DEVELOPMENT OF OMNIDIRECTIONAL DRIVE SYSTEM USING MECANUM WHEELS FOR PATIENT TRANSFER DEVICE

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LIST OF ABBREVIATIONS

AC	Alternating Current
ASOC	Active Split Offset Castor
CAD	Computer Aided Design
DC	Direct Current
FMWMR	Four Mecanum Wheeled Mobile Robot
I/O	Input/Output
I2C	Inter-Integrated Circuit
LBP	Lower Back Pain
MDS	Mecanum Drive System
MSD	Musculoskeletal Disorder
NIOSH	National Institute of Occupational Safety and Health
PS2	PlayStation 2
PSU	Power Supply Unit
USB	Universal Serial Bus
WMR	Wheeled Mobile Robot
WMSD	Work-related Musculoskeletal Disorder

LIST OF APPENDICES

PEMBANGUNAN SISTEM PANDUAN SEMUA ARAH MENGGUNAKAN TAYAR MECANUM UNTUK ALAT PEMINDAHAN PESAKIT

ABSTRAK

Gangguan muskuloskeletal berkaitan kerja (WMSD), terutamanya sakit pinggang, telah dilaporkan sebagai antara masalah kesihatan utama yang dialami pekerja kesihatan. Masalah kesihatan ini berpunca daripada tugas-tugas penjagaan pesakit termasuklah pengurusan pesakit manual dan menggerakkan katil. Beberapa penyelesaian telah pun tersedia di dalam pasaran seperti pemindah katil berkuasa atau lif pesakit, yang telah terbukti mampu untuk menyelesaikan masalah ini. Walaubagaimanapun, belum ada lagi alat bantuan di pasaran yang menawarkan pergerakan semua arah, yang mana menyukarkan cara pengawalan dan mengehadkan pergerakan alat bantuan tersebut terutamanya di kawasan sempit. Projek ini telah menghasilkan sebuah sistem pergerakan semua arah menggunakan tayar Mecanum dan memasang sistem tersebut kepada sebuah alat pemindahan pesakit. Prestasi prototaip yang telah dihasilkan diuji dengan membandingkannya kepada simulasi MATLAB. Keputusan menunjukkan bahawa prototaip tersebut mampu melakukan pergerakan yang sama seperti yang telah disimulasikan dengan sedikit penyelewengan. Penyelewengan terbesar telah diukur semasa pergerkan ke kiri, dengan nilai penyelewengan sebanyak 11.5 cm pada tayar kiri dan 11.8 cm pada tayar kanan. Walaupun terdapat penyelewengan, prototaip tersebut tetap berjaya menyelesaikan satu proses pemindahan pesakit.

DEVELOPMENT OF OMNIDIRECTIONAL DRIVE SYSTEM USING MECANUM WHEELS FOR PATIENT TRANSFER DEVICE

ABSTRACT

Work-related musculoskeletal disorders (WMSD), especially lower back pain is reported as one of the main health problems among healthcare workers. The causes of the problem are mainly healthcare tasks such as manual patient handling and moving beds. There are several solutions that are already available in the market, proven to be able to solve the problem. However, there are currently no device in the market that is equipped with omnidirectional movement capability, which strictly limits the mobility of the device in cramped space, and also complicating the controls. In this project, a Mecanum wheel drive system is created and integrated onto a patient transfer device to allows omnidirectional movement. The completed prototype's performance is verified by comparing it with a MATLAB simulation. The result shows that the prototype is able to move in the same motion as simulated with some deviation. The largest deviation measured is during leftward movement with deviation of 11.5cm on the left wheel and 11.8cm on the right wheel. However, even with the deviation, the prototype successfully completed a patient transfer process.

CHAPTER 1

INTRODUCTION

1.1 Project Overview

Work-related musculoskeletal disorders (WMSD) have been reported to be one of the main health problems for healthcare workers.[1]-[3] In 2017, nursing assistants recorded an incidence rate of work-related musculoskeletal disorder of 166.3 per 10,000 workers which is one of the highest among all occupations reported with the same problem.[4]

One of the primary causes of WMSDs among nurses has been identified to be manual patient handling activities, which frequently involve transferring, repositioning, and lifting.[5] Manual patient handling, requires the nurses to exert extreme force with awkward pose, which have been proven to inflict high load magnitude on the spine that exceeds the spinal loading and push-pull force injury threshold.[6] Several engineering interventions have been introduced in attempt to solve this problem, and several researches have been done to verify the intervention.[8] Overall, the usage of patient transfer assistive device is shown to be beneficial and is recommended to be used whenever possible.[9]

Another task that is also causing WMSDs among the nurses is moving beds. Moving beds is actually a challenging task as the worker needs to push and pull a bed with a weight of 100 to 250kg not including the weight of the patient on the bed. Research has shown that the peak pushing and pulling forces required when moving a bed are higher than the recommended guidelines, which will risk injuring the worker.[10] Another research has shown that when pushing the bed, the compression at L4/L5 joint is more than 3400N which exceeded the action limit set by NIOSH, resulting in a higher risk of lower back injury.[11] To ensure their safety, multiple workers are required in moving a single hospital bed. The need for multiple workers increases the human resource cost for this process. Thus, a method to reduce the number of workers required in moving the bed while also ensuring the safety of the worker is needed.

With the advancement of technology, solution for this issue is already available in the market. The currently available solution is the powered bed movers. A powered bed mover is a device that can lift the hospital bed, and move it with the help of an electric-powered motor. Researches have proven that using a powered bed mover can significantly reduce the physiological strain and muscle activation level of its user.[12]-[13] However, there are still a few improvements to be made. Guo et. Al. (2017) introduces omni-directional mobility to their version of bed movers, as they highlight that limited mobility is a key limitation in conventional powered bed movers.[14] The limited mobility results in difficult control of the device especially in cramped space.

In this study, we aim to design a Mecanum wheel drive system to be used with a patient transfer assisting device. Mecanum wheels are a set of 4 wheels that are specially designed to allows omni-directional movement, which means that it can move instantaneously in any directions whether it is a longitudinal, lateral or rotary motion.[17] Omni-directional capability has been proven to significantly reduces the amount of time and area required for manoeuvres.[15] The Mecanum wheel has rollers instead of treads, with the roller having axles skewed with respect to the wheel axle. The wheels are required to be arranged in a particular configuration, with all wheels being independently powered. For a device with Mecanum wheels equipped, the direction of rotation for each wheel will determine the resulting direction of the device.

The completed device is expected to reduce WMSD risks caused by patient transfer and moving beds. The device can be remotely controlled using a controller with a user-friendly button configuration. This control system will eliminate the extreme force exertion and posture problem associated with moving beds.

1.2 Problem Statement

Moving the bed during the patient transport and transfer process has been proven to inflict a serious physical burden on a healthcare worker. It is dangerous for the process to be carried out alone, thus requiring multiple workers on the task, making the process labor extensive. A new patient transfer system is required to ensure the safety of the healthcare workers and reduce the number of people required during the process.

1.3 Objectives

The objectives of this project are as follows:

1. To design and develop a Mecanum wheel drive system to be used with a patient transfer device.
2. To develop a control interface for the Mecanum wheel drive system.
3. To verify the developed prototype by comparing actual performance and simulations.

1.4 Scope of Research

This project will complete a working prototype of a Patient Transfer Device equipped with a Mecanum wheel drive system. The completed prototype will be able to transfer a patient from one place to another place within a facility in a safe manner by omni-directionally. The prototype will be controlled remotely using a wireless controller with user-friendly programmed button. The developed prototype will be verified by comparing its actual performance with a simulation done using MATLAB. A demonstration of a patient transfer process will also be conducted using the prototype.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to WMSD

Musculoskeletal disorders (MSD) are disorders or injuries of muscles, tendons, nerves, joints, ligaments, and spinal discs. Work-related musculoskeletal disorders (WMSD) refer to either MSD where the work environment and performance contributed significantly to the condition, or the condition gets worse or lasts longer due to the working conditions.[1] Examples of work conditions that may cause WMSD include routine lifting of heavy objects, daily exposure to whole body vibration, routine overhead work, work with the neck in chronic flexion position, or performing repetitive forceful tasks. Examples of WMSD commonly found includes the carpal tunnel syndrome, back injury or back pain, and arthritis.

WMSDs are not only detrimental to the injured employee but also to the employer. The amount of absence, lost productivity, and increased healthcare, disability, and worker's compensation costs results in a huge loss to the employers, making WMSD cases more severe than other non-fatal injuries. In 2015, there were 29.8 cases of MSD per 10,000 workers have been reported among private industry workers. The injured workers required a median of 12 days off from work to recover before returning to work. Among the private workers, number of cases involving nursing assistant was one of the highest, second to only laborers and freight, stock, and material movers. Nursing assistants have also recorded the highest incidence rate of MSD cases among private workers since 2013.[4]

WMSD have identified to be a common injury experienced by nursing assistants or healthcare workers. Various papers have discussed the problem of WMSD in the healthcare industry. Rahman et. Al (2017) found in their study that 68.1% of healthcare professional including doctors and nurses had musculoskeletal pain or discomfort in the last 12 months, with 28.4% of them being severe cases that is affecting their job.[1] Azma et. Al (2016) reported in their papers that Malaysia has a prevalence rate of 73.1% for WMSDs.[2] Ando et. Al. (2000) found in their study that among the WMSD cases reported, the prevalence for lower back pain (LBP) was the highest with the rate of 54.7%. These studies have shown that WMSD, especially LBP, is indeed a serious problem among the nursing assistants or healthcare workers.[3]

2.2 Manual Patient Handling and Assistive Device

Manual patient handling has been identified to be a huge challenge in the healthcare industry due to its high risk of WMSD. Manual patient handling includes tasks such as lifting, repositioning and transferring patients from a bed to another location such as wheelchair, bath tub, toilet or another bed. These task poses high risk of WMSD because the nurses are required to exert extreme forces and working in awkward postures.[5]-[8] To solve the problem, several engineering interventions have been invented and verified.

Wiggermann et. Al. (2015) did a study on a feature called “Turn Assist” that are offered by several manufacturers on their hospital bed mattresses. The Turn Assist feature are able to assist nurses in turning and repositioning the patients. The study was performed to test out the performance of the Turn Assist feature. The study is carried out by comparing hand force, spine compression force, spine shear force and shoulder strength accommodation between manual turning and repositioning and using Turn Assist. The study found that lateral repositioning is more dangerous than turning the patient. The pull force when laterally repositioning a 63 kg patient exceeded the psychophysical limits by more than 50%. The use of Turn Assist feature have been shown to be effective as it reduced the hand force, compression forces, and shear forces not only for turning the patient, but also for the dangerous lateral repositioning.[5]

Hwang et. Al. (2019) did a study on four different interventions. The interventions that were studied by them were friction-reducing patient transfer devices. These devices are to be placed under the patient to reduce the friction between the patient and the bed, allowing nurses to be able to pull the patient from one bed to another bed. The process of transferring patient from one bed to a bed placed directly besides it is called lateral transfer. The result of their study shows that the patient transfer devices, mainly a slide board and an air-assisted device were effective in reducing hand pull force, shoulder flexion, shoulder net moment, and muscle activities in upper extremities and low back. They concluded that the slide board and air-assisted device can be effective engineering intervention to reduce WMSD risk among nurses while also improve patient's safety.[6]

Engst et. Al. (2005) did a study on effectiveness of overhead lifting devices in reducing the risk of injuries in extended care facilities. Patient lift is another type of engineering intervention that is used to assist in patient lifting process. It features a sling and hoist to lift the patient. Patient lift generally consist of two types, a floor lift and ceiling lift. The ceiling lift have been proven in the study to be beneficial in patient lifting and transfer process. The use of ceiling lift was found to significantly reduce perceived risk of injury and discomfort to the neck, shoulders, arms, and upper and lower back, for the healthcare staffs. This claim was further supported by a 68% reduction in compensation claims after the staffs started using the ceiling lifts. [7]

2.3 Risk in Bed Moving

Aside from manual patient handling, bed moving has also been reported as a cause of WMSD.[3] As patients are regularly moved around in a hospital (e.g., from ward to operation theatre) moving bed is a task that is done on a regular basis by the healthcare workers. The healthcare workers are required to push and pull the bed weighing between 100 to 250kg, not including the weight of the patient on the bed, several times per day. Due to the heavy weight of the bed, minimum of 2 workers are required, where one of them are pushing the bed while the other steers it.

Research has shown that the peak pushing and pulling forces required when moving a bed are higher than the recommended guidelines, which will risk injuring the hospital assistant.[10] Another research has shown that when pushing the bed, the compression at L4/L5 joint is more than 3400N which exceeded the action limit set by NIOSH, resulting in a higher risk of lower back injury.[11] To perform the task safely, several hospital assistants are required to be assigned to the task. Generally, two persons are required in the process, one at the back to push the bed, and another one in front to steer the bed. This results in the need for the hospital to recruit more hospital assistants, thus increasing the human resource cost needed just for moving the bed. As mentioned previously, this sparks the need for a new method to move the bed with a fewer number of workers while also ensuring their safety.

2.4 Powered Bed Mover

Powered bed mover is the solution that is currently being used by most hospitals to lessen the burden inflicted upon nurses moving the bed in the hospital. Daniell et. Al. (2014) conducted a study to assess how powered bed movers impact the levels of physiological strain and muscle activation for the user. The study compares the muscular efforts for six male subjects moving the bed using three different methods. The three different methods are using powered StaminaLift Bed Mover, powered Gzunda Bed Mover (shown in Figure 2-1), and manual pushing. The results proved that the powered bed mover indeed reduces the level of muscular strain required to move a hospital bed. Muscle activation levels of most muscle tested (including lower back muscles) for both the powered bed movers are significantly lower than manual pushing. The significantly high muscle activation level for manual pushing in the lower back muscles might be one of the causes of lower back injuries among healthcare workers, however, further research is required to support this claim.[12]

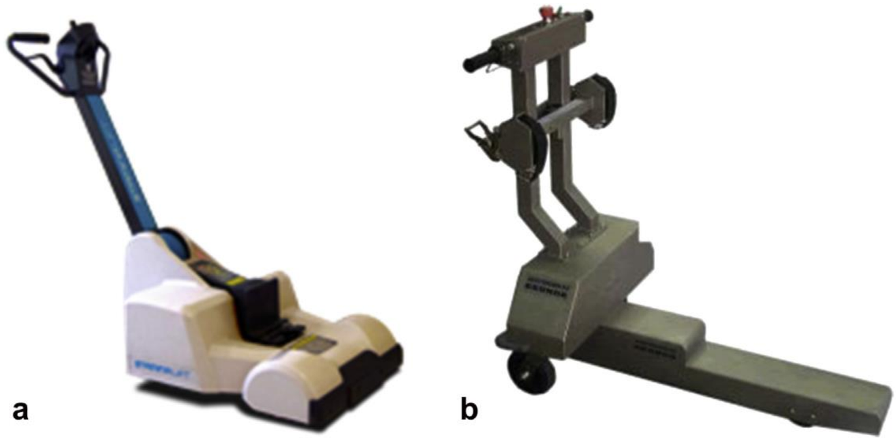

Figure 2-1: (a) StaminaLift Bed Mover, (b) Gzunda Bed Mover.[12]

Wiggermann, N. (2017) have carried out similar research but instead of muscle activation level, he measures the pushing and pulling force required to move the bed. The research compared a normal bed and a bed installed with a powered drive (shown in Figure 2-2). The participants are ten caregivers from actual hospitals. The force is measured by a load cell installed on the handle of both normal and powered beds. The result shows that the pushing and pulling force required for certain actions exceeded the physiological limits. The actions are initiating movements, decelerating, negotiating ramps, maneuvering in confined spaces, and quickly stopping the bed. Performing these actions that exceeded the physiological limits poses a high risk of injury. Meanwhile, the bed installed with a powered drive reduces the forces to an acceptable limit, thus reducing the risk of injury. [13]

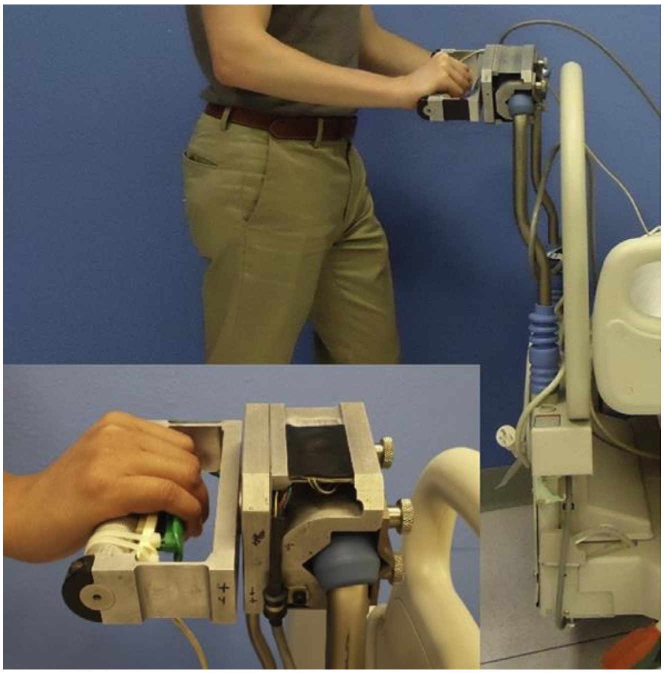

Figure 2-2: Powered drive installed on a hospital bed.[13]

2.5 OmniBed

Guo et. Al. (2018) designed and evaluated a brand-new solution to the problem which is the OmniBed (shown in Figure 2-3). There are two problems with conventional powered bed movers that are highlighted in their paper, which they are trying to solve. The first problem is limited mobility due to the use of a conventional wheel. Powered bed movers are generally only able to move forward and turn. This limited mobility makes it hard to maneuver, especially in cramped spaces. The second problem is the complex control system with a high learning curve. Control interface for powered bed movers featured joystick and buttons. The paper claims that the control interface requires the user to be thoroughly trained to familiarize themselves with all the functions available. If a wrong button is pressed, it can potentially cause crashes and accidents. Therefore, it is very important to have a control interface with a shorter learning curve.

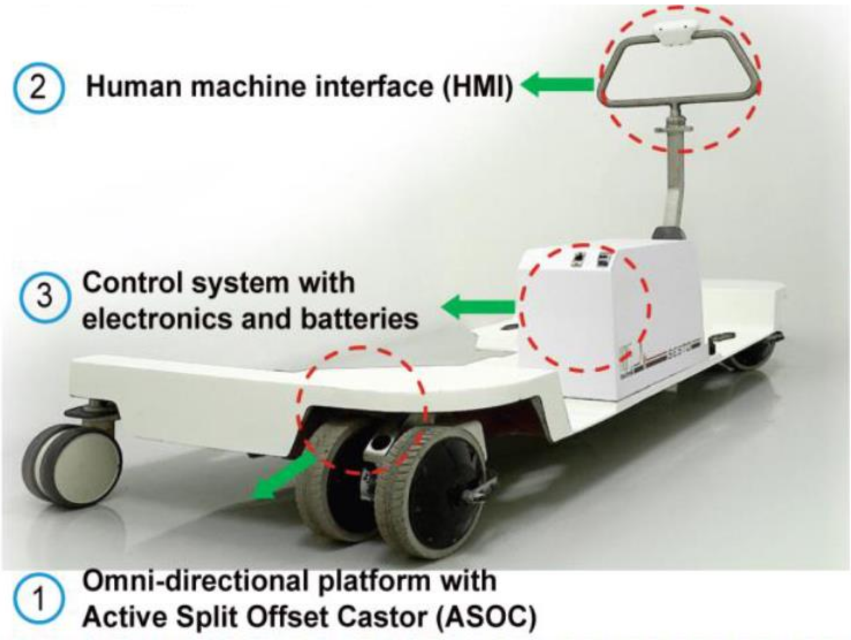

Figure 2-3: Prototype of the OmniBed.[14]

The solution that the OmniBed offers to solve the mobility issue is by using Active Split Offset Castor (ASOC) (shown in Figure) for omnidirectional mobility. The unique ASOC omni-wheel platform allows the device to move omnidirectionally with several advantages compared to other platforms. The advantages of using the ASOC are silent operations, excellent ground adaptability, and superior loading capacity. For the control issue, a force/torque (F/T) sensor is installed on the control handle. The F/T sensor will detect force from the user and move the OmniBed according to the force applied. According to the paper, this control interface gives the user the experience of pushing a bed with better control performance and lighter weight.[14]

The OmniBed project have shown that omni-directional mobility is indeed a desirable feature for this type of device, thus justifying this study of designing Mecanum wheel drive system for patient transfer device.

2.6 Mecanum wheels

Mecanum wheels are a special set of wheels that are designed to provide omnidirectional mobility. It has been a popular mechanism for wheeled mobile robot

(WMR). Having the advantages of better maneuvaribility, ability to turn in any direction without orientation, and capability to move in confined space, omnidirectional wheeled mobile robots, including four Mecanum wheeled mobile robots (FMWMR) have become a popular topic among researchers.[16] The Mecanum wheel, as shown in Figure 2-4, features rollers instead of treads. These rollers have axles that are skewed in respect to the wheel axles.[17] By arranging these special wheels in a specific arrangement and independently controlling each of the wheel, an FMWMR can move in any directions without steering the wheels. This happens due to the resulting forces of each individual wheels produced a total vector in the desired direction.[18] The direction of the resulting vector can be controlled by using the combinations of wheel direction as shown in Figure 2-5.

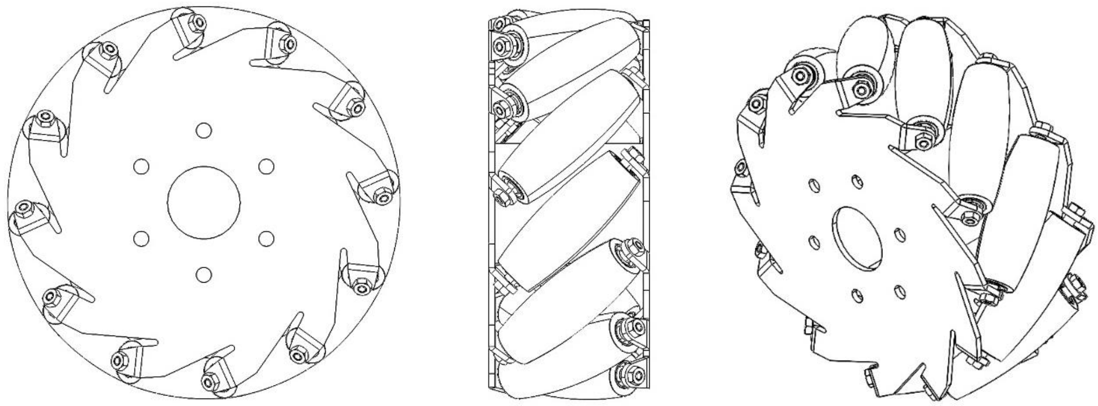

Figure 2-4: Design of Mecanum wheels

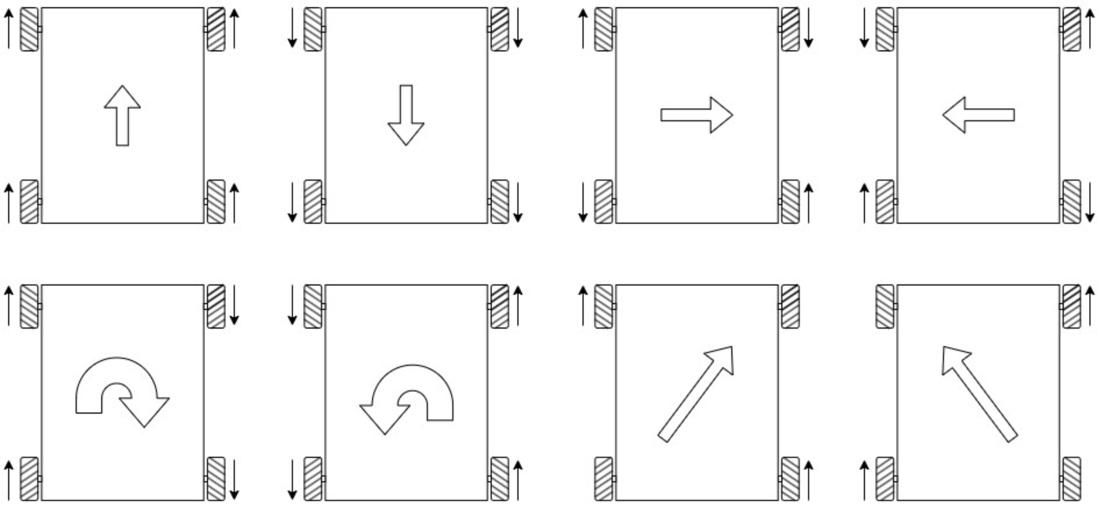

Figure 2-5: Combination of wheel directions and its resulting vectors

CHAPTER 3

METHODOLOGY

3.1 Introduction

As discussed in the previous sections, a Mecanum drive system for a patient transfer device will be designed and developed to solve the problems discussed. Figure 3-1 shows the flowchart of this project.

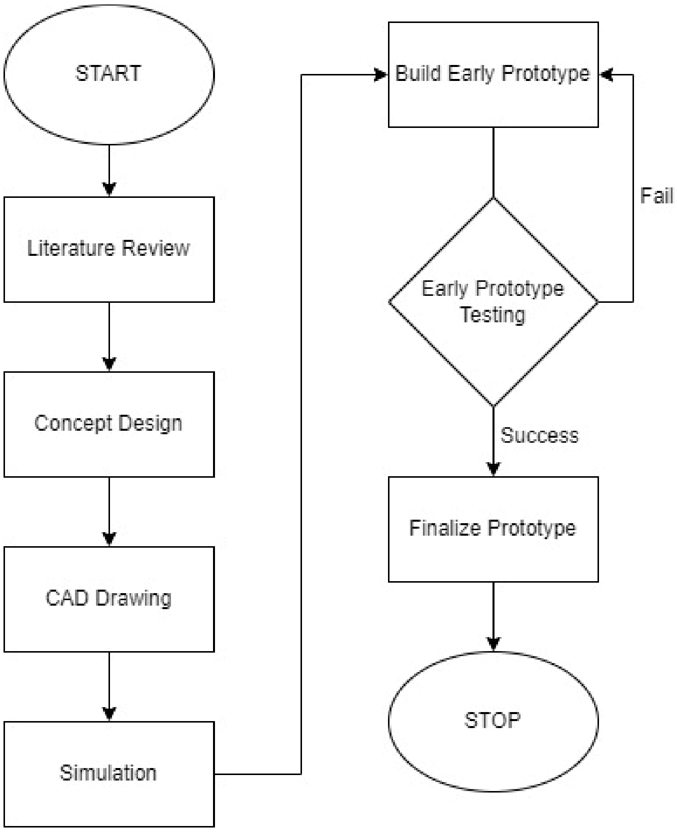

Figure 3-1: Flowchart of the project

The project is started with a literature review to understand the concept of Mecanum wheel and its working principal. Once the concept is understood, a concept design is created. The concept design is important to identify all the necessary components that needs to be prepared. Once the concept design is confirmed, a CAD drawing is created. The CAD drawing is sketched based on the design of the patient transfer device as shown in Figure 3-2. The CAD drawing is important to figure out the method to mount all the necessary components onto the patient transfer device. The next step is to do a simulation. This simulation will act as a baseline to measure the performance of the prototype. The fabrication process is started with building an early prototype, the early prototype is built to test out the system. The early prototype is modified and improved until it achieves a satisfying result. Once the early prototype is working properly, all the components are mounted properly and the wiring is tidied.

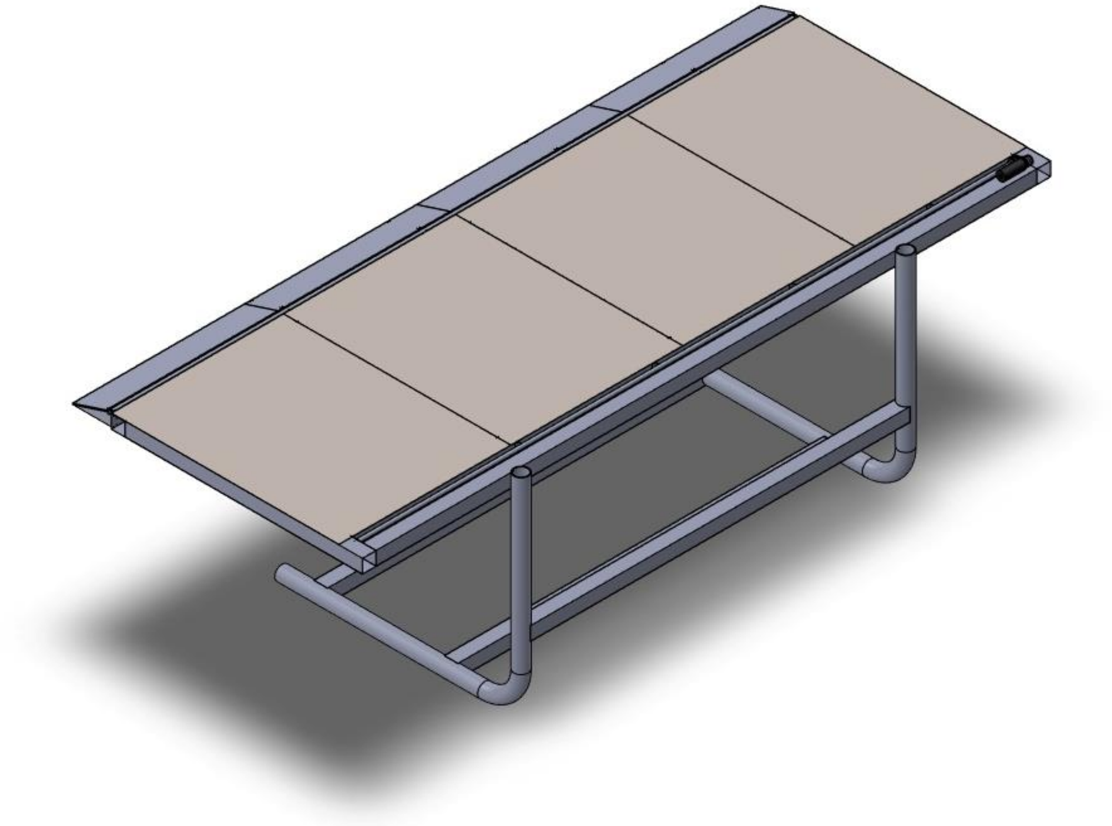

Figure 3-2: CAD model for the patient transfer device used in this project.

3.2 Concept Design

A concept design as shown in Figure 3-3 is created. By creating the concept design, the crucial component of the system is identified.

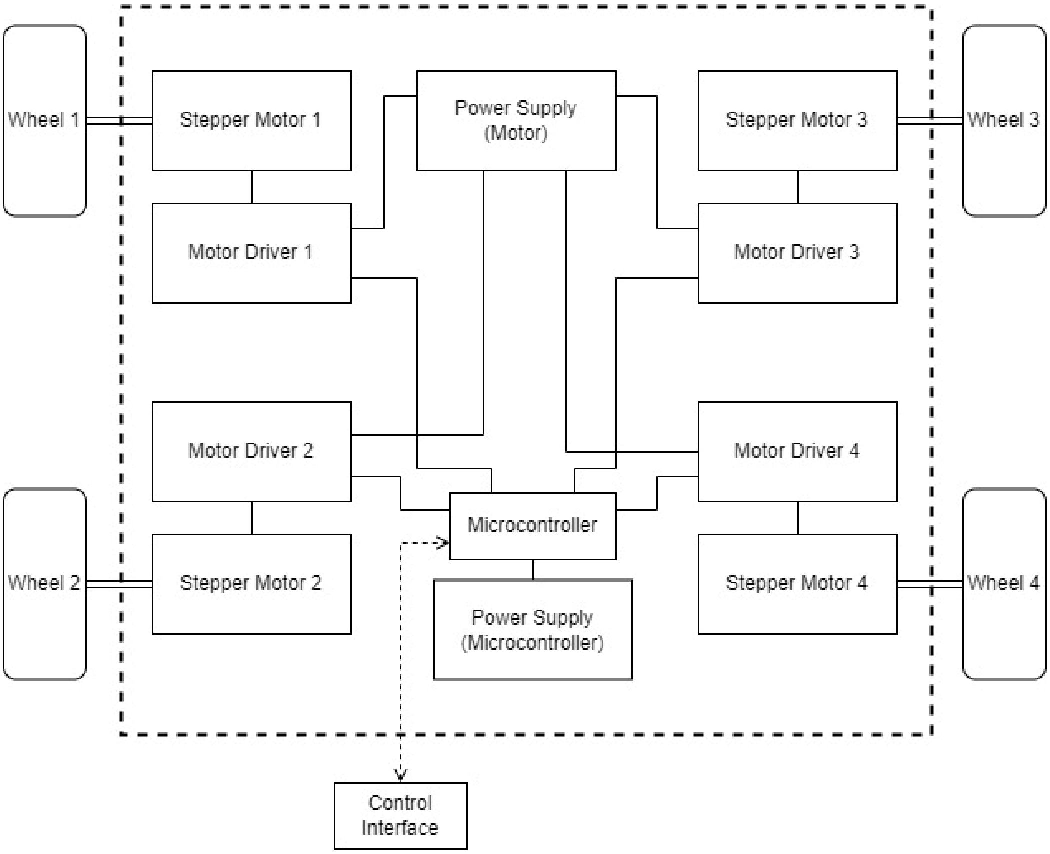

Figure 3-3: Concept design for the system

As the Mecanum wheel requires each wheel to be powered independently, a total of four motors are required. Stepper motor is chosen instead of DC motor because stepper motor allows precise speed control regardless of the load, given that the load does not exceed the load limit of the stepper motor. The precise speed control will allow consistent speed throughout the operation of the device with or without the patient. To control the motor, a motor driver and a microcontroller is required. The motor driver will act as an intermediary between the microcontroller and the motors, while also supplying power from the power supply unit to the motors. A motor driver is required for every motor, giving a total of four motor driver required. Only one microcontroller is required, as multiple motor driver can be connected to one microcontroller. Lastly, two power supply is required, one for the motors and another one for the microcontroller. As the motors will require a much higher power compared to the microcontroller, it is easier to use two separate power supply and power them up separately.

All of the components are then purchased from the online marketplace, Shopee and Cytron. The components purchased are listed in Appendix A, along with their respective specifications.

3.3 CAD Drawing

After finishing the concept drawing, a detailed CAD drawing is sketched. The process is started by sketching a simplified model of the patient transfer device, focusing only on the leg part. The simplified model, which will be called main frame from here on, is shown in Figure 3-4.

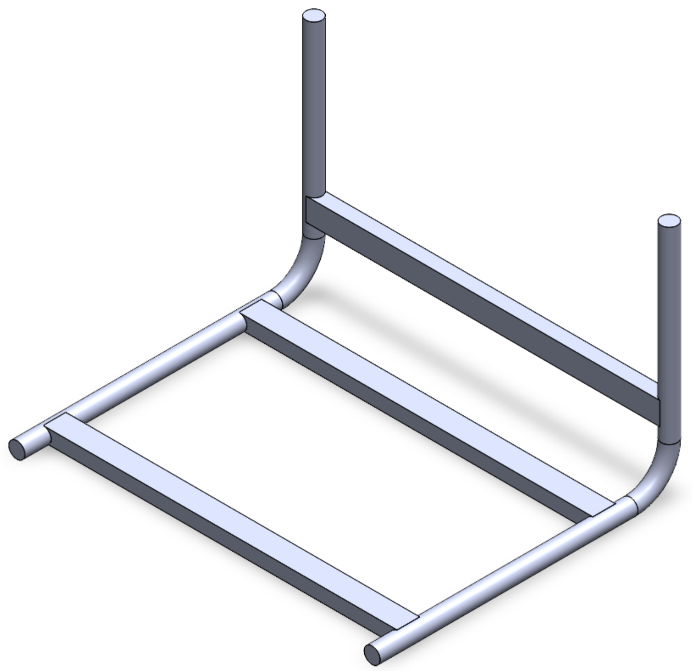

Figure 3-4: CAD model of the main frame

Then, CAD models of all the components are downloaded from an online library called GrabCAD. All of the components downloaded are assembled to the main frame. This assembly CAD model is important to plan the placement of all the components. The motor is first connected to a bracket using bolt and nut, while the bracket is welded to the main frame. The other components are mostly just screwed to the main frame. The assembly CAD model sketched is shown in Figure 3-5.

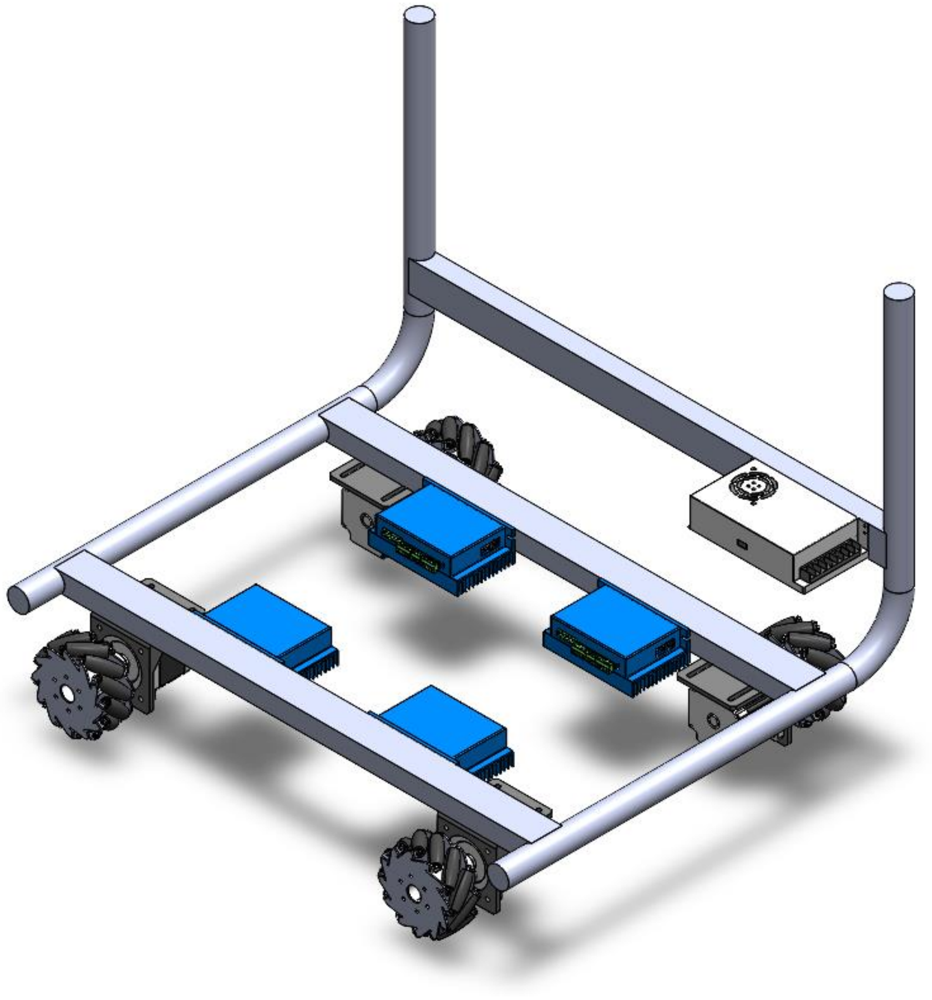

Figure 3-5: Cad model of the assembly.

3.4 Simulation

A simulation is done by using MATLAB to simulate the movement of the Mecanum wheels. The simulation is done by using the kinematic modelling of the

Mecanum wheels. The simulation is able to demonstrate the movement of the Mecanum drive system by giving the following inputs.

1. Distance between the wheels
2. Dimension of the system
3. Direction of each wheel

Appendix B shows the MATLAB program used to perform this simulation. The program shown is to simulate the system moving forward.

3.5 Early Prototype

An early prototype as shown in Figure 3-6 is built. This early version of the prototype is built by simply placing most of the components on top of a board placed on the main frame. This early prototype is built in this way so that it is easy to make any changes or improvements before moving on to building the finalized version of the prototype.

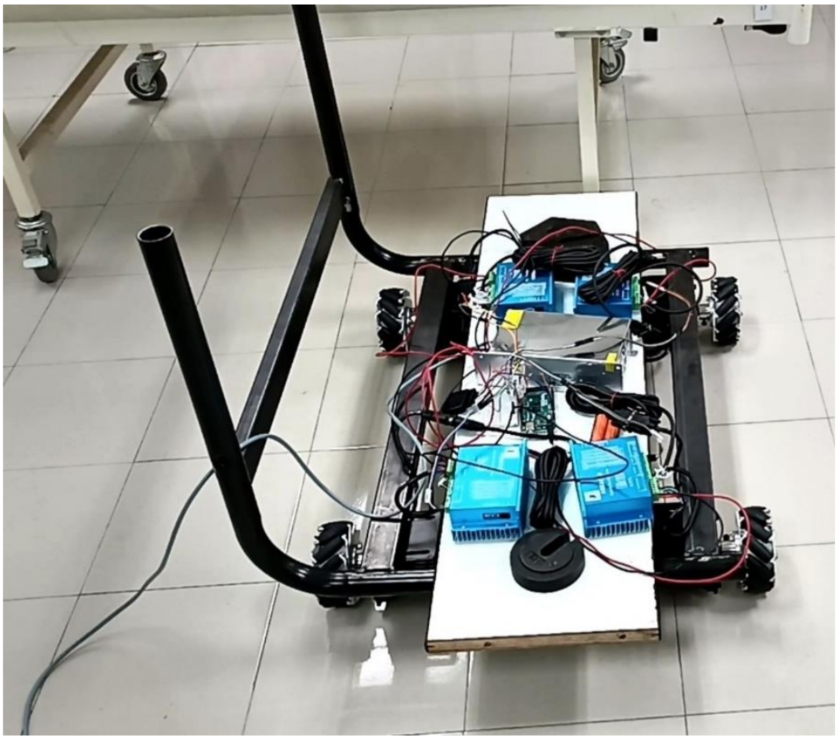

Figure 3-6: Early version of the prototype

3.5.1 Improvements and Changes

This prototype shown great result as it is capable of moving in the proper designated direction. However, the PS2 controller is not working. This version of the prototype has to be controlled by changing the direction of each motor using the dip switches in the motor drivers. When the PS2 controller is used to control it instead, the motor becomes very jerky and failed to move in the designated direction. The cause of this problem is suspected to be the microcontroller not being powerful enough. The Arduino Mega used in this prototype is suspected to be not powerful enough to process the input from the wireless PS2 controller while controlling four stepper motors at once. The Arduino Mega are also having trouble adjusting the speed of the system. This problem happens because the program needs to have some delay for it to match the frequency of the PS2 controller. The delay also delays the frequency where the microcontroller is commanding the motors to move, thus, making the motor speed falls.

To solve this problem, a second microcontroller is brought into the system. The second microcontroller is the Maker Uno by Cytron. The Maker Uno is programmed to receive the input from the wireless PS2 controller and process it into a simpler input. The simplified input is then sent to the Arduino Mega using I2C bus, to control the motors. This new setup reduced the huge burden seriously placed on the Arduino Mega, giving it more power to control the 4 motors. The main program in the Arduino Mega also no longer needs to have the delay function, as the delay function is now programmed in the Maker Uno instead. This gives more flexibility to controlling the motor speed.

3.6 Finalizing the Prototype

As the early prototype is already working properly, a finalized prototype is built by properly mounting all of the components onto the main frame. The finalized prototype is shown in Figure 3-7. The prototype can be controlled by using a PS2 controller with button configurations as shown in Figure 3-8.

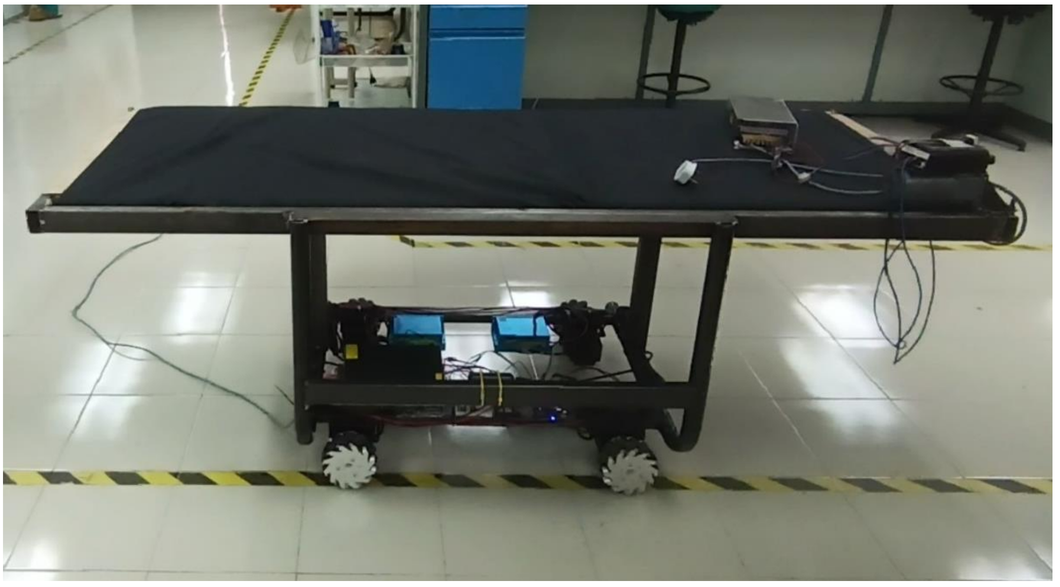

Figure 3-7: The completed prototype

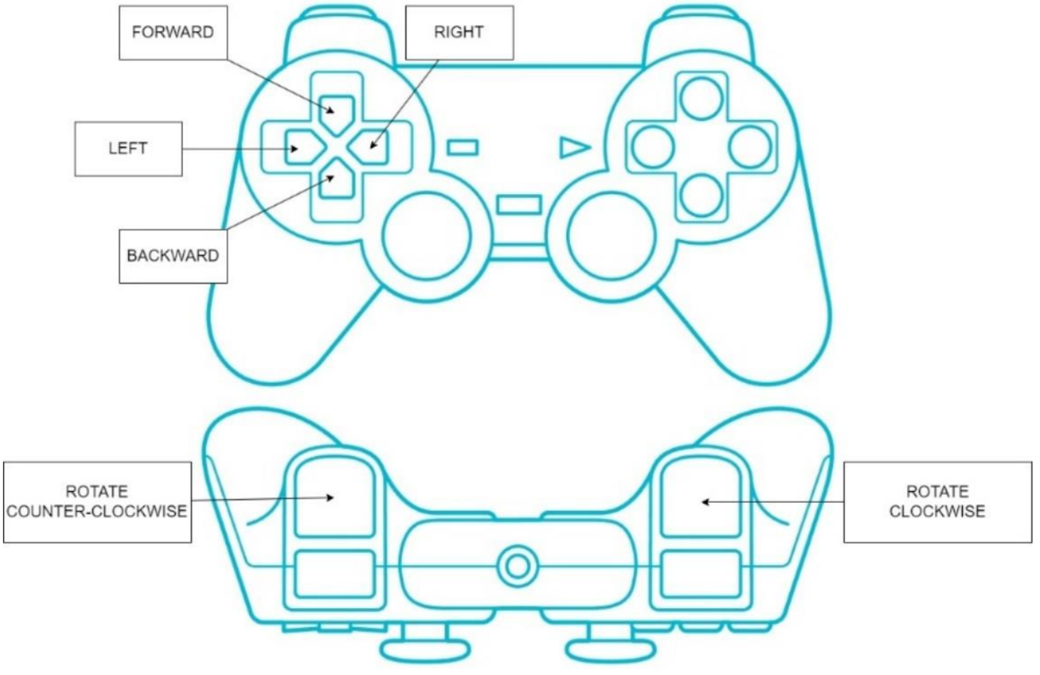

Figure 3-8: Button configuration on the PS2 controller

3.6.1 Hardware

The hardware can generally be split into three categories, the power supplies, the actuators (stepper motors, motor drivers and Mecanum wheels) and control system (Microcontroller, and PS2 controller).

The power supply unit (PSU) used for the four motors has a rated power of 1200W (65V, 18.5A). This PSU is chosen as it has a voltage that is in the range of the motor drivers working voltage (DC 30-100V). The current is also enough to support all 4 motors where each of them requires 4.2A of current, resulting in a total of 16.8A of current required. For the microcontroller, originally the Arduino Mega is powered by two Li-ion rechargeable battery with a total of 7.4V of voltage. However, as the Maker Uno is added into the system, the power supply is changed to a portable power bank with two output ports, each rated at 5V and 2.1A. Aside from having two output ports, the power bank is also chosen because it is easy to use as it features a capacity indicator and can be easily charged by using USB cable and phone charger that is widely available.

Due to budget and time constraint, the Mecanum wheel set used in this project can only support load up to 70kg for the whole set. Mecanum wheel of higher load capacity are currently not available in Malaysia and needs to be purchased from overseas. This increases the cost of the Mecanum wheel tremendously as the shipping cost is very high. The wheels will also take too long of a time before it can be delivered and received. Therefore, this set of wheels which has the highest load capacity that are currently available in Malaysia is chosen. Even though the load capacity is low, it is still sufficient to prove the design that is proposed in this project. The motors used to move the wheels are Nema34 stepper motors with rated torque of 4.2N.m. As the device is planned to only run at low speed, the torque provided by the stepper motors are sufficient. Each stepper motor is connected to a motor driver. The motor driver is required as the microcontroller is unable to handle the large power required by the motors. Thus, the motor driver will act as an intermediary by receiving signals from the microcontroller and controls the motor according to the signals received.

For the microcontroller, two Arduino boards are used. The first one is the Arduino Mega 2560 R3 or simply Arduino Mega. This board is chosen for its large number of I/O ports. It is also a more powerful version of the Arduino Uno R3, which is the most commonly used Arduino board. However, the early prototype testing shows that even the Arduino Mega is not enough to handle the processing load in this system. The second Arduino board, which is added to assist the Arduino Mega is the Maker Uno by Cytron, or simply Maker Uno. The Maker Uno is an Arduino board manufactured by local manufacturer, Cytron for education purposes. It has similar specifications with the Arduino Uno R3, but cheaper price as it is manufactured locally. The low price of the Maker Uno is the main reason it is chosen. As the Arduino Mega is still the main microcontroller, the second microcontroller doesn’t require high specification, thus having lower price becomes a priority. Another component in the control system is the wireless PS2 controller. The PS2 controller acts as the user interface to allows the user to input commands to the microcontroller. The wireless PS2 controller is chosen due to its compatibility with Arduino. Furthermore, its wireless 2.4Ghz capability is also a nice addition to the system.

3.6.2 Wiring

The wiring of the system is quite simple. All the motors are each connected to a motor driver, while the motor drivers are connected to the Arduino Mega. The PSU is connected to every motor driver to supply power to the motors. The PS2 controller is connected to the Maker Uno. Then, the Maker Uno is connected to the Arduino Mega so that it can send the simplified input. Lastly, both the Arduino board are connected to the portable power bank via USB. A detailed list of all connections is shown in Appendix C.

3.6.3 Software

Two programs are written as there are two microcontrollers used. The program is written in Arduino IDE software as the microcontroller used are both Arduino boards. The first program, which is the main program is for the Arduino Mega. This program main purpose is to control the direction of each motor based on the input received by the Maker Uno. The Arduino Mega will read the variable ‘motorState’ sent by the Maker Uno and moves the device in the corresponding direction (e.g.: 1=forward, 2=backward, etc).

The second program is the controller program, which is the program uploaded into the Maker Uno is to process the input received from the PS2 controller into a simpler input for the Arduino Mega. The Maker Uno reads the button pressed on the PS2 controller and changes the value of the ‘motorState’ variable based on the button pressed. The variable ‘motorState’ is then sent to the Arduino Mega for it to control the motors. Flowcharts showing the algorithm for both programs are shown in Figure 3-9, while the full programs are attached in Appendix D and Appendix E.