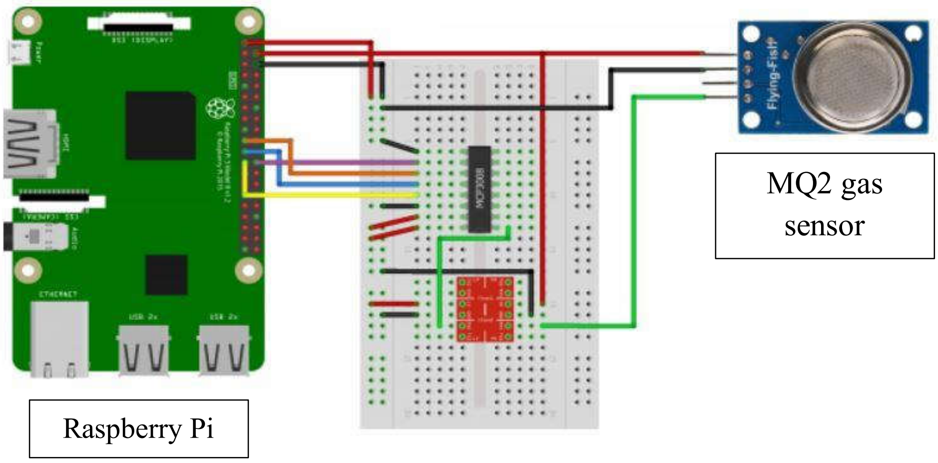


Figure 3.6 Circuit diagram for gas sensor

3.4.1 Analog-Digital Converter

The analog-to-digital converter is a type of data converter that has the function of unidirectional conversion from the analog-digital domain. The realization of ADC is usually completed in the form of serial or parallel converters. Before converting the signal into the digital domain, first, use a sample and hold circuit to convert the analog signal into a discrete form. Next, if the samples are simultaneously compared with different quantization levels and converted to the digital domain in a single step, it is called a parallel converter. If the system compares the sampled output with different quantization levels in a serial manner, it is called a serial converter. Examples of parallel converters are flash converters, and examples of serial converters are single slope, double slope, and successive approximation registers (SAR). The high-performance converter is a special kind of analog-to-digital converter with improved characteristics, such as a high sampling rate on the order of MHz and a resolution above 16 bits. Such converters include self-calibration converters, pipeline converters, Delta Sigma converters, etc (Razavi & Behzad,1995).

The MCP3008 10-bit analog-to-digital converter (ADC) combines high performance and low power consumption. The power consumption of the small package makes it ideal for embedded control applications. MCP3008. With continuous approximation register (SAR) architecture and industry standard SPI serial interface, it allows 10-bit ADC functions to be added to any microcontroller. MCP3008 has 200k samples/sec, 8 input channels, low power consumption (typical standby power consumption is 5nA, effective power consumption is usually 425µA), and is available in 16-pin PDIP and SOIC packages. Applications of MCP3008 include data acquisition, instrumentation and measurement, multi-channel data loggers, industrial PCs, motor control, robotics, industrial automation, smart sensors, portable instruments and home medical equipment.

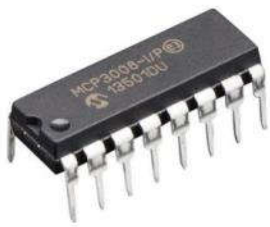


Figure 3.7 Analog-Digital Converter (8 Ports) - MCP3008

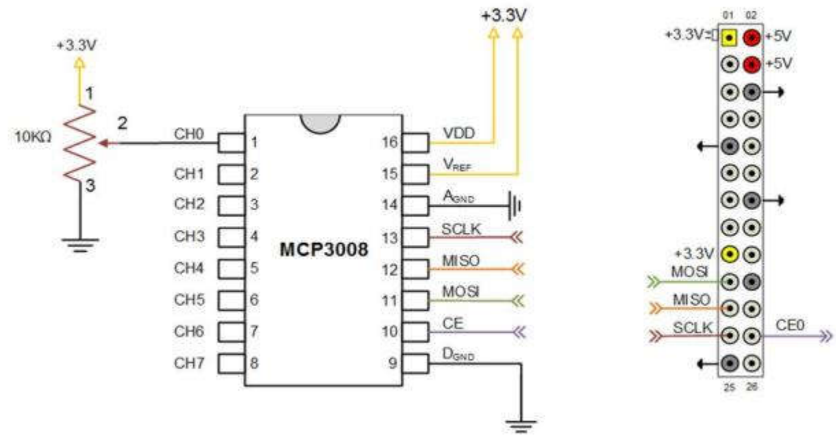


Figure 3.8 MCP3008 & Raspberry Pi 3B+ Pin specifications

3.4.2 Logic Level Converter

Since TTL and 5V CMOS are the main standards for logic circuits, the electronic design has changed a lot. Modern electronic systems are becoming more and more complex, resulting in lower logic voltages, which in turn will lead to incompatible input and output levels of the logic series in the system. This article studies the basic knowledge of logic operations and believes that it is mainly used in serial data systems, and analyses the logic level conversion of current digital ICs. Including unidirectional high level to low level conversion, input overvoltage tolerance, mixed high and low level and low high-level conversion. The transmission gate method is used to realize the conversion dual-layer mode transceiver. By designing an acceleration scheme that actively lifts the rising edge, the impact of the capacitive load is minimized, thereby solving the speed problem. Now, the bidirectional and topology-independent functions of a single chip (push-pull or open-drain) solve the general voltage problem (Yang, Baosheng & Lu, Hongmei & Yang, Xiaoying 2012).

The bidirectional level shifter is used to interconnect the two parts of the I2C bus system, each part has a different power supply voltage and a different logic level. Each part of the device has I/O with logic input levels and open-drain output configurations related to the power supply voltage. There are a total of 12 pins on the logic level converter, and two parallel rows contain six connectors. One row contains all high voltage (e.g., 5V) inputs and outputs, and the other row contains low voltage pins (e.g., 3.3V).

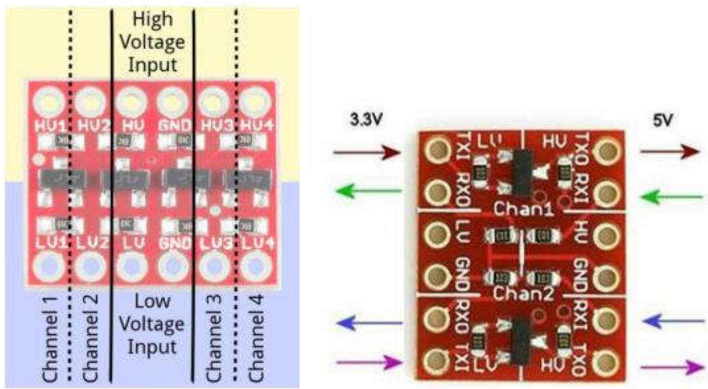


Figure 3.9 Logic Level Converter 5V to 3.3V Pin specifications

The pins are labeled on the bottom and top of the board and are divided into groups. There are voltage input and data channel pin groups.

3.4.3 Microcontroller

Smart objects play a central role in the vision of the Internet of Things. These objects equipped with information and communication technology can store their context, network them together, can access Internet services, and can interact with each other and with humans (D. Uckelmann, M. Harrison, F. Michahelles, 2011).

The Raspberry Pi is a small, strong, cost-effective, and educational computer board. It operates like a standard PC and includes a keyboard entry, a display unit, and a power supply. Raspberry Pi's processor is a 32-bit 700 MHz system-on-chip, which is based on the ARM11 architecture and can be overclocked to obtain greater power (D. Uckelmann, M. Harrison, F. Michahelles, 2011). SD flash memory is used as the hard drive of the Raspberry Pi processor. The device is powered by a micro-USB connector, and the Internet connection can be via an Ethernet/LAN cable or USB dongle (Wi-Fi connection) (M. Schmidt, 2013). One of the great advantages of Raspberry Pi is that it has a wide range of uses.

3.4.4 The connection between MQ-2 and Raspberry Pi

The output voltage required for this project is 5V. Raspberry Pi GPIO (General Purpose Input/Output Pin) only requires 3.3V, which is why we have to use a logic level converter (TTL) to reduce the voltage from 5V to 3.3V. After the MCP3008 is properly connected, use port 0 and connect it to RX0 of TTL. The other end is RX1, which is connected to the analog pin (A0) of the MQ2 sensor. Similarly, connect the 3.3V and 5V (HV) of Raspberry Pi (LV) to TTL, connect 5V to the VCC pin of the gas sensor, and connect the GND of Raspberry Pi to GND on the LV and HV side of the TTL, and connect the GND of MQ2 GND. The connection diagram between Raspberry Pi and CO_2 gas sensor is shown in Figure 3-5.

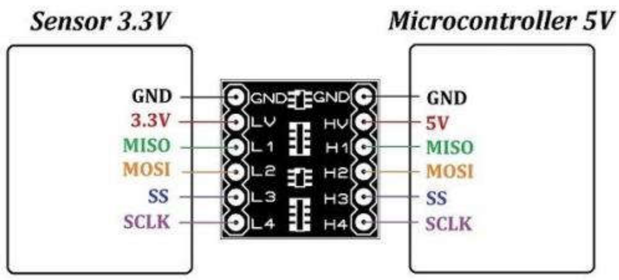


Figure 3.10 Connection between MQ-2 and Raspberry Pi

3.4.5 Raspberry Pi gas sensor configuration

The gas concentration is measured in PPM (parts per million). One of the difficulties of MQ-2 is that it gives a single simulation value by which the gas content in the air must be calculated for various load gases. However, the sensor must be configured for this. The scaling of the value is not linear, but a logarithm to the base 10. Therefore, the first stroke on the X axis is 200, then 300, and so on. The first stroke after 1000 is 2000, and so on. The distance between the two is linear. The idea of this script for calibration and reading is to create a straight line and calculate the amount of gas (in ppm). For this, two points are needed to calculate the slope.

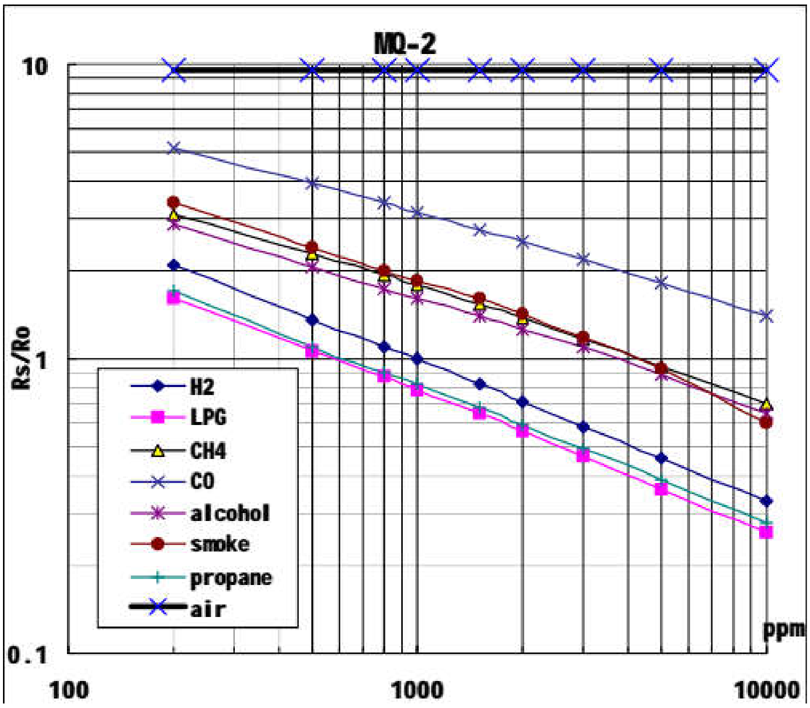


Figure 3.11 Sensitivity characteristics of the MQ-2, Source (HANWEI ELETRONICS CO., LTD)

3.4.6 IoT cloud

Cloud computing and the Internet of Things are working hard to improve the efficiency of daily tasks, and there is a complementary relationship between the two. The Internet of Things generates a lot of data, and cloud computing provides a method for these data transfers. Many cloud providers take advantage of this advantage to provide a pay-per-use model in which customers pay for specific resources used. Besides, cloud hosting as a service reduces its overall cost structure by providing economies of scale, thereby adding value to IoT start-ups.

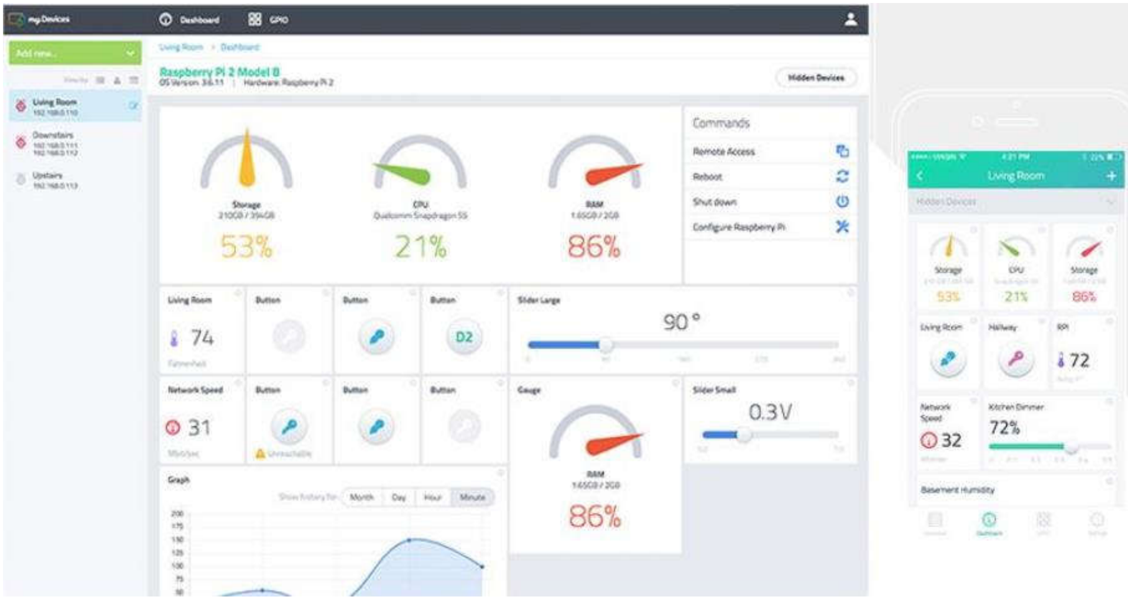


Figure 3.12 Cayenne Cloud

Cayenne is the first of its kind. The drag-and-drop IoT project builder enables developers to quickly create and host their connected device projects. Cayenne is specifically designed for the Internet of Things. It can remotely control hardware, display sensor data, store data, analyse it, and perform many other excellent tasks.

Every time press a button from the Cayenne app or online dashboard, it will propagate to the Cayenne cloud where it will be processed and find a way to the hardware. The opposite direction has the same effect. Users can use the Cayenne mobile app or online dashboard, depending on you. When users view the online dashboard, any changes users make to the hardware in the mobile app will be reflected, and vice versa.

3.5 Vision system

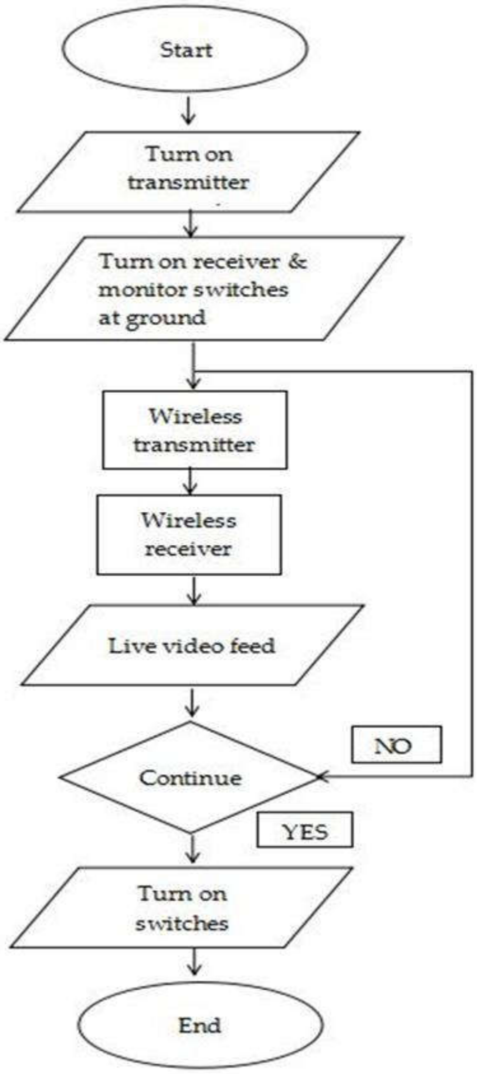


Figure 3.13 Flowchart of the FPV system

To allow First Person View (FPV) attributes, a small camera will place on the top front of the robotic arm. The transmitter signals are then transformed into images by a display with a receiver so that users can view the safety rover's real-time monitoring. Figure 3.6 used in the rover displays a flowchart of the transmitter and receiver system.

3.5.1 Transmission

The first-person view (FPV) framework is used to remotely transmit continuous video from the UAV to the ground station. The captured video can be used to drive an airplane or ground vehicle to assist in shooting. Since most FPV frameworks transmit low-definition video, and the signal is frequently lost and occasionally re-captured, the drone will periodically transmit different non-FPV HD cameras to record excellent video. Many different antenna patterns and frequencies are used to transmit the captured video, and each has its own unique characteristics. Similarly, on-screen display (OSD) frames can be added to superimpose constant flight information on the video content, such as speed, heading, elevation angle and other parameters.

Table 3.1 Frequency band characteristics

Frequency Band	Characteristics
900 MHz	Excellent range and strong penetration, but the band conflicts with the phone.
1.2 GHz	Wide range and good penetrating power.
1.3 GHz	Wide range and good penetrating power.
2.4 GHz	Most RC systems operate in this frequency band
5.8 GHz	If set correctly, it will provide a good range. The equipment is cheap and compact. This frequency band is not subject to other interference, but the penetration rate is low.

Generally, FPV systems operate in many different frequency bands. They offer available frequencies of 900 MHz, 1.2 GHz, 1.3 GHz, 2.4 GHz, and the most common one you encounter today is 5.8 GHz.

3.5.2 Components of FPV System

3.5.2.1 FPV Camera

FPV cameras are used to capture images and send them to the transmitter. Small and lightweight cameras are often used for this task. An excellent FPV camera must point the "even number" directly at the sun and capture medium low-light image quality. The lens angle is an important consideration because some users prefer a wide-angle lens, while others prefer a narrower field of view. There are two types of cameras with charge coupled device (CCD) or complementary metal oxide semiconductor (CMOS) sensors on the market. CCD Made through a special manufacturing process. The process creates a high-quality sensor that can produce excellent images. It generates less noise than CMOS Peer. The disadvantage of CCD is that it requires more power than a CMOS sensor.

3.5.2.2 Video Transmitter

An FPV video transmitter (VTX) is a device that generates a wireless video signal and uses an antenna to transmit it to the ground. Although most video transmitters operate on a single specific frequency, some video transmitters can still switch between multiple operating frequencies. In addition to its frequency, the most important characteristic of a video transmitter is power. A higher power transmitter produces a stronger signal, which can travel longer but consumes more power and is usually heavier. Although FPV operation usually does not include this feature, most video transmitters can also send sound.

3.5.2.3 Video Receiver

FPV video receiver (VRX) is a device that uses a dedicated antenna to receive wireless video signals and send the signals to a monitor and other viewing devices.

3.5.2.4 Antenna

The FPV antenna is connected to the video transmitter and receiver to generate and capture wireless signals. The proper choice of antenna is the key to the performance of the FPV system and has a great influence on the quality and range of the video signal. Various antenna styles are used in FPV frames, including clover leaf, patch, spiral, cross, etc. Some are used for receivers and some are used for transmitters. They can be classified according to the signal polarization they produce. Polarization refers to the way a signal propagates in 3D space, which has an important impact on the transmission effect of the signal to the ground station. Popular polarizations include linear and circular. The receiver and transmitter antennas should use the same polarization type.

3.6 Summary

The suggested method of creating a UGV is described in Chapter 3.1. Next, from the perspective of overall architecture, movement, arms and grippers, Chapter 3.2 introduces the UGV design. In addition, Chapter 3.3 introduces the motor control mechanism used to move the chassis and robotic arm. In addition, it explains how to manage the rover for manipulation control. Then, Chapter 3.4 introduces the functions of gas sensor and vision system embedded in UGV. Finally, experimental settings such as visual ability tests are evaluated in Chapter 3.5.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

After summarising all the methods in the previous chapter, the rover using mechanical parts includes joints and mechanical grip, while electrical parts include the servo motors of the vision system, servo controllers, transmitters and receivers, and wireless controllers and their Control System. In addition, as a mobile sensor platform, it is equipped with a gas sensor that can display the amount of harmful threshold gas to the user through an FPV camera (first-person view). The integrated camera on the rover will provide the rover driver with a good view and direction. The project is designed for control and safety purposes.

4.2 Rover characteristics

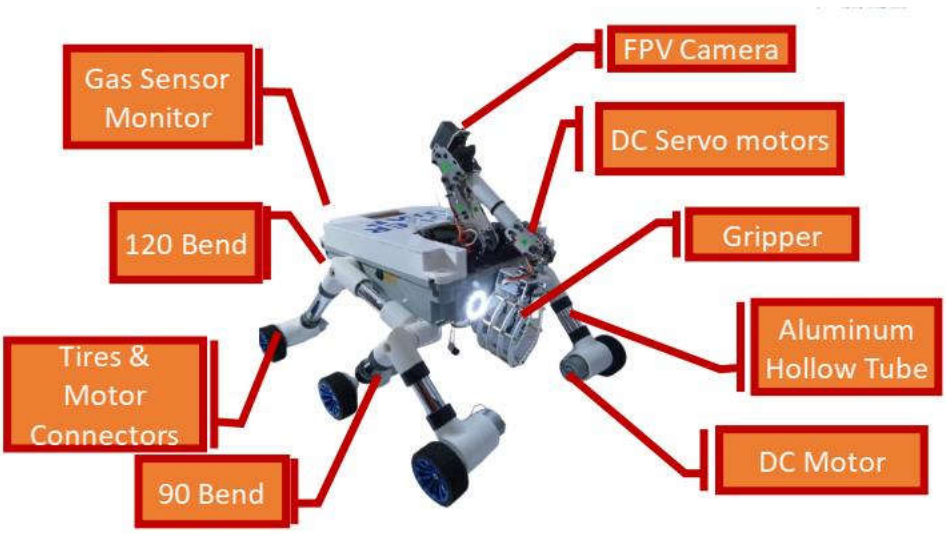


Figure 4.1 Component used in the robotic rover

The smart robotic rover's prototype is well established in this review. The rover focuses on three tasks primarily. The state of the hazard area is controlled, obstacles surface, and hazardous gases are identified at the exposure site. The principal parts of the robotic rover are shown in Figure 4.1. The electrical components and controls of the rover system hold all in the body part. To control the power of the rover, the frame was developed using a hollow aluminium tube.

The gripper can perform the basic functions of picking, fixing, and grabbing objects through a servo motor, and constitutes a mechanism. The human hand deformed the basis of this project for the development of a robotic gripper and was a source of inspiration for use with the wrist and arm to obtain a sufficient level of flexibility in the field of grasping and manipulation. It is equipped with a robotic arm and real-time vision camera integration, adding more functions to the rover. The rover is equipped with an FPV camera (first-person view), and the integrated camera on the rover will provide a good view and direction for the driver of the rover.

4.3 Architectural System Developed

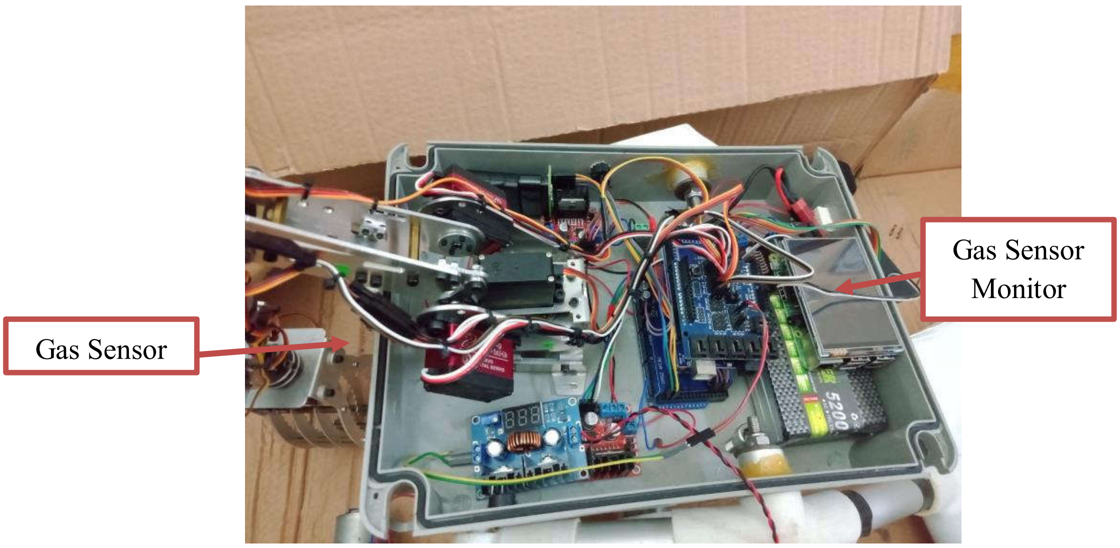


Figure 4.2 Circuit system of Gas Sensor

The gas sensor requires about 5 volts of power to work. The output pin outputs the reading of the voltage, which is proportional to the amount of smoke the sensor is exposed to. Again, high voltage output means that the sensor is exposed to a lot of smoke. Low or 0 voltage output indicates that the sensor is exposed to either little or no smoke. The output of the sensor goes to the MCP3002 pin CH0, which is pin 2 of the MCP3002 pin. This is one of the analog input pins for the MCP3002. The MCP3002 must transform this analog signal from the smoke sensor to a digital signal, which is the only form of signal that the Raspberry pi can interpret. The FPV camera is fixed with the grip while the transmitter and the Li-PO battery are attached by a button to the electrical box.

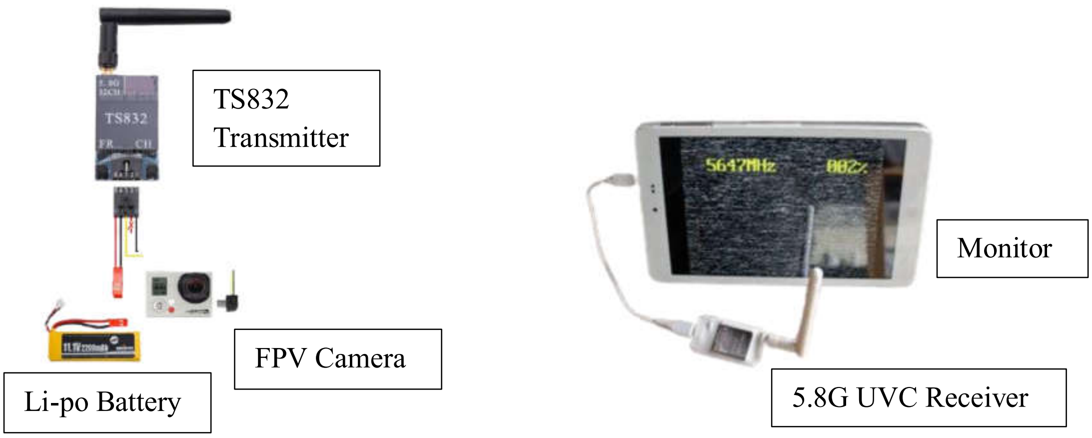


Figure 4.3 Transmitter & Receiver Circuit of Vision System

Figure 4.3 is the circuit design of the vehicle-mounted FPV system on the safe rover. A button has been added so that can control the system based on when the user needs to turn on or off. Therefore, by performing this operation, Li-PO battery power can be saved. The receiver circuit design was made at the ground station located on the receiver side.

4.4 Gas Detector

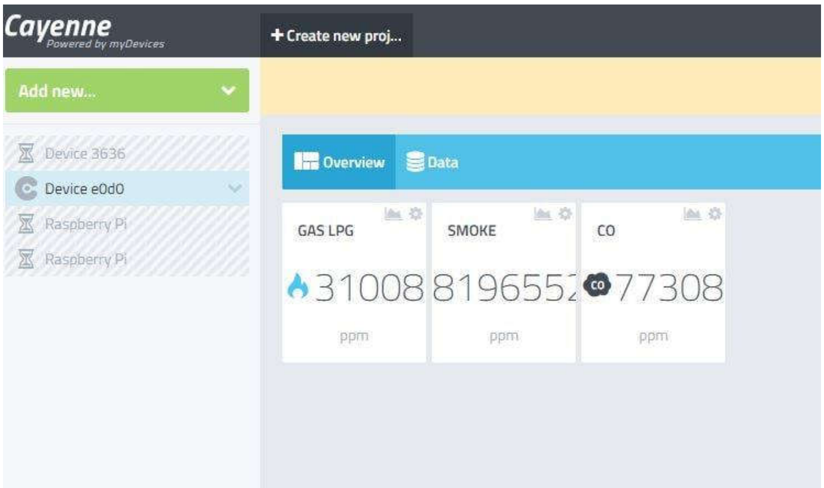


Figure 4.4 GUI results of the gas sensor on web monitor.

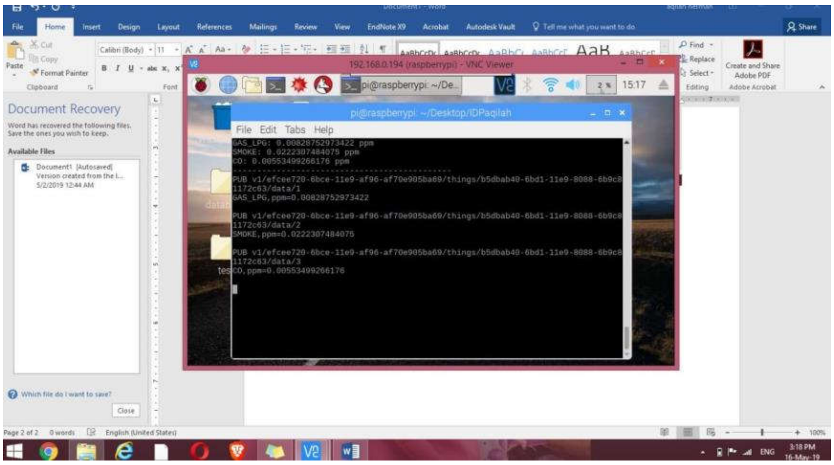


Figure 4.5 The commands in the Raspberry Pi terminal

To track the hazardous gases in the danger region. The outcome of the MQ-2 gas sensor that generates the app is shown in figure 4.4. All Cayenne about the app. Cayenne is a smartphone and computer app that allows you to monitor the Raspberry Pi and soon the Arduino with the use of an elegant graphical interface and a strong, friendly communication protocol. An automated cell phone link, an app should be installed by the user. The GUI monitor as in figure 4.4 by using the computer. Figure 4.5 shows the customized code can be found in a GitHub repository. A class is also included for reading the MCP3008 as in appendix C, Then, change the path to the directory and run the existing Python test file.

First, attach to the gas sensor's receiver. This finding shows that the gas sensor MQ-2 detected LPG gas, smoke gas, and CO. The LPG gas, smoke, and carbon monoxide (CO) values are respectively 447.8, 2525.3, and 19290.2. All the compound values are very high and if these gases are found in a residential area, the region may be considered to be in a hazardous and high-risk state.

4.5 Performance of Vision System

Figure 4.6 Views from FPV monitor

One of the main challenges of driving any vehicle remotely is to provide users with an intuitive and easy-to-understand operation. An easy way to solve this problem is to provide a vision-based GUI. Consumers can better understand the world from an in-vehicle perspective, and get more intuitive input on the location and condition of the remote-control vehicle (ROV). First-person view (FPV) is an auxiliary tool used by pilots. From their perspective, it can control a remotely controlled aircraft. Therefore, FPV cameras are used to capture images and send them to a transmitter, generate a wireless video signal, and then send it to the ground through an antenna. Then, the FPV video receiver (VRX) is a device that uses a dedicated antenna to receive wireless video signals and relay the signal to the viewing device (such as a monitor or FPV goggles). As shown in Figure 4.6, this research successfully installed the vision system on the rover and gained wireless access from the ground station. The receiver on the ground station can record the rover's field of view up to 20 meters.

4.6 Summary

The rovers that use mechanical parts are composed by joint and mechanical grip after summarizing all the methods in the previous chapter, whereas the electrical parts include servo motors, servo controls, transmitters and receivers, and a wireless controller and their control device. In addition, it has an FPV camera to show the amount of damaged threshold gas to the consumer as a mobile sensor platform (first-person view). The built-in camera on the rover gives the rover driver a clear view and direction. The project is intended for safety and control purposes.

CHAPTER 5

CONCLUSION

5.1 Introduction

All in all, this senior design project has achieved its goal. Besides, it gained a lot of new knowledge, new skills, and new experience, and study information about new technologies used in the world today. Perhaps through this project, as a group to learn more about robotic systems and applications with electrical, electronic, and mechanical characteristics, and enhance our knowledge and creativity in science, technology, engineering, and mathematics.

5.2 Conclusion

In short, a gas detector and robot vision system were successfully constructed using the MQ-2 gas sensor and the typical FPV system currently available on the market. The MQ gas sensor uses a small heater with an electrochemical sensor inside. They are sensitive to gas. Whenever the gas concentration increases, the resistance will decrease (but the current will increase). It causes a voltage change and is read on the analog output pin. This value indicates how much gas is concentrated in normal air. This changing analog voltage is used to calculate the PPM of the gas. MQ-2 gas sensor module can be used for gas leak detection in home and industry. It can detect liquefied petroleum gas, isobutane, propane, methane, alcohol, hydrogen and smoke. The captured image is transmitted to the ground station, which includes a monitor connected to the receiver module. The transmitted image frequency is set to 5.8GHz, and many channels can be selected. The image processing unit can give a digital image of the object captured by the camera. Finally, the FPV system can be further upgraded with a larger radius, higher resolution, and object recognition and recognition. At the same time, advances in computer vision and machine learning are also moving towards deployable more complex systems.

5.3 Recommendations

To recommend detection gas, using the lower explosive limit (LEL) varies with gas, but for most flammable gases, the explosive volume is less than 5%. This means that relatively low gas or vapor concentrations are required to create a high explosion risk. Safety regulations usually involve detecting combustible gases before they reach explosive concentrations. Therefore, gas detection systems and portable monitors are designed to sound an alarm before the gas or vapor reaches the LEL. So, the gas detector fitted with a data logger that can record gas concentrations and alarms on a moment-by-moment basis attached to the rover, and the result of the monitor can be shown on the control station box so that it provides a lot of benefits to the user where it can be conveniently controlled away from a dangerous situation.

A vision system on the rover in the future, a complex thermal imager can be added to the system. The thermal imager can enhance search and rescue operations, especially in the dark or at night. A thermal imager is a device that uses infrared radiation to form an image. Relative to their temperature, all objects have their certain amount of black body radiation. The higher the temperature of the object, the blacker body radiation it emits. In addition, flashlights help to illuminate dark areas, flashlights primarily use incandescent lamps or light-emitting diodes and use disposable or rechargeable batteries.

5.4 Future Work

In the end, the project has established its goal by using some advanced wireless methods to control the 6-DOF robot arm and embedded system to achieve safety purposes. Since the time taken to complete the project is very limited, the project can only be completed as it is. The future work of this project will almost use Bluetooth as a wireless connection protocol. In this case, you can use the android application to control the robot arm. The user can use the software to remotely control the robot arm through Bluetooth technology. Wireless robot arm control technology is very important in certain dangerous areas or military fields.

5.5 Summary

Overall, this senior design project has achieved its goal. In addition, he gained a great deal of new knowledge, new skills, and new experience, and became acquainted with information on new technologies used in today's world. Perhaps through this project, as a group, we can learn more about robotic systems and applications with electrical, electronic, and mechanical properties and increase our knowledge and creativity in science, technology, engineering, and mathematics. Besides that, learned to gain experience in an ecosystem of creative and innovative technology to maximise human potential for societal good.

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APPENDICES

Appendix A: Datasheets MQ-2

HANWEI ELETRONICS CO.,LTD MQ-2 http://www.hwsensor.com

crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-2 have 6 pin ,4 of them are used to fetch signals, and other 2 are used for providing heating current.

Electric parameter measurement circuit is shown as Fig.2

E. Sensitivity characteristic curve

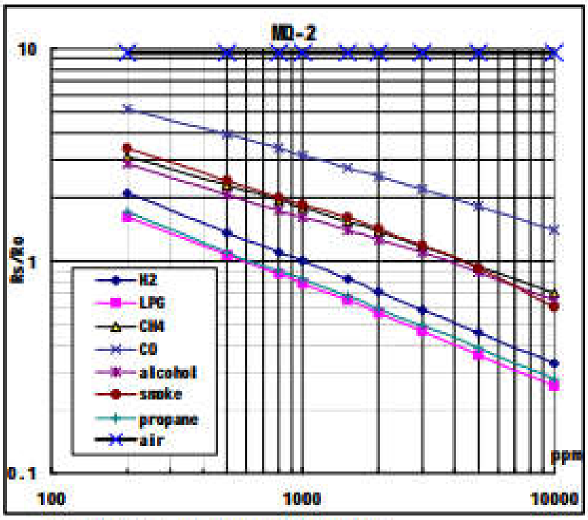


Fig.2 sensitivity characteristics of the MQ-2

Fig.3 is shows the typical sensitivity characteristics of the MQ-2 for several gases.
in their: Temp: 20℃、
Humidity: 65%、
O_2 concentration 21%
RL=5kΩ
Ro: sensor resistance at 1000ppm of H_2 in the clean air.
Rs:sensor resistance at various concentrations of gases.

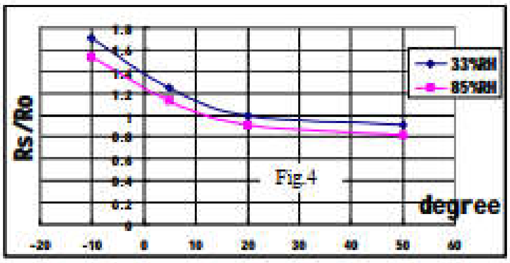


Fig.4 is shows the typical dependence of the MQ-2 on temperature and humidity.
Ro: sensor resistance at 1000ppm of H_2 in air at 33%RH and 20 degree.
Rs: sensor resistance at 1000ppm of H_2 at different temperatures and humidities.

SENSITVITY ADJUSTMENT

Resistance value of MQ-2 is difference to various kinds and various concentration gases. So,When using this components, sensitivity adjustment is very necessary. we recommend that you calibrate the detector for 1000ppm liquified petroleum gas<LPG>,or 1000ppm iso-butane<i-C_4H_{10}>concentration in air and use value of Load resistance that(R_L) about 20 KΩ(5KΩ to 47 KΩ).

When accurately measuring, the proper alarm point for the gas detector should be determined after considering the temperature and humidity influence.

TEL: 86-371- 67169070 67169080 FAX: 86-371-67169090 E-mail: sales@hwsensor.com

Appendix B: System Specifications

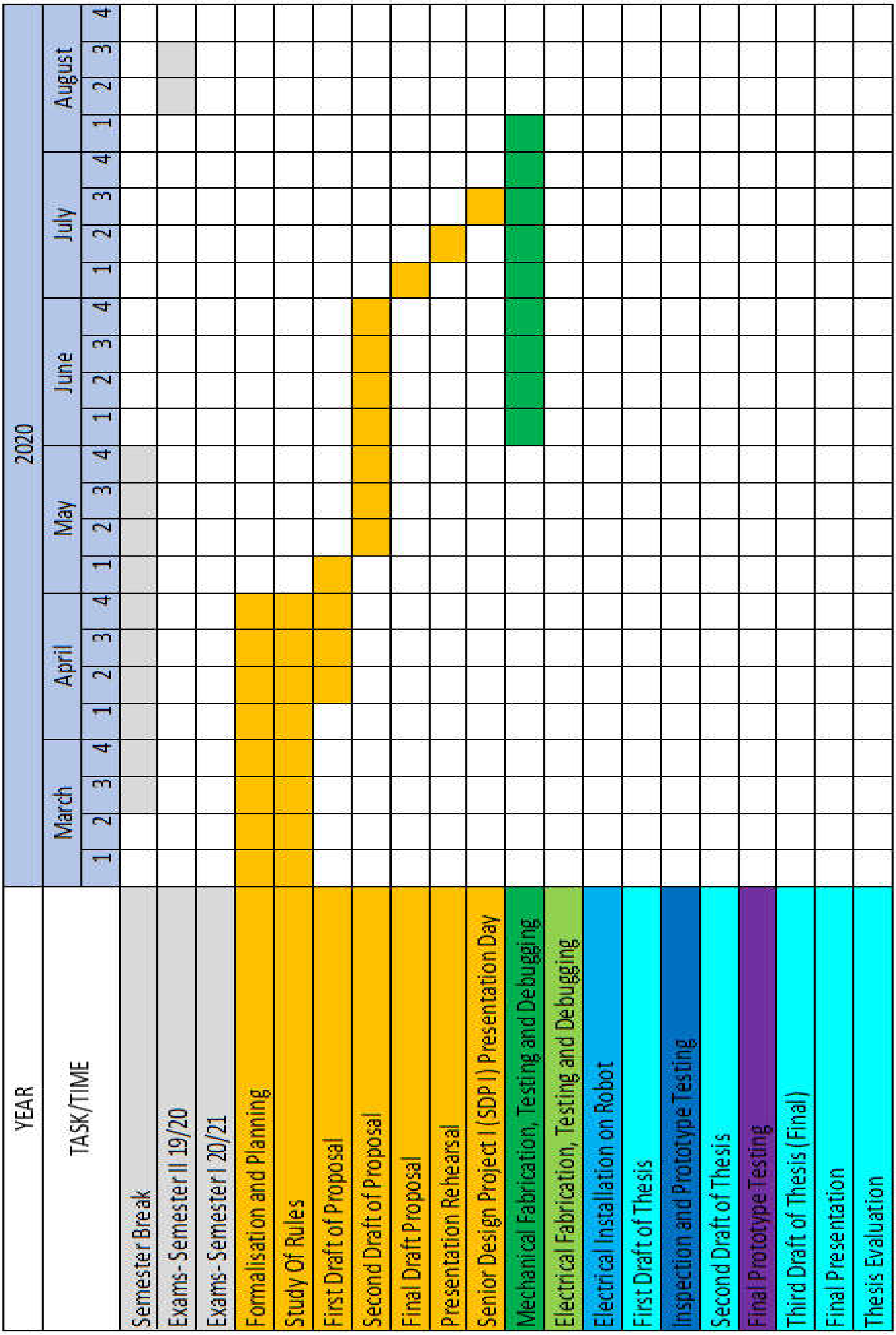
 TS832 5.8G 600mW 40 CH Wireless Transmitter	 5.8G UVC Wireless Receiver
Transmitter Frequency (GHz) 5.8G	**Receiving Frequency** 5.8GHz
Transmitting Power 600mW	**Input Voltage** 12V
Transmission Frequency Point 40 points	**Max Working Current** 200mA max
Antenna gain 2 dBi	**Rx sensitivity** -90dBm
Antenna Connector launch module end RP-SMA, antenna jack end RP - SMA plug	**Antenna gain** 2 dBi
Input Voltage 7-16V	**Antenna Impedance** 50 ohm
Work Current 220 mA / 12V	**Antenna Connector** RP-SMA jack
Working Temperature - 10 to 85 Celsius Degree	**Video Impedance** 75ohm
Automatic Video Formats NTSC/PAL	**Video Formats Support** NTSC/PAL
Video Bandwidth 0~8M	**Dimension** 80 x 65 x 15 mm
	Receiver Net Weight 85g
	Receiving Frequency 5.8GHz

Appendix C: Programming

```
git clone https://github.com/tutRPi/Raspberry-Pi-Gas-Sensor-MQ

cd Raspberry-Pi-Gas-Sensor-MQ\

python example.py
```

```
from mq import *
import sys, time
mq = MQ();
while True:
perc = mq.MQPercentage()
print perc["GAS_LPG"]
print perc["CO"]
print perc["SMOKE"]

import MySQLdb
db =
MySQLdb.connect("DIRECCION_IP_SERVIDOR_MYSQL","USUARIO","CONTRASEÑA"
,"BASE_DE_DATOS")
cursor = db.cursor()
cursor.execute("""INSERT INTO gases (LPG, CO, humo) VALUES (%s, %s,
%s) """,( perc["GAS_LPG"], perc["CO"], perc["SMOKE"]))
db.commit()

time.sleep(60)
CREATE TABLE `gases` (
`LPG` FLOAT NULL DEFAULT NULL,
`CO` FLOAT NULL DEFAULT NULL,
`humo` FLOAT NULL DEFAULT NULL,
`fecha` TIMESTAMP NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE
CURRENT_TIMESTAMP
)
COLLATE='latin1_swedish_ci'
ENGINE=InnoDB
ROW_FORMAT=COMPACT
;
```

Appendix D: Gantt Chart I (SDP I)



Appendix E: Gantt Chart II (SDP II)

YEAR	2020																2021							
TASK/TIME	September				October				November				December				January				February			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Semester Break																								
Exams - Semester II 19/20																								
Exams - Semester I 20/21																				X	X	X		
Formalisation and Planning																								
Study Of Rules																								
First Draft of Proposal																								
Second Draft of Proposal																								
Final Draft Proposal																								
Presentation Rehearsal																								
Senior Design Project I (SDP I) Presentation Day																								
Mechanical Fabrication, Testing and Debugging	X	X	X	X	X																			
Electrical Fabrication, Testing and Debugging	X	X	X	X	X	X	X	X	X															
Electrical Installation on Robot						X	X	X	X	X	X	X												
First Draft of Thesis	X	X	X	X	X	X	X	X	X	X	X	X												
Inspection and Prototype Testing													X	X	X									
Second Draft of Thesis													X	X	X	X								
Final Prototype Testing																	X							
Third Draft of Thesis (Final)																	X	X						
Final Presentation																			X					
Thesis Evaluation																				X				