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REMOTELY CONTROLLED AND DRIVE SYSTEM DESIGN ON MINI OMDIRECTIONAL MOBILE MANIPULATOR ARM

MUHAMMAD AFIQ BIN RUSLLI

Thesis submitted in fulfillment of the requirements
for the award of the degree of
BACHELOR OF ENGINEERING TECHNOLOGY (ELECTRICAL)

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ABSTRAK

Ramai sarjana baru-baru ini menumpukan usaha mereka pada penyelidikan berkaitan peranti larian omnidirectional beroda. Dalam ketenteraan, penyimpanan dan pengangkutan, perkhidmatan sosial, dan lain-lain, kenderaan omnidirectional mecanum telah menemui penggunaan yang meluas. Dari segi mobiliti di ruang sempit dan persekitaran yang sesak, kenderaan robot omnidirectional mempunyai pelbagai faedah berbanding kenderaan tradisional. Dalam persekitaran yang sesak dengan halangan statik, halangan dinamik atau ruang terkurung, mereka boleh menyelesaikan beberapa tugas dengan mudah. Cabaran pertama dalam lengan manipulator mudah alih omnidirectional ialah mengawal lengan dan kenderaan secara serentak menggunakan pengawal tunggal memandangkan sistem sedia ada kenderaan dan lengan dikawal secara berasingan. Sebaliknya, pengurusan elektronik dan kuasa juga merupakan cabaran dalam membina sistem ini. Ini memerlukan pengubahsuaian kod sekarang untuk lengan, mecanum dan grasper, serta konfigurasi jauh. Penyelesaian untuk sistem elektronik dan pengurusan kuasa diubah suai kod pemacu semasa untuk setiap pemacu, pengurusan kuasa dan reka bentuk litar pengawal utama. Hasil yang diharapkan untuk projek ini adalah untuk mewujudkan kawalan jauh untuk kedua-dua mecanum dan lengan manipulatornya. Keputusan ini boleh dicapai dengan menggabungkan kedua-dua lengan manipulator mecanum terlebih dahulu. Seterusnya, semua motor disambungkan ke papan Arduino yang mengandungi kod pengaturcaraan yang boleh mengawal kedua-dua mecanum dan lengan manipulatornya dari jauh. Kemudian, laksanakan kod pengaturcaraan. Ini akan menghasilkan reka bentuk dan mewujudkan kawalan jauh untuk kedua-dua mecanum dan lengan manipulatornya.

ABSTRACT

Many scholars have recently focused their efforts on research concerning wheeled omnidirectional running devices. In the military, storage and transportation, social services, and other industries, mecanum omnidirectional vehicles have found broad use. In terms of mobility in narrow spaces and congested environments, omnidirectional robotic vehicles have various benefits over traditional vehicles. In congested environments with static obstructions, dynamic obstacles, or confined spaces, they can easily complete some tasks. The first challenge in omnidirectional mobile manipulator arm is controlling the arm and vehicle simultaneously using a single controller since the existing system the vehicle and the arm are controlled separately. On the other hand, the electronic and power management also the challenge in built this system. This requires modifying the present code for arm, mecanum, and grasper, as well as remote configuration. Solutions for the electronic system and power management is modified current drive code for each driver, power management, and design of the main controller circuit. The expected result for this project is to establishing remotely control for both mecanum and its manipulator arm. This result can be achieved by first combine both mecanum manipulator arm. Next, all the motor are connected to Arduino board containing programming codes that can remotely control both mecanum and its manipulator arm. Then, execute the programming codes. This will result in design and establishing remotely control for both mecanum and its manipulator arm.

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LIST OF SYMBOLS

V	Volt
g	gram
kHz	kilohertz
MHz	megahertz
mAh	milliampere/hour
A	ampere

LIST OF ABBREVIATIONS

OMSys	Omnidirectional Manipulator Unmanned System
3-DoF	Three Degree-of-Freedom

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of study

Mobile robotics is similar to an interdisciplinary course that combines electrical, mechanical, and electronic engineering with computer science. Omnidirectional robot platforms, which have been around since the 1980s, are a popular method for mobile manipulation. Because of advancements in the manufacturing business, many industrial worker skills were replaced by mobile manipulators prior to the twentieth century. Because of the extensive automation and manufacturing in industrialised countries, workers employing automated equipment such as autonomous and adaptive mobile manipulators are essential in every modern workplace. Among the earliest types of mobile manipulators were those designed to assist humans in manual tasks such as wire stripping and sealing open circuits. Mobile manipulators were also frequently used to inspect, clean, and transport things.

Many academics have recently concentrated their efforts on studies involving the usage of wheeled omnidirectional running mechanisms. Mecanum omnidirectional vehicles, in particular, have found widespread application in the military, storage and transportation, social services, and other industries. Omnidirectional robotic vehicles have several advantages over traditional vehicles in terms of mobility in tight places and congested areas. They can accomplish some jobs with ease in congested situations with static obstructions, dynamic obstacles, or tight places. Such situations are commonly seen in factories, workshops, warehouses, and hospitals, among other places.

1.2 Problem Statement

We must construct a remotely operated tiny omnidirectional mobile with a manipulator arm for this project. With this, we are updating the current omnidirectional mobile, where the mobile is controlled independently in the previous system, however in this project, the mobile and manipulator arm are controlled simultaneously using a single controller. However, it has flaws. The initial problem is maintaining control of the arm and vehicle. Then there are the electronic and power management systems.

1.3 Objective

1. Design the circuit drive for both vehicle and its manipulator arm.
2. Design remotely controls for both vehicle and its manipulator arm.

1.4 Project Scope

1. Solder the components on the PCB board based on the circuit.
2. Remotely control for both vehicle and its manipulator arm.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature reviews is one of the research methods which is defined as an evaluative report of statistics and facts found in the literature related to scope of study. The review was consisting of describe, summarize, and clarify this literature. In description, the author names, sources and all the details will be stated. Moreover, for the summary, it will only be stated what had been understood and what is related to this project. For clarification part, it can be defined as the conclusion and decision made after the respective literature review had been done.

A literature review is more than the search for information as it gathers the methods and solutions and come out a best solution. The reference sources can be come from research papers, websites, books, articles, journals and magazines. The processes of doing literature reviews are included read, evaluate, analyses and cite but it must be related to the field of research.

2.2 Mecanum Wheel Design and Configuration

One of advantages of OMR using omnidirectional wheels is that it does not have nonholonomic constraint which exists in differentially driven mobile robot. With the input of the rotating speed of each omnidirectional wheel, the mobile robot can easily move wherever the user wants. This simplifies the control law which can be achieved easily. Omnidirectional wheel consists of wheel and rollers, which means that the speed of the whole omnidirectional wheel is the combination of wheel speed and roller speed. Robot's control is very complicated, and sometimes it is necessary to consider state constraint of the robot to complete the control design [1].

An omni-directional mobile robot is necessary to move flexibly in confined areas because the environment of intelligent production systems is frequently advantageous interior sites crowded with equipment and supplies. According to Jun Qian, Bin Zi, Daoming Wang, Yangang Ma & Dan Zhang, 2017 [2], stated that a four-wheel independent driven structure by using the advantages of Mecanum wheels is designed and the mobile robot named RedwallBot-1 as shown in Figure 2.1. In order to ensure expansibility and versatility, multi-layer mechanical modules and a modular wheel structure are used for its body.

Figure 2.1 Omni-directional mobile robot RedwallBot-1 [2]

The small solid rollers on the circumference of each Mecanum wheel are arranged with gaps, which may bring periodical vibrations in the mobile platform. One solution is to use elastic wheel hubs to absorb the vibration. Another solution is to add suspension mechanisms on the whole Mecanum wheel. Different suspension mechanisms have been designed to keep four Mecanum wheels in contact with the ground. Traditional suspension mechanisms use a link with dampers for shock absorption, which is similar to the damping of automobiles. However, a mobile robot using this suspension has variable distances between longitudinal or lateral wheels.

A modular wheel structure with vertical suspension mechanisms is designed as shown in Figure 2.2. The Mecanum wheel on the bottom board is connected with the mobile chassis compliantly. The connectors include two cylinder slides and linear bearings, while the shock absorbers include two springs and buffers, respectively. Therefore, the

Mecanum wheel can regulate its position vertically and passively with springs according to the loads and the ground topography. In the design, two hydraulic buffers are used to absorb the damping energy quickly. Both the springs and the buffers can be replaced easily according to different loads on the mobile platforms.

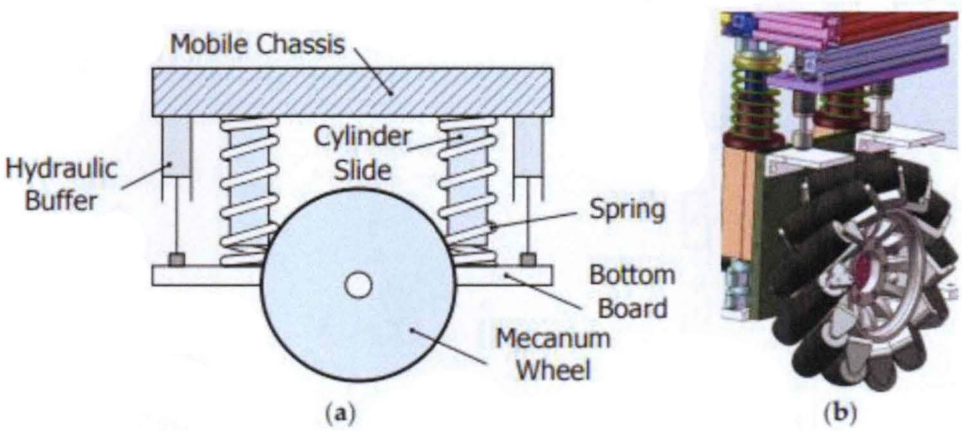


Figure 2.2 Modular wheel structure with suspension. (a) The components of the modular wheel; (b) 3D model of the modular wheel.[2]

2.3 Mecanum Wheel Kinematic

Yunwang Li, Sumei Dai, Lala Zhao, Xucong Yan & Yong Shi, 2019 [3], For an independent Mecanum-wheeled mobile robot, the wheel configurations can be mainly divided into two categories: centripetal configuration and symmetrical rectangular configuration, as shown in Figure 2.3. In Figure 2.3, the Mecanum wheel is represented by a rectangle with an oblique line in the middle, in which the oblique line represents the bottom roller that contacts with the ground. In the former configuration, the axles of all wheels intersect at the same intersection point, as shown in Figure 2.3a. In Figure 2.3a, the centerline OOi of the mobile robot coordinate system XOY and wheel local coordinate system XiOiYi is collinear with coordinate axis Xi . In order to balance the load of each wheel, the wheels are evenly distributed in a 360° circumference. This centripetal configuration of an omnidirectional mobile robot usually composes of three or four Mecanum wheels. In the symmetrical rectangular configuration in Figure 2.3b, the Mecanum wheels are symmetrically arranged on both sides of the line going through the center of the robot, and the overall structure is rectangular. Based on the study of the kinematics constraints of a single Mecanum wheel, the kinematics model of an n-Mecanum-wheel mobile robot can be further derived, and then the omnidirectional motion characteristics of the mobile systems can be analyzed.

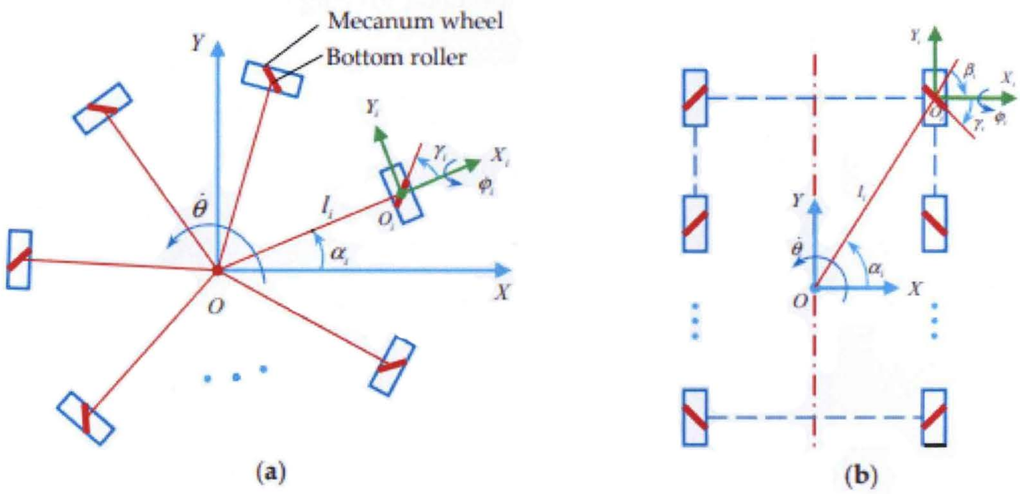


Figure 2.3 Wheel configurations of the single-Mecanum-wheeled robot: (a) centripetal configuration; (b) symmetrical rectangular configuration.[3]

2.4 Application of Mecanum

2.4.1 Military field

Omnidirectional vehicles' manoeuvrability can be used and is highly significant in a variety of outdoor applications, including search and rescue missions, military activities, planetary expeditions, and mining operations.

According to Lipit, T.C., Jones," Omnibot Mobile Base", KSC research and Technology report, NASA,USA, 1998 [4], this wheel is often employed in robotic applications that require a high degree of manoeuvrability. Those encountered by NASA while exploring hazardous environments. The OmniBot project's goal is to aims to create a hazardous duty mobile base that will serve as an advanced development test bed for alternative technologies based on Figure 2.4 below. Remotely controlled operations in hazardous areas: technical approaches This foundation will also be used to test various automated umbilical technologies for autonomous mobile vehicle.

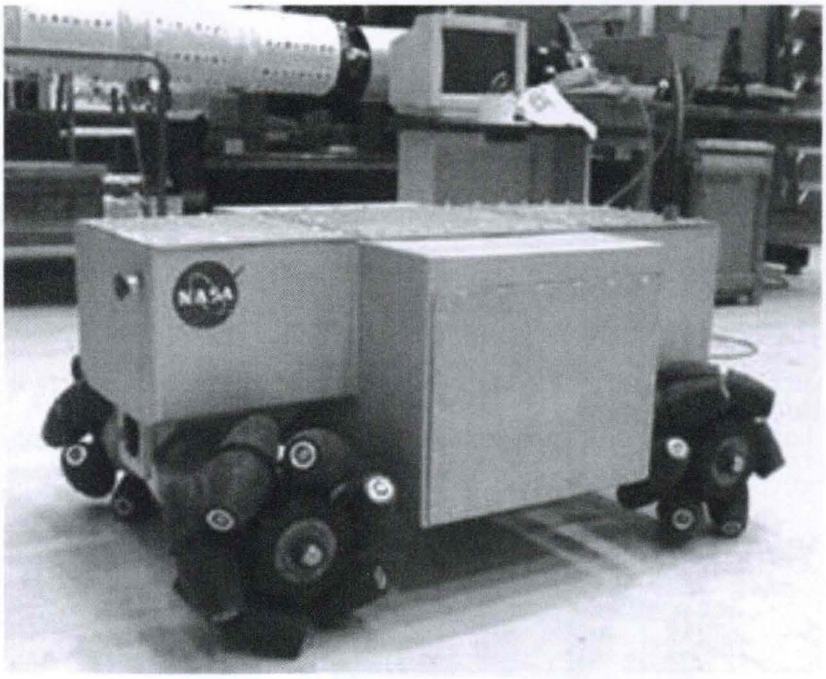


Figure 2.4 NASA Omnibot mobile base [4]

A mobile base could be used to conduct remote inspections, site surveys, and operations in hazardous locations when sending in unprotected employees would be too dangerous. Four brushless servomotors are coupled to omnidirectional wheels to power the OmniBot (Mecanum). This provides for full 2-degree freedom of movement, resulting in incredible mobility. When the vehicle is operated in teleoperational mode, the value of this motion profile is truly experienced. A radio frequency (RF) control box or a hardwired joystick can be used to operate the vehicle. Teleoperation is feasible up to a distance of 1,800 feet with the video transmission gear equipped.

2.4.2 Industrial field

According to Tuck-Voon How, 2010 [5], Airtrax ATX-3000 industrial forklifts based on Figure 2.5 below, excel at tight manoeuvring and delivering lengthy goods sideways through regular sized doors or narrow aisle ways. Because of the ATX's unique OmniDirectional mobility, it can travel in all directions, making it a perfect vehicle for working in small locations where turning is impossible and finite control is required. The truck is equipped with state-of-the-art 48-volt transistor controls, endlessly variable travel, lift and lower speeds, outstanding visibility, ergonomic controls, and operator comfort.

The ATX's OmniDirectional capabilities are enabled by the unusual design of the four 21x12 independently operated Mecanum wheels. Individual transaxles drive each wheel directly. The wheels are made out of a huge, heavy-duty hub and 12 polyurethane rollers with unique designs. The vehicle may go in any direction thanks to the wheel and roller design, which is based on the speed and direction of each wheel as regulated by the traction joystick. Each roller is equipped with bearings that, in most cases, do not require lubrication or maintenance. Scrubbing against the floor is minimised when turning or going sideways because each roller rotates independently.

Figure 2.5 Airtrax Sidewinder lift truck [5]

According to Schulze, L., Behling, S., Buhrs, 2011 [6], as a drive-under tractor with very small dimensions, an Automated Guided Vehicle was designed. The vehicle's design and construction are optimised for the transportation of tiny items based on Figure 2.6 below.

The major goal was to create a compact, low-cost car. Furthermore, the vehicle must be able to transport a variety of containers in a cost-effective manner. Towing a trolley or carrying one container with the same vehicle was an innovative technique to accomplishing accumulated and single shipments. Floor block storage, order picking, assembly, and production were identified to be the most promising applications for transit and provision of tiny items. The vehicle has an omnidirectional drive with four mecanum wheels that are independently and electrically operated. The completed prototype is smaller than any vehicle already on the European market. As a result, compared to conventional methods, the required space for logistic operations, such as the width of the track and stations, might be reduced. The vehicle's height, in particular, is extremely low, allowing for efficient use as a drive-under tractor. The findings revealed an effective method for automating the transportation of trailers and small load carriers.

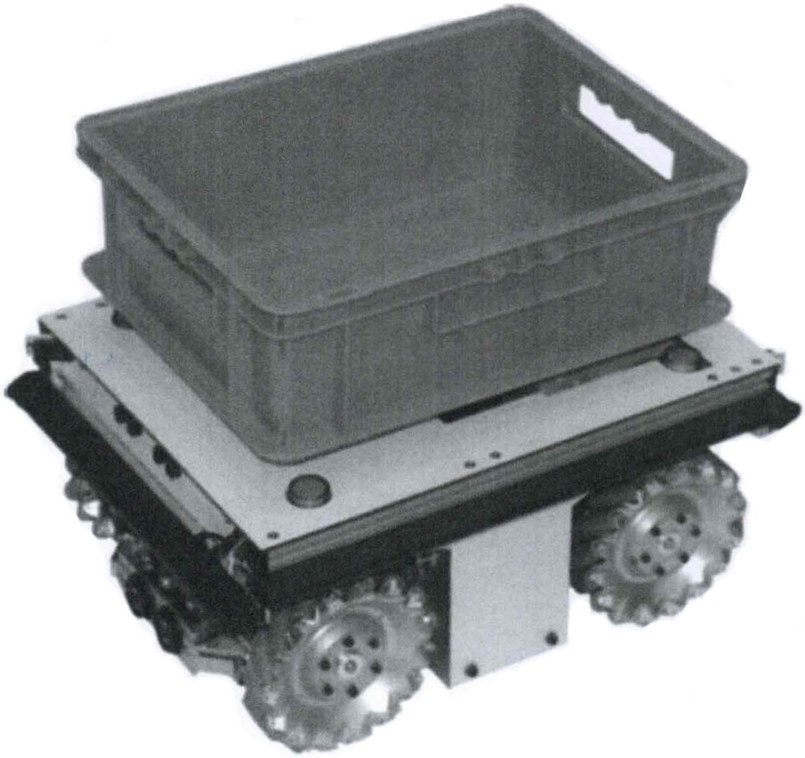


Figure 2.6 Vehicle with small goods container [6]

2.4.3 Educational field

According to Muir, P.F., Neuman, C.P., 1987 [7], Uranus based on Figure 2.7 below was the first robot with mecanum wheel, designed and constructed in Carnegie Melon University. It was built to provide general purpose mobile base to support research in to indoor robot navigation. As a base, it provides full mobility, along with support for a variety of payloads, such as sensors and computers. It had not a suspension system, which is absolutely necessary if the ground is not completely flat.

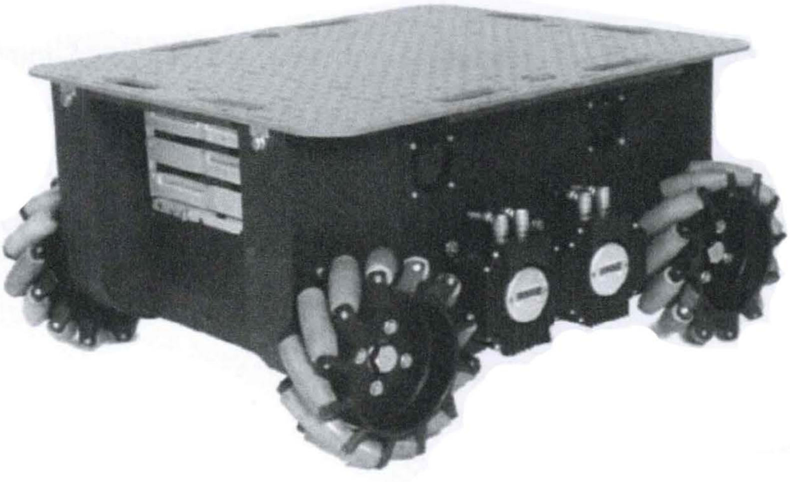


Figure 2.7 Uranus omnidirectional mobile robot [7]

Other researchers, such as Braunl, T., 2003 [8], from University of South Australia have developed two different mecanum wheel omnidirectional mobile robot, Omni-1 and Omni-2 based on Figure 2.8 below. Figure 2.8 shows the structure of Omni-1 and Omni-2. The first design, Omni-1 used the mecanum wheel design with rims that only leave a small gap/clearance for the roller. The motor and wheel assembly tightly attached to robot's chassis. The Omni-1 can drive very well on hard and flat surface but it loses the omnidirectional capability on soft surface.

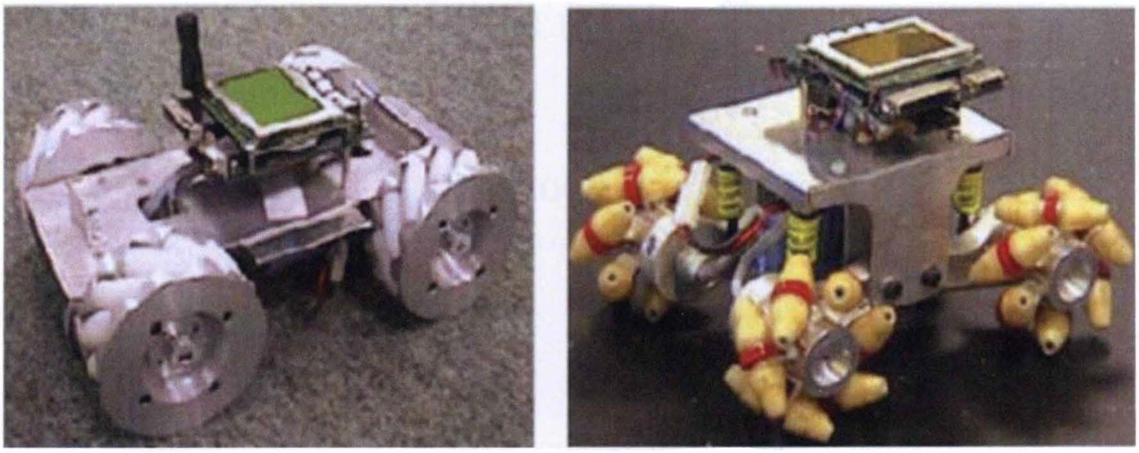


Figure 2.8 Mecanum wheel mobile robot Omni-1 and Omni-2

Omni-2 was develop using rimless and with centrally mounted roller. The motor and the wheel assembly attach to cantilever wheel suspension with shock absorbers. The rimless mecanum wheel and shock absorbers encounter the sinking-in on softer surface and uneven work surface as a result allows omnidirectional driving for Omni-2.

CHAPTER 3

METHODOLOGY

3.1 Research Flowchart

Flowchart in Figure 3.1 shows all process involved in this project. Firstly, process of identifying problem from previous circuit that when the robot is turn on, motor will move by itself without remotely controlled was done. Next, was done to choose the suitable components for new circuit. Last, soldering the components on the new PCB board.

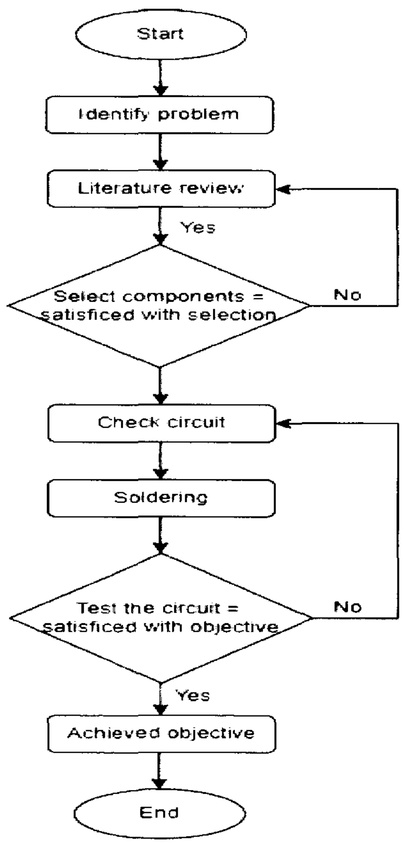


Figure 3.1 Overall flowchart of the project

3.2 Block Diagram

The previous built OMA, there are two parts which is mecanum parts and manipulator arm part. The strategies in designing remotely control for both mecanum and manipulator arm, the manipulator arm part has been built. Then, connect the manipulator arm part and mecanum part to the microcontroller which is Arduino mega. After both mecanum and manipulator part connected to microcontroller, set coding in Arduino mega to control the movement of each motor in order to move mecanum and manipulator arm. Figure 3.2 below shows the block diagram of OMA.

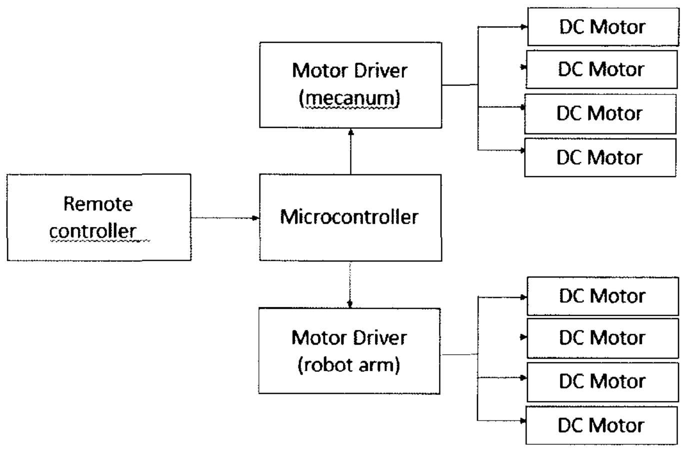


Figure 3.2 Block Diagram of OMSys

From the block diagram above, the connection of the circuit can be made. Figure 3.3 below shows the connection of OMSys

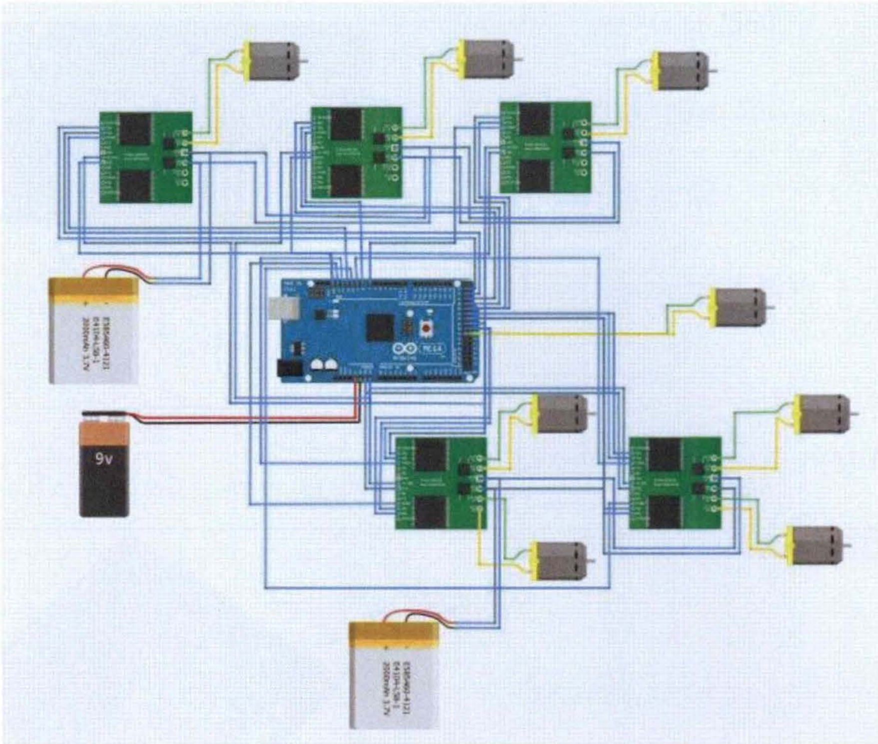
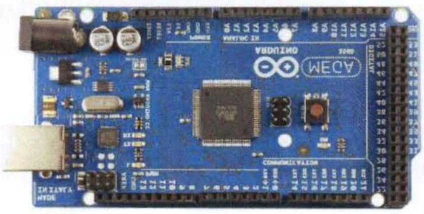
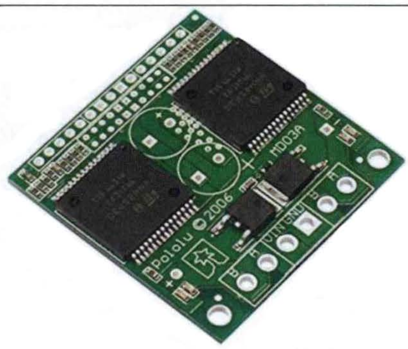


Figure 3.3 The Connection of OMSys

3.3 Component Used

Table 3.1

Components	Specification
	Li-po Battery Voltage: 11.1V Capacity: 5200mAh Weight: 420g

	Arduino Mega 2560 Digital I/O pins: 56 Analog pins: 16 Input voltage: 6V-20V Weight: 35g Operating frequency: 16MHz
	VNH3SP03 Motor Driver MD03A Operating voltage: 5.5V-36V Max. current: 30A Max. PWM frequency: 10kHz
	PS2 Controller Starter Kit Input voltage: 4.5V-5.5V Current consumption: 100mA-500mA Max. range: 100m line-of-sight

3.3.1 Li-Po Battery

Power supply of voltage is needed from Li-Po battery to turn on the servo motor used in the gripper and motor in the mecanum. It is light weight and have longer life span compared to other batteries such as Li-ion batteries, Lead-acid batteries.

3.3.2 Arduino Mega 2560

The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

This project using the Arduino Uno because the input and output pins suitable with the component that used. The bootloader footprint is 256 kB of which 8 kB depending on the model used in the system. Permanent storage memory is 4kB EEPROM with working storage and memory storage being added to the system.

3.3.3 Motor Driver

Pololu Dual VNH3SP30 Motor Driver Carrier is a compact carrier for the VNH3SP30 motor driver integrated circuits from ST. Pololu Dual VNH3SP30 Motor Driver Carrier incorporates most of the components of the typical application diagram of the VNH3SP30 datasheet, including pull-up and current-limiting resistors and a FET for reverse battery protection. To keep the number of I/O lines down, the two enable/diagnostic lines on each chip are tied together.

3.3.4 PS2 Controller Starter Kit

SKPSW is the wireless version of SKPS, and it's meant to take the place of a standard wireless PS2 controller. For a robust and dependable wireless connectivity, the SKPSW uses the nRF24L01+ 2.4GHz tranceiver with frequency hopping technology. When interference is detected, SKPSW will automatically switch to a different frequency band. In other words, control loss and interference with other wireless controllers will be a thing of the past.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

There are few outcomes that have been predicted for this project. First, the expected result for this project is to design and establishing remotely control for both mecanum and its manipulator arm. This result can be achieved by first combine both mecanum and its manipulator arm. Next, all the motor was connected to Arduino board containing programming codes that can remotely control both mecanum and its manipulator. Then, execute the programming codes. This will result in design and establishing remotely control for both mecanum and its manipulator arm.

4.2 Circuit build

In Figure 4.1 the circuit connection is showed. TX (Transmitting) of SKPSW is connected with pin 26 in Arduino, RX (Receiving) in SKPSW is connected with pin 25 in Arduino. All motor driver are connected with Arduino based on motor driver port in schematic diagram (Figure 4.2).

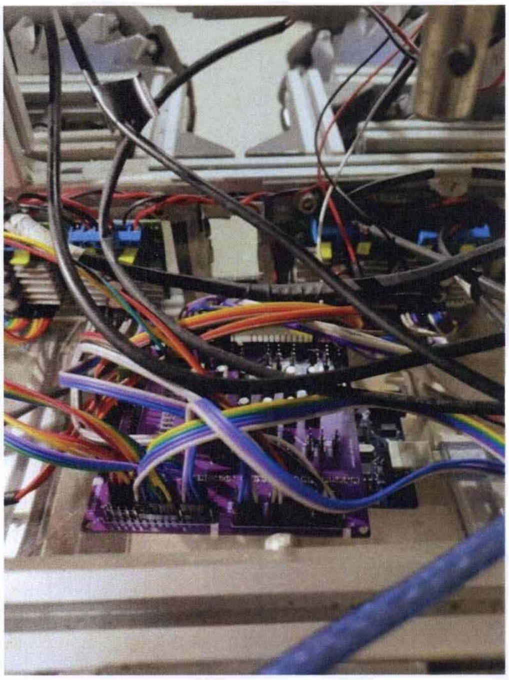


Figure 4.1 Circuit of omnidirectional mobile arm manipulator

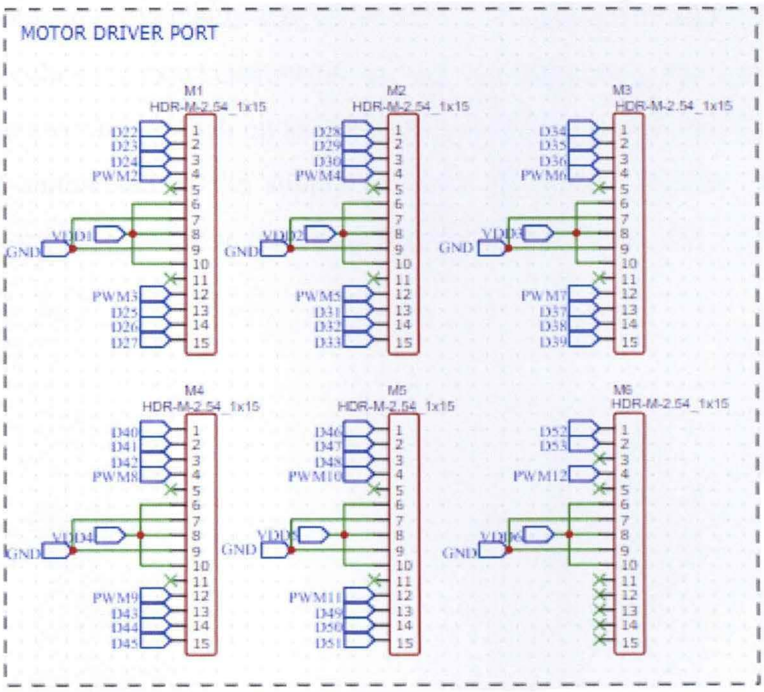


Figure 4.2 Motor Driver port

CHAPTER 5

CONCLUSION

5.1 Conclusion

In conclusion, the vehicle can move omnidirectional and able to remotely control for both vehicle and its manipulator arm. For this project, why the project cannot get a result are because the current supply for the motor are not enough. Besides, the transmitter and the receiver are not link so the robot cannot be control using remote control. Finally, from this experiment also enhanced our knowledge about the movement of mecanum wheel and it function that can be used.

5.2 Recommendation

There are few improvements can be done for the future development on this project which is calculate the exact current and voltage that needed for the circuit to move the motor. Next, put switch to switch on and off the circuit because in current project, the circuit are directly connected to the supply to move the motor. Finally, adding the absorber at wheel for it easy to move omnidirectionally on rough and soft surface.

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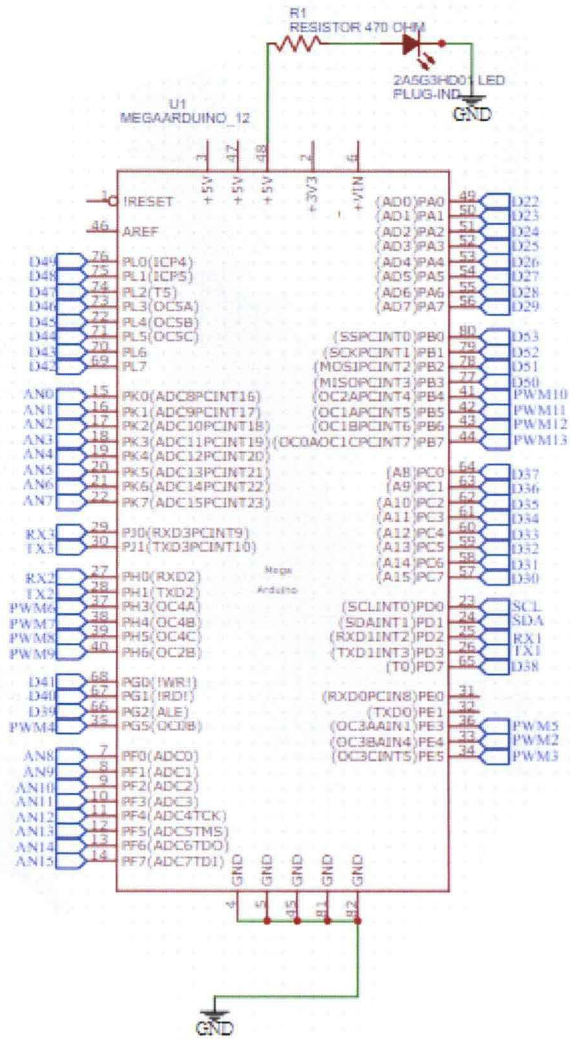
APPENDICES

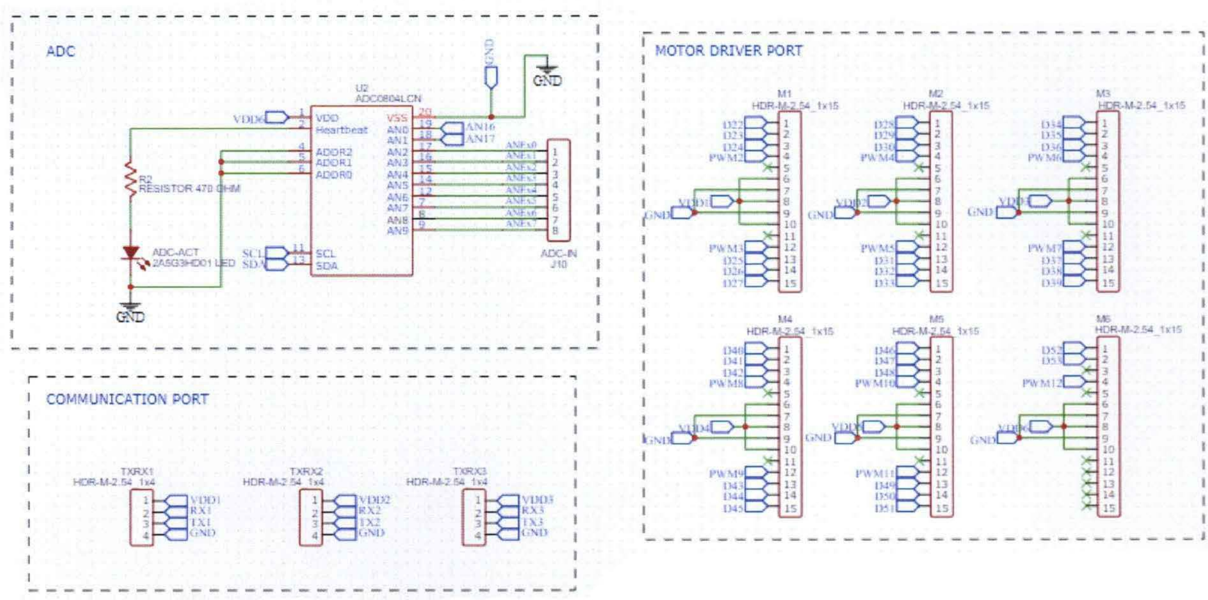
Appendix A: Gantt Chart

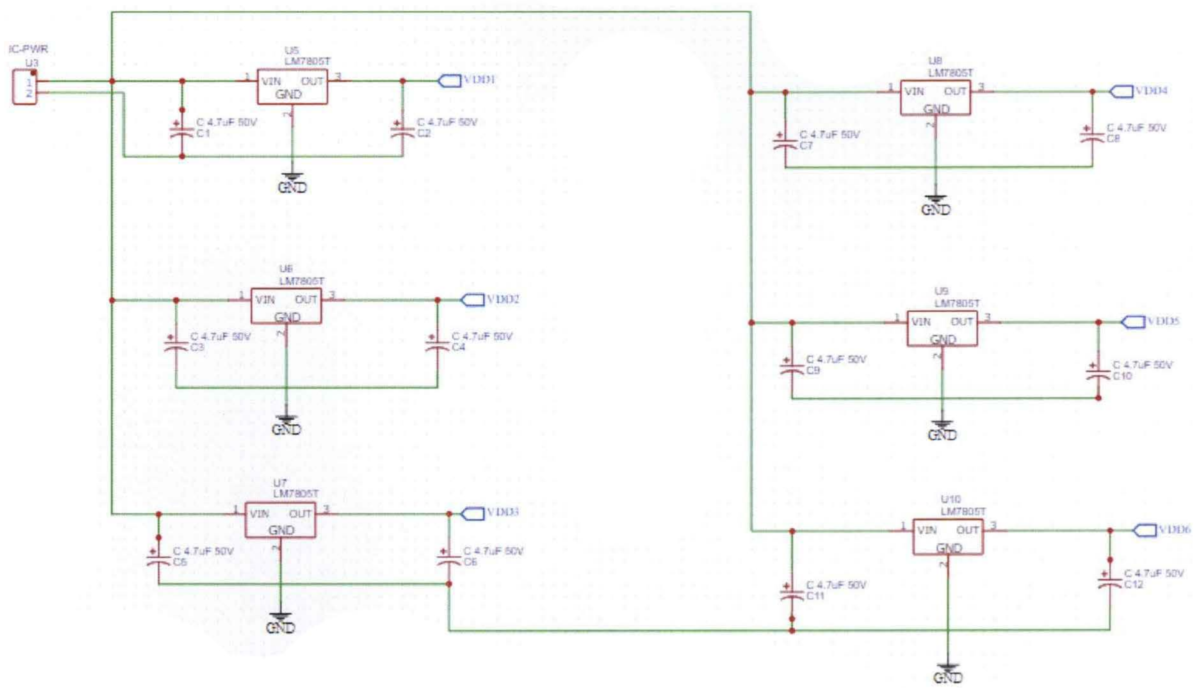
Table 1 Gantt Chart

TASK/WEEK	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Redesign project														
Fabrication of design														
Testing and troubleshoot														
Analysis data														
Project submission														
Project presentation														

Appendix B: Schematic diagram




ADC
U2
ADC0804LCN
R2
RESISTOR 470 OHM
ADC-ACT
2ASG3HD01 LED
ADC-IN
J10
GND
MOTOR DRIVER PORT
M1
M2
M3
M4
M5
M6
HDR-M-2.54_1x15
COMMUNICATION PORT
TXRX1
TXRX2
TXRX3
HDR-M-2.54_1x4


IC-PWR
U3
U5
U6
U7
U8
U9
U10
LM7805T
VIN
OUT
GND
C 4.7uF 50V
VDD1
VDD2
VDD3
VDD4
VDD5
VDD6