Senior Design Project II

UMP-GMI Offshore Program

Bachelor of Engineering Technology (Manufacturing)

Bachelor of Engineering Technology (Electrical)

Universiti Malaysia PAHANG
Engineering • Technology • Creativity

GMI GERMAN-MALAYSIAN INSTITUTE
Training for Advanced Technology

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9.45 – 10.30 am	2	**Integrated System for Pilot Bottling Assembly** Advisor : Dr Samson Mekbib Atnaw (UMP) Supervisor : 1. Ir. Nor Azilan Jaafar (GMI) 2. Mr Hanief Ahmad (GMI)
10.30 -11.15 am	3	**Semi-Auto Propeller Duplicator Machine** Advisor : Dr Samson Mekbib Atnaw (UMP) Supervisor : 1. Mr Muhammad Khairi Abd Rahim (GMI) 2. Mdm Hafidzah Ahmad (GMI)
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PROTOTYPE EXOSKELETON ARM

Muhammad Sufi bin Rani, Mohd Amir Aiman bin Samsul, Adly Akhyar bin Abdul Bahri, Farhana binti Mohd Rosli, Mr. Khairul Anuar bin Juhari, Mr. Abdul Razak bin Ramly, Dr. Samson Mekbib Atnaw

***Abstract* : Accessing to give a rehabilitation process for disable people was a big challenge. Prototype exoskeleton arm offer benefits for both disabled and healthy populations. Therefore, the necessary components for studying the interaction between robot and human body have been implemented. Using a method of design and operating system surely can develop this prototype exoskeleton arm which has been discussed in this paper. The mechanical design could be considered well while the electrical part could be enhanced for the better results.**

INTRODUCTION

The goal of this project is to aid the rehabilitation process of people with arm functional disorder. The arm whether it is the left arm or the right arm, is the upper limb on human anatomy.

The upper arm, extending from the shoulder to the elbow, provides pulling and lifting action. The elbow is a hinged joint that allows the arm to open up to 180 degrees at full extension. The area between the wrist and the elbow is known as the forearm. With five fingers, the hand allows human to do much more complicated task in daily life.

There are many type of injuries related to the arm but the most common injuries are twisting, lifting and falling. These injuries are known as Musculoskeletal disorders (MSDs). This term is used to describe a variety of condition that affects the muscle, bones, and joints.

Other than injuries, illness such as stroke can also cause the arm to have functional disorder. If a side of the brain is damaged by stroke, the opposite body side will be affected by paralysis. The most often affected area is the face, an arm, a leg, or the entire side of the body.

The number of people with physical disability registered by the Ministry of Health for the years during the year 2011 is 143. In the year 2012, there is a climb to the number with 23 more registered cases [13]. It shows that there is possibility of increasing number of people with physical disability from year to year. Therefore, there will be a lot of people that need some kind of aiding device or equipment to help them live normally.

To assist such physically disabled people, a research has been carried out, especially in the branches of robotics, particularly on exoskeletons armor. Exoskeleton armor is a mobile machine consist primarily an outer framework worn by a person and powered by a system of motors, hydraulics, pneumatics or levers that delivers at least part of the energy for limb movement

In this project, we aim to make an exoskeleton arm which will able the user to move their arm with less effort. To do this, we have acquired anthropometric data and body weight statistic of an average Malaysian.

METHODOLOGY

A. Mechanical Parts

Design

The exoskeleton frame is ergonomically designed based on the anthropometric data. Anthropometry consists of the measurement of body characteristics such as reach, body segment length and circumferences, widths, and heights, among others. [14]. The body areas that we took into consideration when designing the exoskeleton are shoulder breadth, chest breadth, forearm hand length shoulder-elbow length, chest depth and upper arm length.

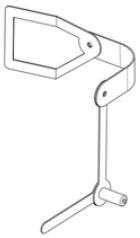

Fig. 1 3D drawing of the main frames

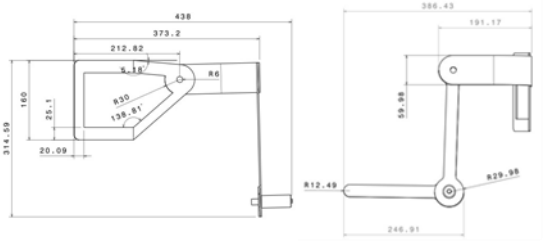

Fig. 2 Front view and left view dimensions

Material Selection

Aluminium is chosen for the main frame because it has the characteristic that we are looking for.

- It has low density and therefore it is lighter than other metal. This is to ensure the machine is suitable to be wear by the patient.
- There are time limit for us to fabricate the machine, the material should have superior malleability and easy to machine.

Machining Process

Wire-Cut Electrical Discharge Machining (EDM) is a process of metal machining in which a tool discharges thousands of sparks to a metal workpiece.

This machining process method is chosen for the machining process because it has the characteristic that we are looking for:

- It can get the desired shapes of materials by using the electrical discharges of sparks and it is the most suitable machine according to our design that has more curve shape.
- There are time effective machine compare to CNC machine, since we have a limit time to fabricate the product.

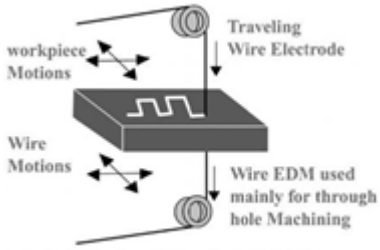

Fig. 3 EDM Wire Cut machining principle

Material removal rate (MRR)

$$MRR = 4x10^{4}\, IT^{1.23}$$

I = current (ampere)

T = workpiece melting temperature (°C)

B. Electrical parts

Controller Wiring Diagram

In the Fig. 4 below show the controller wiring diagram for the exoskeleton arm system which is use EMG sensor, its act as signal to detect any muscle reaction occur and send data Arduino. In this situation, DC motors were ready to operate when the EMG sensor is start detected muscle reaction. Arduino will take action send signal to port which is has connect with motor driver and operate output DC motor.

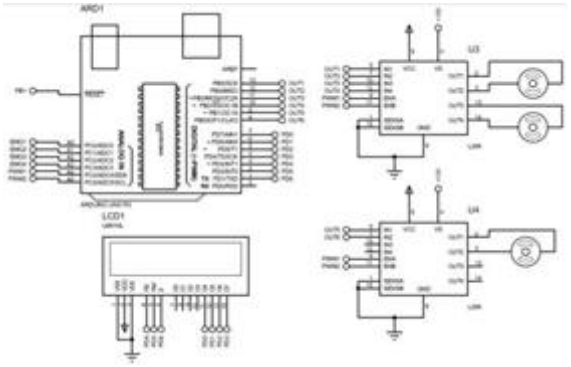

Fig. 4 Controller wiring diagram

Potentiometer Reading Circuit

Fig. 5 shows that the potentiometer is attached with the DC motor for reading analysis and limiting purpose. While DC motor operates, potentiometer rotates sync with motor rotation. This can measure the angle rotation from voltage reading and meanwhile also set the limiting voltage limiting signal can be DC motor operating. From that it can be consider as safety features to the user from overshooting motor rotating angle

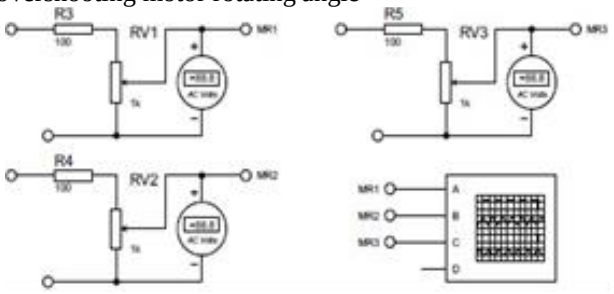

Fig. 5 Potentiometer Circuit

Motor

The motor that is chosen as an actuator in this project is dc motor. This dc motor is combined with a gear box. The purpose of the gear box is to amplify the torque that is produced by the dc motor.

However, the angular rotation will be different since there is ratio of the gear. The figure shows the gearing in the gear box that is used for this project.

Fig. 6 Inside the gearbox

The gearing in Fig. 6 is called the complex gear machines. The formula to find the gear ratio for this gearing is:

$$\textbf{Gear Ratio} = \frac{Out}{In} * \frac{Out}{In} * \frac{Out}{In} \ldots.$$

Moreover, to find speed for this gearing is:

***Speed**: RPM Out = RPM In / Ratio*

Finally, to find torque, the formula that used is:

***Torque**: Force x Distance*

From the equation above, the angular rotation, rpm and torque that is needed is determined. Therefore the dc motor will rotate according to what is already being programmed. This is also for the safety purpose, in order to make sure that the exoskeleton is not over rotate.

C. Costing analysis

After the economic analysis has done, it shows the feasibility of this new idea of the exoskeleton arm. It will be based on the raw material and electrical part. The range cost for average construction is from RM3500 to RM4500, it depends on the material are used whether local or imported material. Raw material, Operation, Maintenance and fabrication of part for ease of transportation will affect significantly to the overall cost. Table below will show the summary of cost analysis. The Exoskeleton Arm is completely scalable based on the potential company interested in commercializing our product.

Table 1 Project budget

No	Category	Expense (RM)
1	Electrical parts	2672.00
2	Raw materials	252.00
3	Fabrication processes	300.00
4	Body supports	147.00
5	Travel and miscellaneous	100.00
	Total	3471

D. Ethical consideration

To complete research with appropriate research guidelines research ethics is very important. Considering ethical aspect of research enough time is given to the respondent of the study so that they can depict their true view in the research questions. Primary and secondary data will be used in this study. Consent from the respondents will be taken and appropriate permission will also be ensured for usage of their given data.

Hazards exist in every workplace in many different forms. The first step that we should do is understand basic safety rules before we can use the equipment and machine or attempt practical work in a workshop. These rules will keep us and others safe in the workshop. During the fabrication process there are sparks and heavy objects all over the workshop; with the proper attire we can reduce the percentage of getting injuries in the workshop. We implement 5s in our workshop because it is essential to avoid work hazard during the fabrication of our project

RESULTS AND DISCUSSION

The sensor is analyzed by placing the electrode in the desire muscle position shown in the Fig. 7. Fig 8 shows the result of analysis of the sensor.

For accuracy analysis, six trials were run in all. Table 2 reports the individual trial accuracies. An average of all six trials indicated an accuracy of 74 ± 6 %.

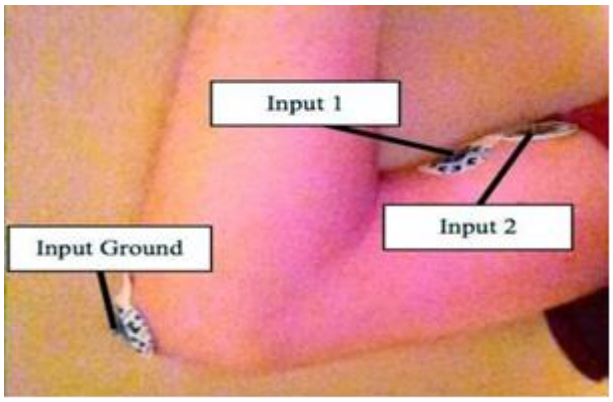

Fig 7 Muscle sensor electrode placement

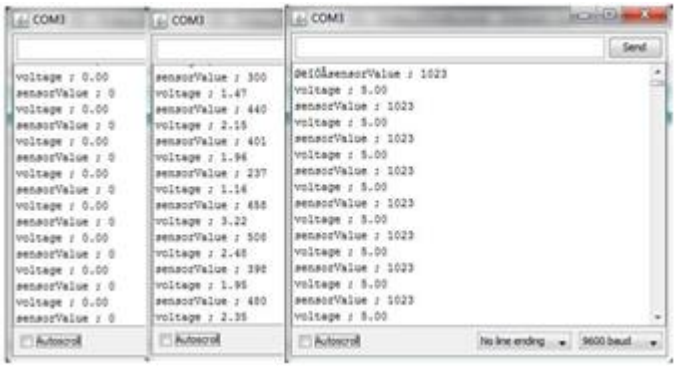

Fig. 8 Sensor analysis result

Table 2 Classification accuracy across multiple trials

Trial Number	Accuracy (%)
1	64.3
2	77.1
3	68.5
4	71.4
5	75.7
6	84.3
Average Accuracy (%)	74 ± 6 %

Fig. 9 shows the analysis that had been done for the servo motor. These are the code that programmed to get the angle of the servo motor synchronizing with the movement of the hand that is attached with the EMG sensor.

Fig. 9 Analysis angle for servo motor

CONCLUSION

In conclusion, the increase reported case of arm injury throughout the years has inspired us to develop new effective physiotherapy machine that can improvising the arm injury. Uniquely, the exoskeleton arm is user friendly because it is a wearable product so the patient can brings it anywhere. Furthermore, the exoskeleton arm is easy to maintenance and it is a low cost product. Since it does not cost the user to spent too much on the product, it is much more affordable then the existing physiotherapist machine. This product has great potential to help any arm musculoskeletal disorder (AMD) to recover faster. Although the patient have be to supervise by a therapist, with this product it is not necessary for the patient to go to the clinic often since the patient can use the machine anywhere

ACKNOWLEDGEMENT

We are deeply indebted to our supervisor, Mr Abdul Razak bin Ramly for his patient, guidance, comment, stimulating suggestions and encouragement which helped us in all the time of research, writing of this thesis and assistant throughout our project work. We would also like to express very special thanks to our co-supervisor Mr.Khairul Anuar bin Juhari for his suggestions and co- operation throughout the study.

We are also like to convey thanks to the Production Technology Department and Industrial Electrical Department for providing both workshop and laboratory facilities for this research. Our sincere appreciation also extends to all our friends, lecturers, technicians and others who provided assistances and advices. The guidance and support received from all was vital for the success of this research.

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Integrated System for Pilot Bottling Assembly

Ahmad Zaheer bin Hamzah, Muhammad Faisal bin Ismail, Fatin Nazirah binti Mohamad Zura, Muhamad Khairul Azhar bin Abdul Rasid, Ir. Nor Azilanbin Jaafar, Mr. Hanief bin Ahmad Azam, Dr. Samson Mekbib Atnaw

This project explored improvements to the bottling industry, specifically in the production of drinking water. It is a combination of electrical, mechanical and pneumatic systems. The process involves transferring bottles from a loading point using a robot to another station. It stemmed from an existing project which consisted of two stations; a Cartesian robot and a buffer conveyor. This project focused on improving the communication between both stations using the master and slave devices on a PROFIBUS network and integrate it using a Human Machine Interface (HMI).On the mechanical side, the design of several parts were improved to make the robot more streamlined and the assembly line fully automated. The success of this project will help to cut costs and reduce production time in the bottling industry.

INTRODUCTION

This Senior Design Project (SDP) is based on the bottling plants background. The bottled water industry does not require any heavy transformation process. Instead it involves a relatively light manufacturing process compared to other industries. An Integrated Pilot Bottling Plant normally has several stations, for this project, only the first two stations are involved.

Previously, the communication between the two substations, which are Cartesian Robot and Buffer Conveyor, is not integrated to each other. The problem is in choosing the method to integrate between the substations. The next problem that has to be tackled is the fabrication process. It is hard to choose the most suitable material and also the tools and equipment that need to be used during the process. Since this is a batch bottling production, the capability and durability of the machine should be appropriately analyzed. The evaluation is needed to maintain the performance of the plant.

Modern automatic plants place ever higher demands for current process technologies. Therefore, there is a need to observe the problems that usually happen when it is operating. This project aims to attain the following objectives:

I. To integrate between a Pneumatic Cartesian Robot &a Buffer Conveyor.

II. To fabricate mechanical parts and install/modify electrical parts.

III. To evaluate the performance of the pilot plant (Substation 1and Substation 2).

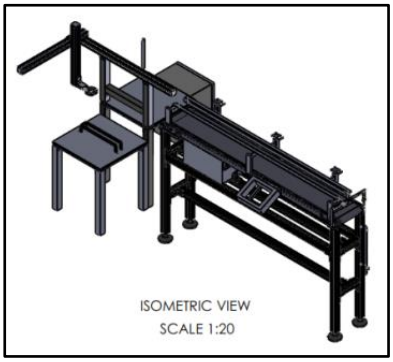

Fig. 1 3D Drawing of Cartesian Robot & Buffer Conveyor

METHODOLOGY

The project is more related to creating a product and a system.

E. Product Function

Pilot which means “Mini” since the project only utilizes a small bottling plant compared to the usual size of machines at factories. The machine operates with a modern technology by using a Human Machine Interface (HMI).

F. Product Specialization

❖ Cartesian Robot

A Pneumatic Cartesian Robot is a robot which has X, Y, and Z axes movement [1]. The mode of operation for this system is pick and place at Substation 1. Therefore, a gripper functions as the main part to grip all bottles. The model of gripper used is the Mini Chuck Gripper Festo. However, the finger gripper was made of Aluminum 6061 material of own design and fabrication.

❖ Buffer Conveyor

A Buffer Conveyor is a type of conveyor belt which has a straight section. It functions to buffer the loading area from the operation in Substation 2. All bottles are treated as the raw input and will be transferred to the next station where they will be filled with drinking water, considered as the place for output. Good assembly sequence planning has been recognized as a practical way to reduce operation difficulty, the number of tools and working time [2].

❖ Programmable Logic Controller (PLC) S7-200

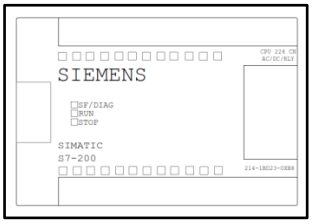

Fig.2 PLC System

The control is made easy with the use of a Programmable Logic Controller (PLC). The function of the PLC is to automatically control every aspect of the operation without human intervention. PLC uses a programmable memory to store instructions and execute functions such as on/off control, counting, timing and data handling of the program [3]. The S7-200 series is a line of micro-programmable logic controllers that can control a variety of automation applications, with the advantage of a compact design, low cost, and a powerful instruction set.

❖ Human Machine Interface (HMI TS1070i)

A Human Machine Interface (HMI) functions to monitor and control the operation with coded signals over communication channels. The brand chosen is a Hakko product with 7–inch wide TFT Color 800*480 Ethernet 24VDC (CE only) criteria.

G. Machine Criteria

- Type of machine: Cartesian Robot & Buffer Conveyor
- Weight: 30 kg
- Dimension: 2281x1127x1124 (mm)

H. Design Criteria

- Price – Reduce the price
- Ergonomics –Mostly focused on the height of parts that is more suitable for Malaysian people.
- Aesthetics – Use modern technologies such as robot and HMI to present a good appearance.
- Properties – The materials are mostly aluminum as it is normally used for assembly lines.

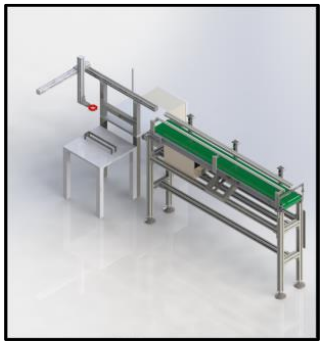

Fig.3 Rendered3D Drawing by Solidworks

I. Equations

❖ Overall Equipment Efficiency (OEE)

OEE is a hierarchy of metrics developed to evaluate how effectively a manufacturing operation is utilized. The results are stated in a generic form which allows comparison between manufacturing units in differing industries. It is an absolute measure and is best used to identify scope for process performance improvement, and how to get the improvement.

OEE Formula: [4]

$$OEE = (available \times performancerate \times quantityrate)$$

$$Availability = \frac{(totaltimeavailable - downtime)}{totaltimeavailabe}$$

$$PerformanceRate = \frac{numberofunitsmanufactured}{possiblenumberofunitmanufactured}$$

$$QualityRate = \frac{(output - numberofdefects)}{output}$$

❖ Coefficient of Friction (CoF)

The coefficient of friction describes the ratio of the force of friction between two bodies. Controlling coefficient of friction values on packaging lines is crucial. A consistent and steady value within a set range is required to stabilize packages for maximum throughput and to reduce loading on conveyor motors. As well as maintaining a consistent CoF, it is important to achieve different CoF values at different zones along the packaging line.

$$\mu = \frac{F}{N} \qquad [5]$$

PROJECT BUDGET

The cost for the project budget is stated in the table below. The entire price of the materials was given by the supplier.

Table 1: Project Budget

No	Category	Expense
1	Raw Materials	RM 505
2	Standard Parts	RM 980
3	Electrical Parts	RM 1870.66
4	Machining and Fabrication	RM 725
5	Travel and Miscellaneous	RM 110
		RM 4190.66

ETHICAL CONSIDERATIONS

Before constructing the diagnostic device, the workspace has to take into account, taking measures to implement design considerations and the ability to easily modify the design for future purposes. There are some reasons why in industry, the automated system may be preferred rather than human operators. In industry, a production line is running continuously until it achieves the daily target. Human are able to work in a certain period of time and gets tired when their limits are exceeded [6]. On the other hand, robots do not suffer from these limitations. This is to ensure the quality of the system and products can be managed.

STANDARD SAFETY OF MACHINERY

The safety features installed in this project are emergency stop button, push buttons on/off, MCB and caution signs. Each of these components has their own function to make sure no accident happens.

Table 2 List of Standard Safety for Machinery

No	Part	Explanation
1	Emergency stop button 	To ensure the safety of the whole system when there is unexpected behaviour during the operation of the machine.
2	Push buttons on/off 	A simple switch mechanism for controlling some aspects of a machine or a process (start or stop).
3	MCB 	Provides protection for the whole process such as in the case of short circuit or current leakage via its magnetic trip element.
4	Caution sign 	To ensure the users are keep informed about the danger that might come from the particular components.

RESULTS AND DISCUSSION

A. *Finite ElementAnalysis (FEA)*

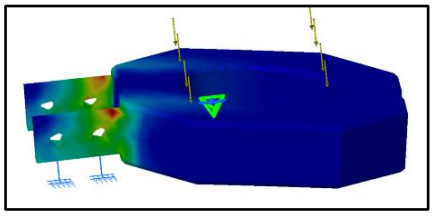

Fig.4 Example analysis with FEA

The engineering analysis proceeded by separating the engineering design into the mechanisms of operation or failure, analyzing or estimating each component of the operation or failure mechanism [7]. The part that has a critical point that needs a further analysis is the gripper area. Some value load was applied to be analyzed using Finite Element Analysis (FEA). The result was calculated automatically to determine whether the improved design can proceed by calculating the strains, stresses and displacements.

B. *Overall Project*

The main result of this project is to upgrade the existing pilot bottling assembly plant. The parts of project that were marked for improvement are:

- Wiring for the Cartesian robot control and buffer control.
- Conveyor belt system.
- Cartesian robot gripper.
- Wiring diagram.

Based on the improvement parts stated above, the part that took the most time to finish was the conveyor belt system. Some features are added in this project which is Human Machine Interface (HMI) by using SCADA (Supervisory Control and Data Acquisition) system. This HMI can control both sections for Cartesian Robot & Buffer Conveyor.

Table 3 Expected Results from Project

Mechanical Part	Electrical Part
Cut cost for material	User friendly
Increase strength, reliability and stiffness	Better wiring layout
Better fabrication quality	Smooth system operation

IEEE STANDARD

IEEE provides a wide range of quality standard that makes the exchange of technical knowledge easier. Hence, the wiring diagram and all symbols has been applied following this format.

CONCLUSION

The integration between the Cartesian Robot and Buffer Conveyor was achieved by communicating the PLC S7-200 controller using NETR/NETW Step 7 Micro/WIN. By doing this, it made the running of the substations easier and smoother. The integration for both substations can be controlled only by using a single Master control which is the HMI. Besides that, the improvement in fabricated parts made both substations stronger, more reliable and with better parts stiffness. It also helped to get better production efficiency. For future work, the Cartesian Robot can be changed from using pneumatic system to DC motor for the robot movement. This will improve the efficiency and provide better appearance. Besides that, in order to reduce the usage of manpower, the automated adjustable guide rail can be replaced.

ACKNOWLEDGEMENT

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Semi-Auto Propeller Duplicator Machine

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***Abstract*: A propeller duplicator machine is a machine that produces an output by duplicating the mold. Manpower is wasted to monitor a single operation since machining requires supervision. Therefore, a semi-automated duplication machine is designed to combat this problem. Improvements from previous machine are the adjustable gripper, a frequency inverter to control the speed of the cutting tool, adding motor for a rotational movement and using a PLC to control the whole system of the machine. With our proposed changes, the machine works by placing a mould and a raw material (Wood) to the gripper. Then, a start button is pressed and the operation will start. The user can stop the operation by pressing a stop button. The operation works by using the rotational and linear movement created by the two motors. The linear movement is used for the lead screw to move the saw left and right. While the rotational movement is used for rotating the mold and raw material.**

INTRODUCTION

This project is a joint venture project between Malaysia Innovation Foundation, Perkasa Propeller Enterprise under Mr. Mujib Ahmad and GMI with title 'Semi-Auto Propeller Duplicator Machine for Perkasa Propeller Enterprise'. This project was started by diploma students and we decided to take up and continue the project.

Propeller is a type of blade that is use for paragliding activity. This propeller is made from Nyatoh or Meranti wood which has its own profile design and usually produced through duplicating process. This duplicating process requires a mould and wooden block to operate. The current machine that is used by Mr. Mujib cannot be automatically operated. Therefore, we designed a machine that is operated in semi-automatic mode.

When the company used full capacity of human energy to operate the machine, it leads to low productivity for high demand of the order. Semi-Auto Propeller Duplicator Machine is an improved machine from the original manual machine in order to reduce the machining time. The main mechanism we are using is rotation of wooden block as work piece and a mould by using two motors. One of the motors is used for rotational movement and the other motor is used for linear movement (lead screw). The cutting process uses a saw and the blade of the saw is carbide tipped.

Semi-Auto Propeller Duplicator Machine works by a designing a guide that copy the profile of the mould and cut the wooden block into shape. The wooden block will be rotated by using a motor. While the wooden block rotate at its position, the guider and cutter will start to move along x-axis using lead screw mechanism for linear movement. The cutting process will occur when the saw blade touch the rotating wooden block.

METHODOLOGY

A. Project Flowchart

Semi – automatic propeller duplicator are machine is an alternative and the best method for creating a propeller in an efficient way. It can work without human supervision and also improve the productivity which is important aspect for a company. The shorter time required to produce a product, the higher productivity of a company. This technical note will describe the process of the semi – automatic propeller duplicator from raw material until finished product. The process flow of Semi – Automatic Propeller Duplicator is showed in Figure below.

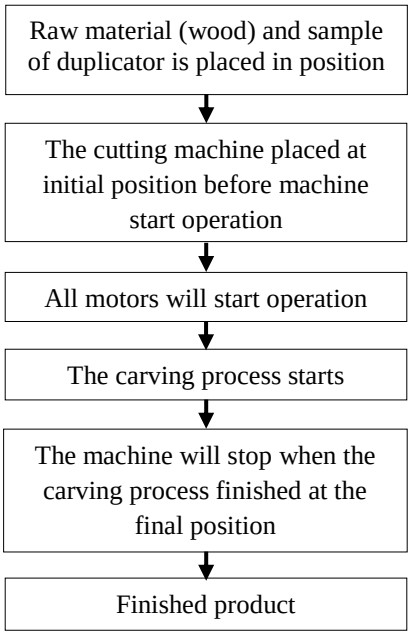


Figure 1: Project Flowchart

B. Mechanical Part

Design

Mechanical part start with designing stage by using Solid Work software. There a few parts that are designing improved in order to get better result including wood gripper, mold gripper, guider and also cutter. Below are the machine 3D modelling design of Semi-Auto Propeller Duplicator Machine.

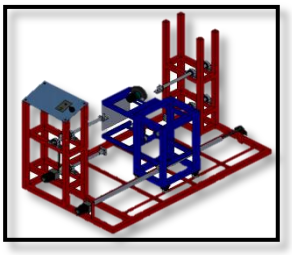


Figure 2: Product Design

Product Specification:

- Dimension: 2,140 x 1,225 x 1,269 mm
- Material structure: Mild steel
- Type of cutter: Hand grinder

Table below shows the comparison design.

No	Part	Previous Design	Improved Design
1	Wooden Gripper		
2	Propeller Gripper		
3	Guider		
4	Cutter		

Table 1: Design Comparison

Product Design Analysis

We have conducted analysis on each important structure using CATIA analysis and simulation features to determine the Von Mises Stress and Displacement of the Main and Back structure.

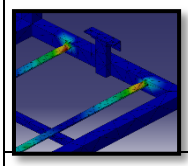
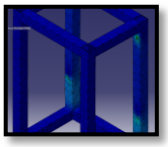
Part	Load	Von Mises Stress	Displacement
Main Structure 	240N	2.57e+005N. m^2 Result: Good	0.00361mm Result: Good
Back Structure 	100N	5.42e+003N. m^2 Result: Good	2.19e+006mm Result: Good

Table 2: FEA Analysis Result

Fabrication

Machining has been done by using DMU-35 (3+2 axis) milling machine, conventional lathe machine and also welding machine. All these machines are occupied at the KT2, GMI.

To have a smooth machining process, we have to get the correct spindle speed, the RPM need to be calculated first. The incorrect spindle speed used can cause tools wear and even worse is broken tools.

$$\text{Cutting Speed (V)} = \frac{\pi \text{ x D x S}}{1000}$$

$$\text{Spindle Speed (S)} = \frac{\text{Ø}\pi}{1000V}$$

$$\text{Feed} = \text{S x f x N}$$

$$\text{Feed per tooth} = \frac{\text{F}}{S \, x \, N}$$

C. Electrical Part

Electrical Diagram

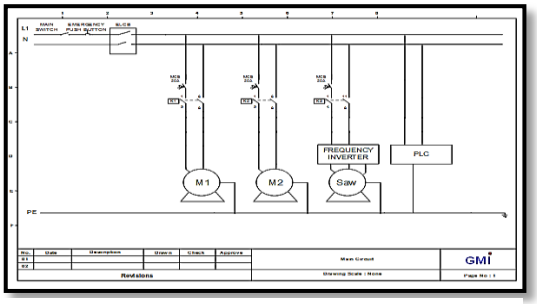


Figure 3: Electrical Wiring

The circuit above shows that we used three single phase motor. They were used for linear movements, rotational movements and the other was used as a saw. A Programmable Logic Controller (PLC) was used to control the system.

PLC Wiring Diagram

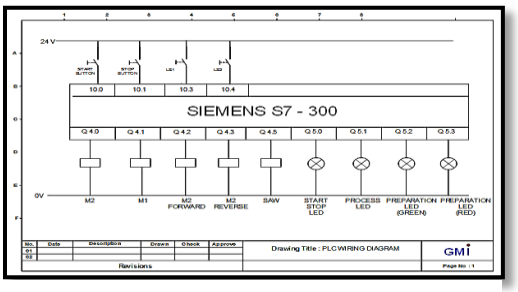


Figure 4: PLC Wiring

The circuit above shows the connection and the ports used in the PLC. In the input ports there were four inputs. Two of them were used for start and stop button and the other two was used for the two limit switches. We used eight of the output ports and they were connected to relays to activate other parts of the system.

D. Problem Encountered and Countermeasure

No.	Problem Encountered	Countermeasure
Mechanical Part		
1	No available tools/equipment	Redesign the parts so we can use the available tools/equipment
2	The shaft cannot provide the maximum length	Re-machine the materials so the shaft can move in wide range
Electrical Part		
1	Installation of electrical equipment in a small spaced electrical panel	Fully redesigned the layout of the electrical panel
2	Positioning of the limit switches are not optimal (No contact)	Reposition the limit switches so that it will come in contact with the structure.

Table 3: Problem Encountered and Countermeasure

E. PROJECT BUDGET

Project budget below is stated based on the materials price given by the suppliers.

No	Category	Expense
1	Raw Material	RM 455.85
2	Standard Parts	RM 952.74
3	Electrical Parts	RM 3,234.80
4	Machining and Fabrication	RM 610
5	Travel and Miscellaneous	RM 122
	TOTAL	RM 5,375.39

Table 4: Project budget

ETHICAL CONSIDERATION

Most of the concerns we have encountered have revolved around safety of the team as we collect data. Before fabricating the improved parts, we had to take into account our workshop, taking measures to implement design considerations of the ability to easily modify and the design for future purposes. There is high rpm of circular saw cutter. Both wood gripper and propeller gripper that attached to the shaft are rotating and move horizontally. The grippers are attached to the shaft by using welding which is high is secured to ensure the rigidity. The wood and propeller are lock by using bolt and but to prevent it from moving and maintain the position. The pillow blocks are used to attach the shaft to the machine and to provide rotating movement at fixed position. The guider is attach to the machine by using the bolt and nut which is proper secure. Besides, the emergency stop button is installed to the machine used as a safety measure in case the machine is required to be stopped immediately. ELCB is used for circuit protection which protects the circuit from electrical surges.

RESULTS AND DISCUSSION

The previous Semi-Auto Propeller Duplicator machine has a quite stable structure, however there are a few parts can be improve so it will be a better machine. The newly designed system using the PLC is able to successfully and smoothly control the machine. The saw that is optimally controlled by the frequency inverter is able to produce a better product. The new designs of wood gripper and mold propeller gripper can hold the variety sizes of wooden block and propeller and definitely gives user the easy way for machine set-up. The right choice of circular saw cutter also hopefully gives a better result in cutting the wooden block and eliminates the spiral problem faced by the previous machine.

CONCLUSION

The machine system is successfully and smoothly controlled by the controller Siemens PLC S7-300. The installation of the PLC improved the whole system and the electrical system. The usage of frequency inverter will gives the advantages in controlling the speed of the saw. Besides, the fabrication of improved parts can make the machine more reliable and user friendly. This machine also can help us to get better output product.

ACKNOWLEDGEMENT

Alhamdulillah, we are grateful to ALLAH S.W.T for giving such strength and courage to finish the project. We would like to give high appreciation towards my project supervisor Mr. Muhammad Khairi Bin Abdul Rahim for his guidance and encouragement throughout this project and to our project advisor, Madam Hafidzah binti Ahmad and Dr. Samson for their suggestions and helps throughout the study. Huge appreciation to Mr. Mujib Ahmad bin Ahmad, the owner of Perkasa Propeller

Enterprise for his idea and concept that helped us a lot in fabricating the machine. Thanks to both Industrial Electrical and Production Technology Department, German Malaysian Institute for providing facilities for project researching and implementing. To all group members, big thanks for co-operation and great enthusiasm to finished up the project. To our parents, family and friends, thanks for the doa and being such supportive throughout our studies.

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CLIMBING RC INSPECTOR (CiRCI)

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***Abstract* : Climbing RC Inspector is a remote control car designed to assist in building inspection to replace building inspectors. Its main use is for maintenance of building. This robot consists of electrical ducted fans for the adhesion mechanism, four servo motors for each of the wheels and a camera mounted on the front for capturing images which is connected via Wi-Fi to a laptop. All of the components will be connected to an Arduino chip which has programs for each of the components.**

INTRODUCTION

Climbing RC Inspector is an idea from the group that is completely designed, constructed and tested. The target for this project is to help people. Specifically, the targeted job scope for this product is the inspection department or anything that involves in building inspection.

In every industry, there is a section or department that inspects the building or area to make sure they are safe to work or live. Usually, the inspection is done by the inspector person to check the condition of something.

The idea to develop such a device that will help them when considering the safety issue for the inspector. This situation attracted some research opportunities about a better way to do the inspection. The objectives are to access narrow areas, high places and confined space, and to reduce hazard for building inspector.

Thus, the idea and design to improve the inspection technique in this urban environment was conceived. The need for a device that can stick and move on walls, thus the product that is called Climbing RC Inspector was created.

It is a remote controlled car that can climb walls and move on walls using suction force generated by four fans for the purpose of building inspection as it captures image of surface condition such as cracks in the walls. This Climbing RC Inspector is designed to assist in building inspection by replacing the works of inspector personnel to personally inspect a building.

METHODOLOGY

Design

A. Isometric view

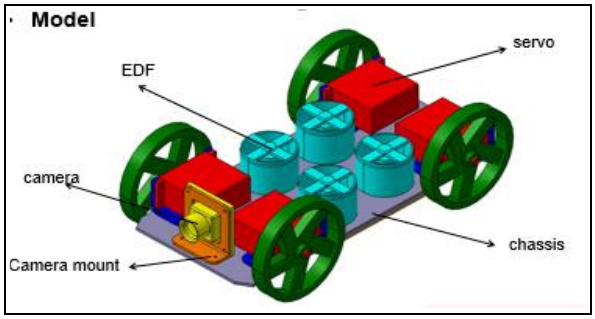

Figure 10 Project Design

B. Technical drawing

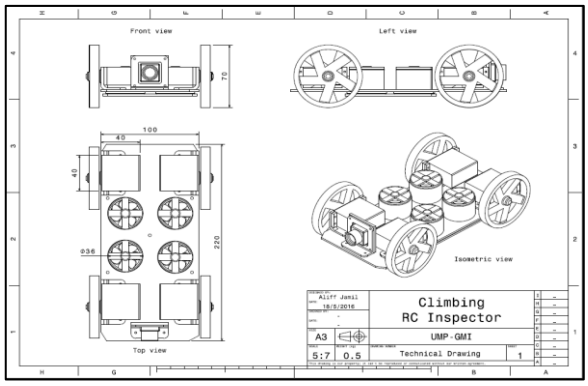

Figure 11 Technical drawing

Product Hardware

The mechanism of CiRCI consists of the following:

A. On-Board Car Components

COMPONENTS	FUNCTIONS
Chassis	Main structure of the car
Camera	Capture images
Camera transmitter	Send images to laptop
Servo motor	Movement mechanism
Electric ducted fan (EDF)	Adhesion mechanism

Table 3 Car components and their functions

B. External Components

COMPONENTS	FUNCTIONS
Camera Power Supply	Supply Power to Camera
EDF Power Supply	Supply Power to EDF
Servo Power Supply	Supply Power to Servo
Variable Resistor (Potentiometer)	Control EDF Speed
Computer	View Video & Image Arduino Software

Table 4 External components and their functions

PRINCIPLE OF OPERATION:

A. Adhesion Mechanism

CiRCI uses a ducted fan to create a suction force provided thrust that pushes the body to the wall.

EDF thrust force = 0.471N
Times by 4 EDFs, 0.471 x 4 = 1.90N

The thrust force is the "new weight" of the car if the vertical wall plane is considered as the horizontal.

B. Drive System

CiRCI is an all-wheels drive. Each wheel is driven by one independent motor. The linear drive force will counter the weight that pushes the car to go downward.

Servo motor torque = 4Nm
Wheel radius = 0.035m
T = F x d
F = 4/0.035 = 114.3N
Four servo motor, 4 x 114.3 = 457N

Weight of car = 0.5kg x 9.81 = 4.91N
Resultant = 452.8N

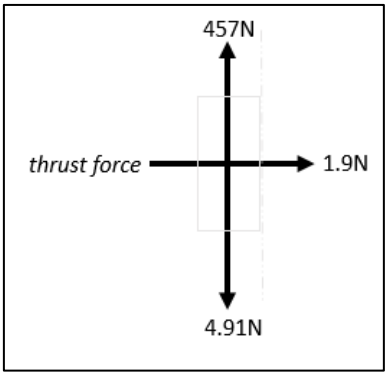

Figure 12 Free body diagram (drive system)

C. Turning System

The turning system is done by the opposite direction of rotation of two sets of wheels (right & left side) that happens simultaneously.

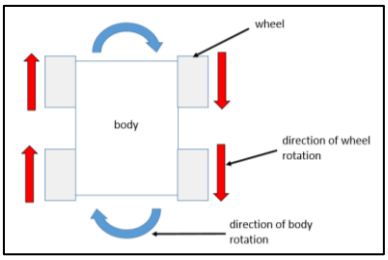

Figure 13 Free body diagram (turning system)

RESULTS AND DISCUSSION

A. Material

Stainless Steel grade 304 is used as the product material. It is suitable due to the excellent forming ability. It is able to be drawn without the effects of annealing that is a problem for most metals such as mild steel. Grade 304 has great welding ability across all welding techniques. Post-weld annealing is often not required to restore the steels corrosion resistance, however, the clean-up after welding any metals is recommended for a better surface finish overall. The machinability of grade 304 stainless steel is lower than most carbon steels however it should be kept in mind that when machining stainless steel, slower spindle speeds as well as a deeper than average depth of cut is preferred. The cutting tools must be sharp, the product and machine must be rigid and cutting fluids need to be used for the best outcome.

B. Servo motor

Servo motor was selected for this product based on multiple conditions. The first condition is torque. Servo motor has a similar torque rating compare to stepper motor, but servo motor offers more flexible speed. The advantage of using servo motor based on torque is that we can control the torque while stepper motors only operate at full torque. (Nigel Dawson, *"10 tips for servos and*

steppers"). The second condition is applications. If an application requires complete standstill stability, stepper motor is the better choice but for an application that require back and forth on standstill servo motor is the most suitable motor. Servos are the better choice in vertical applications in which the motor must hold a load still and for smooth operations. (Nigel Dawson, *"10 tips for servos and steppers"*). The last condition is size. Both stepper motor and servo motor are generally made in many different sizes but servo motor in small size is better because it can provide more speed compare to a stepper motor in small size.

C. Electric Ducted Fan

An electric ducted fan with brushless motor is used to stick this product onto the wall. Some consideration has been made in selecting an inrunner or outrunner brushless motor for the EDF. Since EDF are the main aspect in sticking the robot to the wall, the motor should run constantly in speed to elevate perpendicular to the surface. Inrunner motor produces more rpm than outrunner motor, and required a heat sink mechanism to cools down while the outrunner motors have its self-cooling method regarding its principle of operation. Outrunner motor spins much slower than inrunner motor but producing far more torque. To produce a much higher torque, an inrunner motor requires an external gearbox attached to its shaft. This makes an outrunner an excellent choice for directly driving electric aircraft propellers since they eliminate the extra weight, complexity, inefficiency and noise of a gearbox. To finalize the selection for the EDF motor, last consideration is regarding its weight. With the product features to climb wall, it is very necessary to consider the weight aspect for every component attached to our product. Concerning the requirement of our product, an inrunner motor will require an external gearbox and heatsink and this will make our product heavier.

D. Camera

This product uses a wireless camera as the monitoring mechanism, the reason is without its wire or cable it will reduce the overall weight of this product. Some consideration has been taken in selecting wireless camera using Bluetooth connection or Wi-Fi. First and foremost is to consider the maximum range for the connection. Maximum range for Bluetooth based wireless connections is 30m while for Wi-Fi, it can extend well up to 100m. The next consideration is the data transfer rate for the camera. The latest additions to Bluetooth (Bluetooth 4.0) promises data transfer rates to be up to 25mbps while latest Wi-Fi version of Wi-Fi direct can reach up to 250mbps of data transferring rate. This makes Bluetooth too slow for video transfers or for moving large amounts of large photo images from a digital camera.

CONCLUSION

As for the conclusion, Climbing RC Inspector is a device that can be beneficial in the building inspection department. It is designed and constructed carefully. All parts were chosen based on the suitability and compatibility of the tasks required. There were limitations in producing this product. First, it was time. There was only a short amount of time to complete this project. Time consumed in purchasing and receiving all the items were too long thus making it hard to produce this product, but with a little push to the suppliers, this project can be done on time. Second, was the items. Some of the items were really hard to find because the demand is low in Malaysia and many suppliers in Malaysia were lacking in stock of the items we needed, and everything needed to be purchased and shipped internationally. There are many recommendations for Climbing RC Inspector to improve this product. First is camera. For a better result in live feed video, using a better camera, due to insufficient budget we had to opt for a cheaper version, in which the video is clearer and the transfer rate is faster. Second is sensor. For a better result in inspecting building, sensor can be used to gather more data. Humidity sensor can be used to check the ambient moisture conditions in a structure. Thermal sensor can be used to shows changes in surface temperature.

ACKNOWLEDGEMENT

First and foremost, we are grateful to ALLAH "S.W.T" for the good health and wellbeing, and for all the assistance, strength, patience and wisdom bestowed on us to complete our project work. We would like to express our sincere gratitude to our supervisors Mr Sham Firdaus and Mr Umar Patthi for the continuous support of our Bachelor study and related research, for their patience, motivation and immense knowledge. Their guidance helped us all immensely throughout the SDP 2 session and also in the completion of this project work. We could not have imagined having better supervisors and mentors for our project under the degree programme. We would like to thank to both the Industrial Electrical and Production Technology departments of German-Malaysian Institute for assisting and guiding us in completing our project. Last but not least, thanks to all our parents, family, friends and lecturers for keep giving us strength and nonstop prayers throughout our degree programme.

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Self-Balancing Skateboard as New Way of Transportation

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***Abstract* : Nowadays there are a lot of traffic jam that happened in the sub urban area. In order to avoid this problem, a new kind of transportation is proposed. The idea is to develop a self-balancing skateboard. It is hoped that this technology could promote the green technology transportation without producing carbon emission. The self-balancing skateboard is using an Arduino as the microcontroller to integrate with motor driver and IMU (Inertial Measurement Unit) board. The IMU board consist of accelerometer and gyrometer that is used for balancing, while the motor driver function is to control the rotation of the motor. The self -balancing skate board is operated and controlled using a hand controller which consist of a few buttons known as Wii Chuck.**

INTRODUCTION

Going for long distance using normal skateboard would not be a convenience to certain people as it may lead to exhausting stamina, cramp leg and may as well lead to injury or accident. Besides, sometimes people use their automobile just to go short distance, for example, going from their home to a convenience store. It will eventually lead to increasing rate of traffic jam and wasted gas.

Skateboarding is one of the popular sports in the world. Skateboarding normally uses manpower in order to move forward, backward or doing any skills with it. Besides that, skateboarder has to balance his/her body to play it perfectly

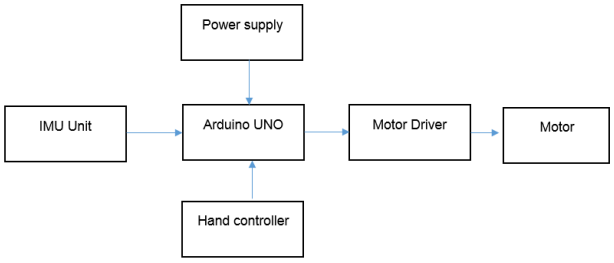
But now with self-balancing skateboard, people who are not a skateboarders or skateboarder themselves don't need to worry about their balancing because the balancing of the skateboard will be generated automatically by some sensors attached on the skateboard. This self-balancing skateboard is not only made for skateboarder but it may help society to learn this game in easier way and also to lower the usage of vehicle in city. A person can ride self-balancing skateboard to anywhere that are in short distance and this will help with encouraging a green environment as we will be saving our money for gas.

The objective is to develop and create self-balancing skateboard that capable transporting a single passenger. Next to produce the green environment technology. Then to design a program and electrical wiring diagram using engineering software for self-balancing skateboard. Last but not least, design and demonstrate a low cost and safe source of transportation skateboard for short distance up to few hundreds of meters.

METHODOLOGY

This project paper is consist of electrical part and mechanical part. The electrical part consist on the software and hardware testing while the mechanical part is focusing on the body frame of the skateboard. In this methodology it consist our task overview during the project.

This is the overview of the project where it consist of IMU, Arduino Hand controller and motor driver .The IMU measure the change in accelerometer and gyrometer while the hand controller is used for change the direction of the motor. Next the Arduino is used as a microcontroller for the process and motor driver is used to control the motor.



C. Wii Chuck Controller for hand controller

The Wii chuck controller are usually used in Nintendo gaming console. The Wii chuck controller consist of 2 button which is C and Z, and one analogue controller. We chose the controller is because the Wii chuck button has built in button and analogue that meets our criteria for the controller. The controller Wii chuck will communicate with the Arduino Uno.

The Arduino Uno is an open source that is suitable for building electronic projects. Arduino is consist of both a physical programmable circuit board and a piece of software It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16

MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. [1].

To create the program, first we need to know the range for the x-axis and y-axis. To get the range of the axis we need to do a simple program that could integrate between Wii chuck and Arduino [2]. Based on the program, we can determine the origin position of the Wii chuck and check the limit of each axis. To enable the detection of the Wii chuck we must download the library at the Arduino website which is WiiChuck.h. This is the constructed circuit for testing the output from the Wii chuck it consist of LED and resistor and Wii chuck adapter to convert the data from Wii chuck to the Arduino

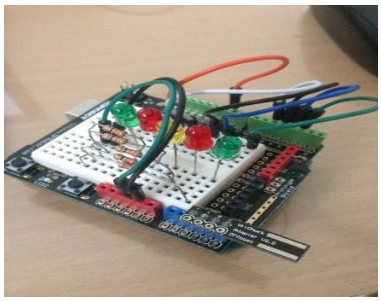
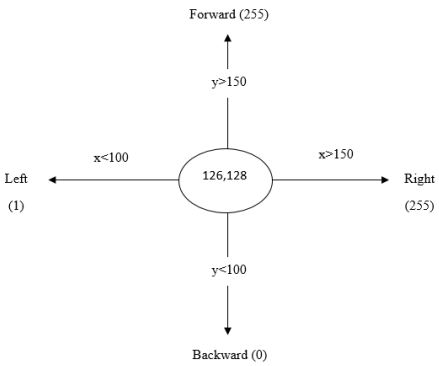


Figure 1: The Wii chuck controller circuit

Wii chuck axis

Based on the Wii chuck testing circuit we can collect the data for each axis range, thus this is the data that has been gather into form of graph.



The program will works when it reach the certain range of the axis for instance if the value x is less than 100 thus the signal will be trigger that is left button, the function of this graph is for us to determine the range that the signal will be on, it is important that because is for used to control the movement of the motor. If the range is not properly set it is hard to control the movement of the motor later.

D. Inertial Measurement Unit (IMU)

To make sure the skateboard balanced, the Arduino need to measure and know the angle of the main mechanical frame of skateboard relative to the ground, so that the motors need a conformity speed and direction needed by receive the command to avoid from falling over. Besides, to get the accurately measure the angle or tilt of the skateboard, we have to detect the speed of rotation and the gravitational force of its X-axis by using the chip we called Inertial Measurement Unit [3].

IMU Implementation to Obtain Tilt Angle

An IMU consists of two sensors which is accelerometer and gyroscope, each of this sensors measuring a different part of angle. From the angle that are obtained from the Inertial Measurement Unit, the Arduino can determine how fast and also knows in which direction should turn the two motors[4]. We used the -90 degree to +90 degree scale as our easiest reference angle, where 0 degree is considered as "level" (figure 1).

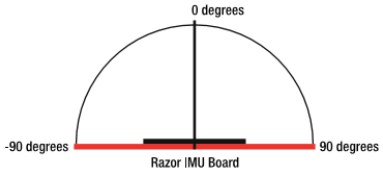


Figure 2: The IMU board measuring 0 degrees

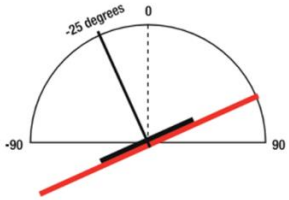


Figure 3: The IMU rotating along its X-axis at -25degrees (reverse)

E. MIG Welding

The selection of a welding process to accomplish a joint of desired specifications and quality is imperative before undertaking the fabrication task [5]. In MIG welding method, an arc is established between a continuous fed filler wire (consumable) electrode and the workpiece. The electrode is fed automatically from the machine, through a liner, then out of a contact tip in the MIG/MAG gun. The weld metal is protected from the atmosphere by a flow of an inert gas, or gas mixture. The contact tip is hot or electrically charged, when the trigger is pulled and melts the wire for the weld puddle. [6]

F. Study Design

Robust is making the product or process insensitive to variation. This variation (sometimes called noise) can come from a variety of factors and can be classified into three main types: internal variation, external variation, and unit to unit variation. Internal variation is due to deterioration such as the wear of a machine, and aging of materials. External variation is from factor relating to environmental conditions such as temperature, humidity and dust. Unit to unit variation is variations between parts due to variations in material, processes and equipment [7].

G. *Equations*

The normal force of the ground (N_f), the load on the assembly (W), the force due to acceleration of the assembly (F_m), and the frictional force between the wheel and the ground (f_f). The normal force is balanced by the load and the force due to acceleration is balanced by the force of friction. Thus, there are no unbalanced acting on the assembly.

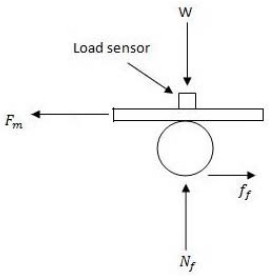


Figure 4: Forces acting on the body assembly.

The equation for the mass limit started with the calculation of the kinetic energy equation as in (1), acting since the body is in motion. Consider that the power output generated by the motor in joules per second (J/s) where it is in Watt (W).

$$E_k = \frac{1}{2}mv^2 \qquad (1)$$

Max capacity of user need to be in mass (kg) and added to the total weight of the skateboard, batteries and motors (2).

$$m_t = m_1 + m_2 + 2(m_3) + 2(m_4) \qquad (2)$$

Speed Calculation can be derived by the kinetic energy E_k and the power of the motor.

Calculate the force (F_m) from the motor torque (T_m) (3) to gain the torque needed to generate motor (T_g) (4).

$$F_m = 2(T_m) \div d \qquad (3)$$

$$T_g = F_m \times d \qquad (4)$$

Calculation for batteries runtime (t_b) by getting using as in (5).

$$Voltage \times Ampere\text{-}Hour = Watt\text{-}Hour \qquad (5)$$

$$Watt\text{-}hour \div Watt = Hour$$

From batteries current and voltage,

24V × 5.5Ah = 132Wh

132Wh/ 600W = 0.22h

0.22h × 60m/h = 13.2minutes.

RESULTS AND DISCUSSION

H. *Problem Countered and Countered Measure*

When the frame has been attached to motor as shown in figure 1 is the frame too much height and when tilt, the corner of the frame touch the floor. It will make the self balancing skateboard not flexible. So the countermeasure of this problem is the side of the frame been cut follow the angle that the self balancing skateboard can tilt as shown in figure 1 red circle. The another problem that been faced is the tyre of self balancing skateboard is not align to motor. This is make the motor failed to divert the force equally. To overcome this problem the tyre is align using a circle pin that hold the tyre on shaft after the shaft have been calculate to parallel with motor as shown in figure 1 yellow circle.

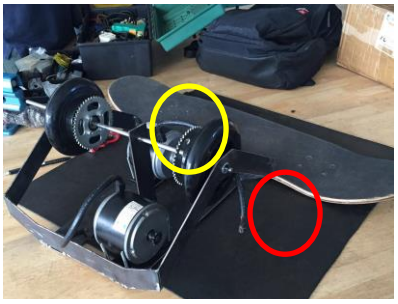


Fig. 5 Assemble frame has been attached with motor

I. *Finite Element Analysis*

A static analysis on the main body structure by giving a distributed load for about 1200N to the negative Y-axis direction.

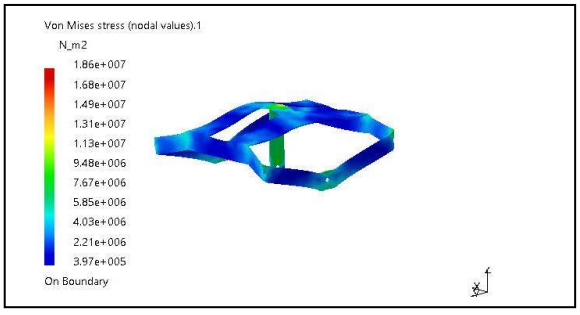


Fig. 7 Von Mises Stress acting on the body frame

On this analysis, by using Low Carbon Steel with yield strength of 370 MPa and Young's modulus of 200 GPa can lift 1200N of load with maximum displacement of 0.106 mm and stress not reaching 32.2 MPa. It is safe to be used.

C. Wii chuck Result

This is the output from Arduino that generate the axis of the Wii Chuck controller ,the ideal condition value for the Wii chuck which is 126 (X-axis),128(Y-axis) thus from this value we can plot an axis graph, for the range of each axis is shown on picture below

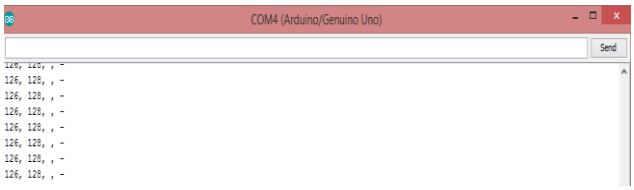


Fig 8 Result from Wii chuck controller

D. Inertial Measurement Unit (IMU)

Figure below shows the example of the output from Arduino for the IMU testing during the IMU board were tilting to the left condition. The readings will be negative value for this condition.

Fig. 9 Arduino output

ETHICAL CONSIDERATION

In each project, safety is very important in project and also an important aspect that should first be noted. In order to prevent errors during implementation and to minimize danger to consumers, we have several safety features included:

Symbol	Description
Caution Sign (Chain) 	To warn people from put their hand into the movement chain during the operation of the skateboard
High Current 	To alert people from touching the area
Grounding 	To prevent from electrical leakage during the operation.

CONCLUSION

As conclusion, we hope that this device can eventually being applied as new form of transportation that can lead to a new kind of lifestyle. As a motorized transportation research matures into a more complex and dynamic system the definition of what can be used as transportation seems to be getting broader.

ACKNOWLEDGEMENT

First and foremost, all the praise to Allah for His kindness and blessing, we are the group of UMP-GMI Semester 5 would like to take this opportunity to thank everyone who has assisted and support in completing this Final Year Project proposal. Besides we also dedicate this gratitude to our parents and also our supervisors, support and guidance.

We also would like to thank all the people including TTOs and friends who are directly and indirectly involved for their encouragement, support and guidance in completing this project proposal. Their invaluable contributions have leaded us to successfully complete this Final Year Project Proposal. This proposal is regarding the Self Balancing Skateboard as a new way of transportation. The proposal summarize the idea and concept on to produce the self-balancing skateboard.

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TraVus (Travel with Us)

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Abstract **: TraVus is an automated carrier device that has the main purpose to assist people on carrying their personal belongings or load. As the world rapidly evolving in technology day by day which changed the way we routinely do things and TraVus may be a successor to the cart/ trolley/ carrier/ luggage/ wagon of the modern era of automation.**

Image processing and several sensors allows TraVus to track as well as determining position and direction of the user to be followed accordingly. The main component in controlling TraVus are the micro controller to compute all the data acquired to allow smooth movement and a camera to capture and target the user accordingly.

INTRODUCTION

Carriers or carts are specifically designed for transportations dated back from the second millennium B.C that is pulled by one of a pair of draught animals. Handcarts pushed by humans had been used all over the world since the 19th century that help people to travel across far distance. Ancient romans often used carts for judicial punishments and transportations. The cart technology began and closely co-related to the discovery of the wheel.

Modern technology today with the advancement of drives and motors has made a gigantic leap in the way we carry things to travel. Baggage cart, luggage trolleys and suitcases are widely used by people to carry their heavy weighted loads to accommodate from a place to another. The carts help people to carry things that are out of the normal human average carrying limit or to avoid fatigue of the body.

"Travus" is an innovative concept of a cart or carrier unit that follows you with the assistance of motor drive with image processing that allows the TraVus to keep track of your movement and carries all your belongings without a hassle. The name TraVus is shorten from the sentence "Travel with Us" that fits the objective of the product. The V in the TraVus name refers to the number 5 (in roman) that means the things that this product can be adapted and replace which are carriers, luggage, trolleys, carts and wagons.

METHODOLOGY

The methodology of TraVus is as follows:

J. Image Processing

A method which is called Image Processing is used as the core essence to determine the current position of the human (user). Several ways to filter all the variables allowing TraVus to locate and lock on to a specific target. Histogram of Oriented Gradient (HOG) descriptor are widely used in pedestrian detection that uses the gradient of contrast in identifying a resemblance of a human shape. [9]. Applying a Gaussian Grey filter paralleled to gradient representation increases the accuracy of the

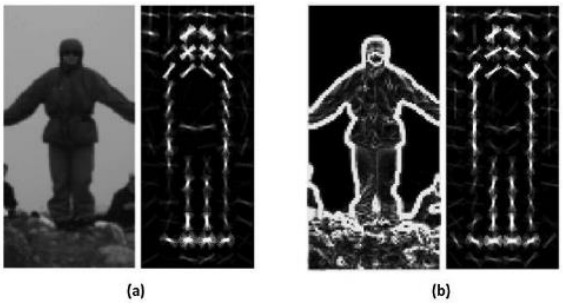

Figure 14 a) Original image with HOG. b) Gradient representation with HOG.

TraVus implements HOG descriptor in corresponding with color detection that signifies the user preset color. Combining more than one variable allows TraVus to detect a specific person known as the user.

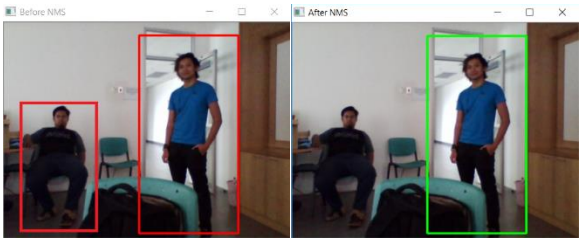

Figure 15 LEFT HOG descriptor without Color filter, RIGHT HOG descriptor with Color filter

Figure 2 shows the Python programming output of TraVus before and after the color filter is integrated in identifying the user. The program translates this in coordinate form demonstrated by the box presents on the picture and then sends the signal to the Arduino for further interaction in targeting the user.

K. Controller and Electronic part

Arduino

Figure 16 Arduino Board

is the open sources physical computing platform based on easy to use hardware and software and a development environment that implements the processing and wiring language. Arduino can be used to developed standalone interactive objects or can be connected to software on your computer. Arduino as the main controller for Travus because its user friendly or easy to use setting, it also like any microcontroller outside there and it is a circuit board with chip that can be programmed to do numerous number of task [7] .

Raspberry Pi3

Figure 17 Raspberry Pi 3 Board

The main controller of Travus is raspberry Pi it is act as a brain of Travus. A Raspberry Pi is a credit-card sized computer originally designed for education, inspired by the 1981 BBC Micro. Creator Eben Upton's goal was to create a low-cost device that would improve programming skills and hardware understanding at the pre-university level. [8].But thanks to its small size and accessible price, it was quickly adopted by tinkerers, makers, and electronics enthusiasts for projects that require more than a basic microcontroller (such as Arduino devices).

Pi Serial Communication

Figure 18 Pyserial Connection

Travus used Pi serial communication to communicate between raspberry pi and arduino to perform the task which Pi as a master while arduino as a slave. Travus used pi serial because it is easy for raspberry Pi to communicate to arduino compared to I2C protocol and others protocol. The figure

below show the picture of Pi serial communication.

DC-DC Converter

Travus uses a dc to dc converter or known as a chopper converter there are a few type of chopper which are step up chopper (boost chopper), step down chopper (buck chopper), and step up and down chopper (buck-boost chopper). To be specified Travus used buck chopper which is step down chopper to step down the 12v to desire value it can be shown on the formula below.

$$\text{Vout} = \text{Vin x K}$$

$$\text{K} = \frac{\text{Ton}}{(\text{Ton} + \text{Toff})}$$

L. Chasis design

Vehicle frames, or also known as chassis, is the main support structure of the motor vehicle which all other components are attached to it and the main functions of a frame in motor vehicles are:

1. To support the vehicle's mechanical components and body
2. To deal with static and dynamic loads, without undue deflection or distortion.

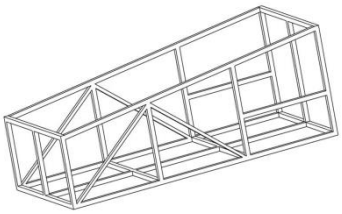

Figure 19 TraVus Chasis Design

TraVus design offers better resistance because the rails continuously from front to rear. Ladder frame is one of the simplest and oldest of all designs. It consists of two symmetrical beams, rails, or channel running according to the length of the vehicle, and transverse cross- members connecting them.

A truss consists of typically (but not necessarily) straight members connected at joints, traditionally termed panel points. Trusses are typically (but not necessarily) composed of triangles because of the structural stability of that shape and design. A triangle is the simplest geometric figure that will not change shape when the lengths of the sides are fixed.

The Pratt truss was patented in 1844 by two Boston railway engineers, Caleb Pratt and his son Thomas Willis Pratt. .[2] The Pratt truss uses horizontal members to respond to tension and vertical members for compression. [3] Therefore, for given planar truss with a fixed depth, the Pratt configuration is usually the most efficient under static, vertical loading. Pratt truss type being choose to reinforce the side body of the TraVus. In real situation, some sudden impact or load may occur from the top, and from the truss concept it actually can absorb the stress and distribute it to it node (joints).

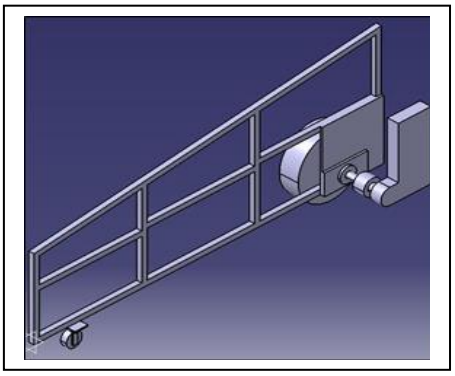

Figure 20: Critical part design standard wheel and free wheel

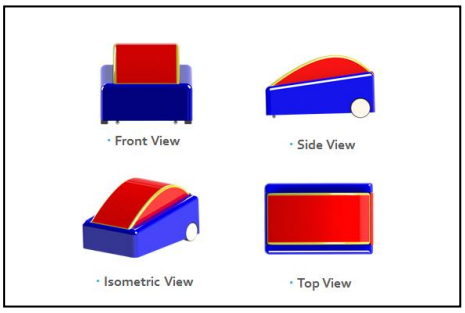

Figure 21: Finalized design of Travus

M. Material selecion

It is determination of properties that used for the product itself. By knowing the properties needed the material can be choose. It seems to be matched for the properties needed from its product design. From the designing process the material must be considered so that it can achieve the performance of the product in term of quality and costing. The goals are to meet the maximum performance with minimum cost. TraVus durability can be highly factioned by the mild steel used as the frame.

N. Machine selection

It is require of process that involve in the making of the product. Acknowledge the process that need to do is the key in machine selection. So by machine selection, tools and equipment needed for the process can be proceed in achieving the product geometry. It also consider the origin of product design, material that need to be machine and machine capability for process involved. When the machine selection match the process needed it can contribute good quality for the product and low time taken to fabricate. TraVus can be

O. Process Involve

In term of process it is how to fabricate the part and assemble it to become one product. By the product design, material selection and machine selection the process involves are cutting, milling, turning, welding and assembly. It is consideration of ideal method of process that contribute easy and low time taken in making the product. In mechanical point of view the specific of the process determine the quality of the product on the last process which is fitness of assembly and functionality of its mechanism.

CONCLUSION

Overall TraVus project was partially completed with minor errors in programming and fabrication. The core essence of image processing in detection of the human body was a total success but due to the processing speed and lack of knowledge in integrating Raspberry Pi with Arduino was a failure to react to the tabulated data retrieved from the raspberry pi.

The fabrication of the mechanical parts was partially completed and was able to withstand certain amount of force act on to the frame. Due to unforeseen circumstances, the total fabrication of parts was undone due to the time constraint required in the Senior Design Project.

TraVus is an innovative solution that caters to several sectors in replacement of the carriers, luggage, trolleys, carts and wagons with the integration of modern technology of automation. Collaterally, the implementation of TraVus in several targeted sectors such as Airports, Shopping malls, and individual may change the lifestyle of people in the near future.

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AUTONOMOUS BRAIN WAVE CONTROL WHEELCHAIR

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Supervosor : Mr. Mohd Faizal Bin Ismail, Advisor : Madam Nurul Nadia Binti Nor Hamran

***Abstract*: Autonomous Brain Wave Control Wheel Chair is a product created specifically for the disabled people which is blind, deaf and sometime for paralyzed disabilities. The wheelchair are bring moved using brainwave device alongside joystick control as it take a reading from brain frequency. The idea of this invention has been selected after make surveys and studies in which the products on the market are only offers a number of features that are limited to a few individuals with disabilities such as paralyzed and partially for paralyzed people.**

INTRODUCTION

Wheelchairs today are limited only to several types' disabled peoples. Those who are blind and paralyzed hand have no opportunity to use the wheelchair even with the help of a joystick. From the statement above, there are many ways to improve current wheelchair design that already have in the market. Based on the problem statement, we decide to build a new wheelchair generation that can interact and interface with a mind wave device and it will be controlled by Arduino microcontroller. This wheelchair can be controlled only by reading the data impulse from user's brain.

METHODOLOGY

A. Project Process

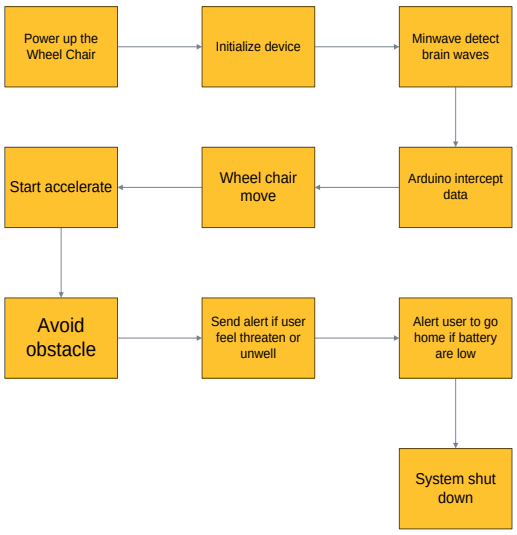


Figure 1 Project process

B. Mechanical Part

Design

Mechanical part start with designing stage by using Solid Work software. Below are the isometric view 3D modelling design of Autonomous Brain Wave Control Wheel Chair.

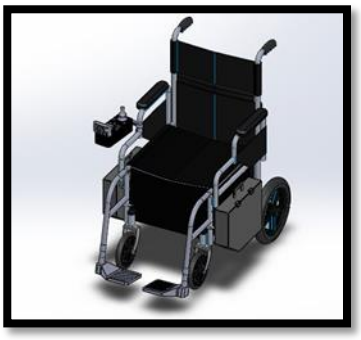


Figure 2 Product Design

Product Specification:

- 200W External motor,36 AH x 2 batteries, Battery holder
- Battery boxes and charger. Flat free 8-inch front castors
- Seat width: 18 inch
- Frame color: silver
- Weight: 60kg
- Packing Dimension: 900mmx420mmx840mm

Table below shows the comparison design:

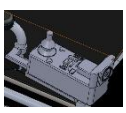
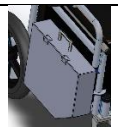
No	Part	Previous Design	Improved Design
1	Controller holder		
2	Box		

Table 1 Design Comparison

Product Design Analysis

We have conducted analysis on each important structure using CATIA analysis features to determine the Von Mises Stress. Finite element analysis (FEA) is a computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed. It is called analysis, but in the product development process, it is used to predict what is going to happen when the product is used.

Element analysis works by breaking down a real object into a large number (thousands to hundreds of thousands) of finite elements, such as little cubes. Mathematical equations help predict the behavior of each element. A computer then adds up all the individual behaviors to predict the behavior of the actual object (autodesk.com, t.t) [2]. FEA analysis has been conduct using CATIA V5 software on the CPU bracket as it will accommodate the important electrical hardware such as microprocessor, and CPU which is the brain of the wheelchair (see Fig. 2). This analysis to ensure the reliability of the wheelchair to contain all the processor hardware. Static structural analysis is considered. The clamp was assign on the four hole at the side of the bracket and the downloading load which is a distributed load was assign on the body of the bracket.

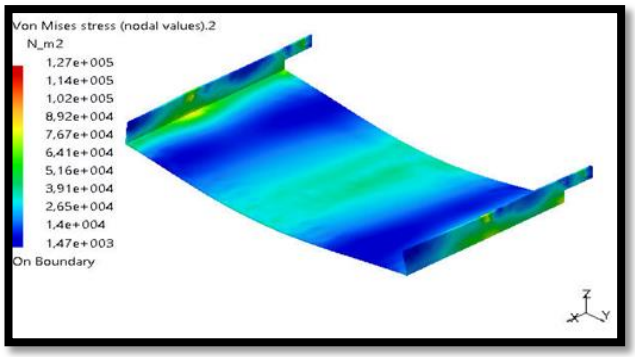


Figure3 Von Mises Stress (Nodal Value) analysis

Figure 3 shows the result of the Von Mises Stress analysis on the CPU bracket which is to check whether this design will withstand the load of processor part with load of 30N. It is shown that higher Von Mises Stress occur on the center and the both side end of the bracket with the maximum value of 1.27e+005. This is less than the yield point value of aluminum (see table 2). This show that the design of the bracket is reliable.

Material	Aluminum
Young's modulus	7e+010N_m2
Poisson's ratio	0,346
Density	2710kg_m3
Coefficient of thermal expansion	2,36e-005_Kdeg
Yield Strength	9,5e+007N_m2

Table 2 Material specification of CPU bracket

C. Electrical Part

Circuit Diagram

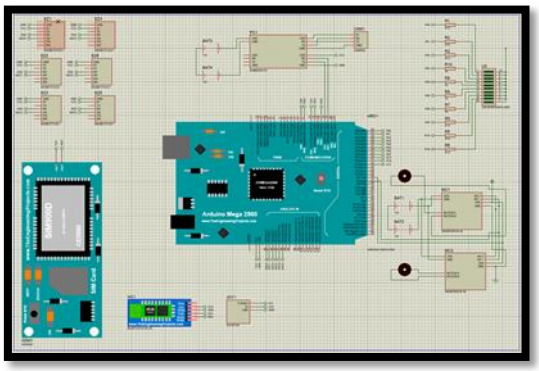


Figure 4 Complete Circuit Diagram

Figure 4 show a complete circuit diagram which is consist of an Arduino, two motor driver, eight proximity sensor, Bluetooth dongle, Arduino GSM shield, and its being connected to embedded PC.

D. Programming Part

Fuzzy Logic

Fuzzy logic is a powerful, yet straightforward, problem-solving technique with widespread applicability in the area of control and decision making [3]. In general, it is most useful in handling problems not easily definable by practical mathematical models. For instance, fuzzy logic has been employed in such tasks as managing stock-market portfolios and controlling subway systems.

Fuzzy derives much of its power from its ability to draw conclusions and generate responses based on vague, ambiguous, qualitative, incomplete, or imprecise information. [4] In this respect, fuzzy-based systems have a reasoning ability similar to that of humans. In fact, the behavior of a fuzzy system is represented in a very simple and natural way. This allows quick construction of understandable, maintainable, and robust systems. In addition, a fuzzy approach generally requires much less memory and computing power than conventional methods, thereby permitting smaller and less expensive systems [5].

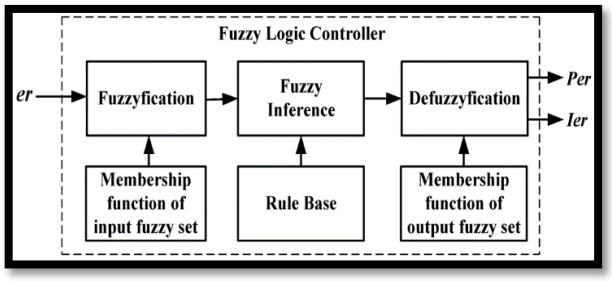


Figure 5 Fuzzy Logic Controller

Fuzzy logic can be implemented using a mathematical software called MATLAB and program it in fuzzy logic toolbox. Designing a fuzzy controller are relying heavenly on the designer experience and knowledge of the system as its being tested in the simulation environment which simulate in the software using MATLAB Simulink along with the rest of the system for debugging and optimization purposes before moving to the hardware mode. [6]

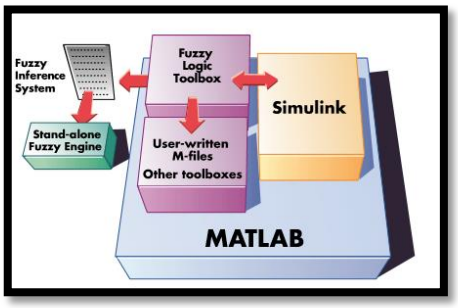


Figure 6 MATLAB Simulink

Arduino Mega

The microcontroller is an Arduino device, a fully open sourced microcontroller for which schematics, programs, and modifications can be found across the Internet. There are multiple models, and several different accessories are available for each. It can be programmed with a programming language similar to C. Programs Available on the Internet provide additional features, such as software serial Ports or the ability to connect multiple micro controllers.

Neurosky Mindwave Mobile Device

The MindWave Mobile accurately measures and gives the EEG power spectrums (alpha waves, beta waves, etc.), Neuro Skye Sense meters such as attention, meditation and eye blinks. The device consists of a headset, an ear-clip, and a sensor arm. The ear clip contains the headset's reference and ground electrodes and the EEG electrode is on the sensor arm, resting on the forehead above the eye. It uses a single AAA battery. The Mind wave headset is a slim, matte black plastic device which fits comfortably over the left ear. [7].

HC-05 Bluetooth Module

The HC-05 Bluetooth Module can be used in both Master and Slave mode, making it a great solution for wireless communication. The HC-05 Bluetooth Module consists of 6 pins- VCC, GND, TX, RX, Key, and LED. It comes preprogrammed as a slave, so the Key pin need not be connected, unless we need it change it to Master Mode. The major difference between Slave and Master mode is that, the Bluetooth module cannot initiate a connection in slave mode, it can however accept incoming connections. After the establishment of connection, the Bluetooth module can transmit and receive data regardless of the mode it is running in. The default data transmission rate is 9600kbps.The range for Bluetooth communication is usually 30m or less. HC-05 module works in two modes namely, command and data mode. We can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to our embedded project, etc. [8]

To control the wheelchair, EEG signals are needed. Here this paper describes EEG signals through a BCI interface. In this system we have a tendency to use simple unipolar electrode to record EEG signal from the forehead to construct a Brain-Computer Interface (BCI) primarily controls electrical wheelchairs through Bluetooth for paralyze and disable person. We have got two signals like meditation and attention. Therefore, attention and meditation signals are collected as the management signals through a Bluetooth interface and therefore the electrically interface in wheel chair. [9].

Structure

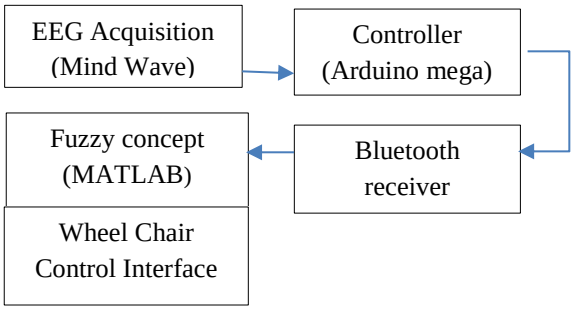


Figure 5 Signal processing of EEG signals with Bluetooth interface

In Fig.5, the framework for the signal processing of EEGs with Bluetooth interface is explained. The EEG signal was extracted from EEG securing. In this system, we use the NeuroSky's Mind Wave headset to record EEG signals with headphones on the sensor to read brain waves, the brainwaves are transmitted by the Bluetooth wireless modules (HC 05). Two types of EEG signal are classified, for example, raw EEG and long EEG. The raw EEG signal is used to convert electrical voltage to control the wheelchair. Then we classified two kinds of digital signal, for example, Attention and Meditation from long EEG brainwave [10].

RESULTS AND DISCUSSION

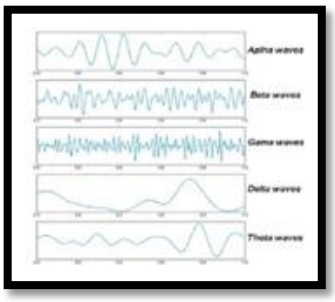


Figure 7 Type of wave frequency

Figure above indicate several type of wave frequency. Analysis of the data gathered from the FmΘ area in frequency domain enables us to measure one's relative level of alertness at any given time. Using this principle, a subject's attention level can be monitored in real time and used as a trigger or command to execute a predetermined task. The result of fuzzy logic behavior for obstacles implementation are being shown in figure 8.

TYPE	FREQUENCY	MENTAL STATES
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-Rem sleep, unconscious.
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream.
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious.
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated.
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings.
High Beta	21Hz to 30Hz	Alertness, agitation.
Gamma	30Hz to 100Hz	Motor functions, high mental activity.

Table 3 Frequency type and mental states

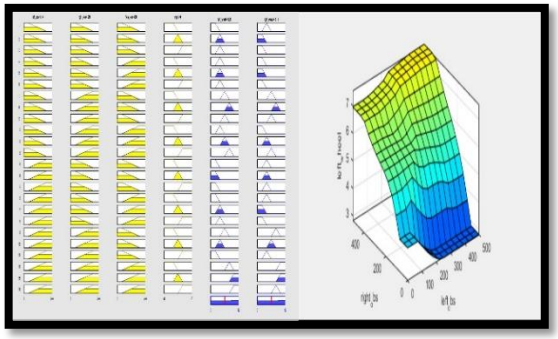


Figure 8 Fuzzy Logic Output

CONCLUSION

In conclusion, we hope that this Senior Design Project, which is Autonomous Brain Wave Wheel Chair Using will have achieved our objective, targets or goals. Besides that, we have gained lot of new knowledge, skill and experience to do researching information about new technology and technique that use in world today.

This product, Autonomous Brain Wave Wheel Chair, is able to be use by all disabled or paralyzed person. This project is using a latest technology wish use brain wave to control the movement of wheel chair that use EEG technique. The wheels will be able to alert the administrator when user having some difficulties when using the wheel chair. Ultrasonic sensor that act as obstacles avoidance is a safety way to the user as it will avoid any obstacles in front of the wheel chair. In addition, if the project is successful, it will give a lot of benefits to the user such as the application of intelligent system used to move the wheel chair using brain wave technologies in daily life.

ACKNOWLEDGEMENT

We are sincerely grateful to ALLAH "S.W.T", the most merciful and most compassionate for his blessings. Had it not been due to His will and favour, the completion of this study would not have been achievable. First of all, we would like to express our gratitude to our most dedicated project supervisor Mr Mohd Faizal Bin Ismail and advisor Madam Nurul Nadia for their time, moral support, suggestions, assistance, supervision and helped us a lot with valuable advices and constructive criticism throughout the study. Thanks to our parents, family and friends for being supportive and helpful.

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Remotely Operated Vision Inspection Underwater Vehicle

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***Abstract*: Remotely Operated Vision Inspection Underwater Vehicle (ROV-IUV) is a version of a submarine that operated on small scale, low cost and remotely controlled. The purpose of the product is to act as a pre-inspection to detect the problem faced underwater where a high resolution camera is used to live streaming the environment or problem underwater and able to record a video for further analysis. The processor used is Arduino to control the movement (left, right, forward, reverse, upward and downward). It also runs with the help of gyroscope and accelerometers to maintain balance and direction via Graphical User Interface (GUI) of Visual Basic software and made from fibre and aluminium material.**

INTRODUCTION

In this millennium era, people want to discover anything beyond their capabilities. This lead human race to the idea how to explore the underwater world. There are few ideas from the past leads to creation of submarine. This Remotely Operated Vehicle (ROV) project also known as Remotely Operated Vision Inspection Underwater Vehicle (ROV-IUV) is a version of a submarine that operated on small scale, low cost and remotely controlled.

Remotely Operated Vision Inspection Underwater Vehicle is a product that has an opportunity to develop more features and applied technologies to discover and explore the underwater environment. This product could use these features to create a geographical underwater mapping system, biology mapping research, underwater survey and inspection for suspicious hazard material under the water.

Most of people do not know things below and depth under the water due to human limitation of underwater knowledge. With this technology of ROV, it can help people by viewing image under the water, open a path for discovery. Most of us still do not know the importance of underwater research. For water inspection, this ROV also can capture the video by using high resolution video camera at certain location under the water.

For the operational system, this Remotely Operated Vision Detection Underwater Vehicle purpose is to act as a pre-inspection to detect any problem faced underwater. Every problem need an analysis before come out with the solution. ROV-IUV provides the first step of analysis where a high resolution camera is used to lively streaming the environment or problem underwater and also able to record a video for further analysis.

The processor that will be used is Arduino in order to control the movement of the ROV (left, right, forward, reverse and downward).It also runs with the help of gyroscope and accelerometers to maintain balance and direction via Graphical User Interface (GUI) of Visual Basic software. The ROV is also equipped with safety mode where user may have different ID number to log in as safety measures. . A body structure of the ROV is made from fibre glass material and aluminium to give high up-trust force

METHODOLOGY

The working principles of the project have been described as below:

P. Sign in and Main Page System

In this system, Visual Basic software is used for easy monitoring and as the program platform. Drag and drop technique is used to ease the programmer. In the first main page, the user need to insert their username and password before they can enter to the submarine system.

Q. Motors and Propellers system

6 units of motors equipped with propeller were used in this project. 2 units were placed at the rear side of the ROV and another 2 units were placed at front body. These 4 motors are used for diving movement of the ROV in the water. With the help of Inertial Measurement Unit (IMU) sensor, these 4 units motor were built mechanically to give stabilizing technique.

R. Balancing System

In order to make it balance, the tilt of the ROV will be read by the gyroscope and accelerometer which will then send a signal to the motor to respond appropriately to the tilt. The values will be differential and integral of the algorithm then it translates into programming of the IMU sensor. [1]

$$\int_0^{\pi} sinx\, dx = \mathrm{A} \qquad (1)$$

$$\int_{t\,k}^{tk+1} a(t)\, dt + v(tk)\,, K = 1{,}2 \ldots 10 \qquad (2)$$

S. Vision System

For the pre-inspection technique, high resolution camera is used for live streaming which is specific to inspection purpose or record the video for analysis method. At the end of the system, stop button will be used to end the ROV-IUV main system then the recording video will be saved in the video database for triggering method. User will get vision from the Graphical User Interface (GUI).

T. Project Design and Materials

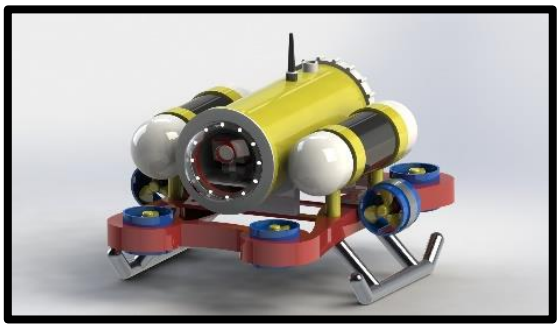


Figure 1: Rendered Design

For design purpose, SolidWorks software has been used to design the product. The concept of the design is based on hydrodynamic and the overall shape is based on the stability of the product while maneuvering underwater. Materials are divided into three parts which are Main Body, Main Structure and Base Structure. Materials that had been choose are Polyvinyl Chloride (PVC), fiber glass, and aluminums. The characteristics of these materials has been referred from the table of standard materials. Fiber glass composites is found to have extensive and successful applications including low-performance non-structural applications as well as high-performance structural applications [2].

U. Pressure Handled and Buoyancy Force

Buoyancy of an ROV is very important characteristic. The basic principle of buoyancy is that the buoyancy force is depending on the ability of the object to displace water same amount of its volume (neutral buoyancy) and obey the Archimedes principle. The buoyant force acts through the centre of the displaced volume of fluid. The buoyant force is equal to the weight of the fluid displaced by the object. The basic rule is if it's denser than water, it will usually sink, if it's less dense, it will float. [3]

$$\rho VG = \mathrm{B} \qquad (3)$$

Equation (3) above shows the Archimedes principles formula used in this project. Ideally, the concept of Archimedes principles used to give full up-trust force in the project system. There are also conditions that able to achieve buoyancy condition either sink, float, stable and submerged as shown in Figure 2.

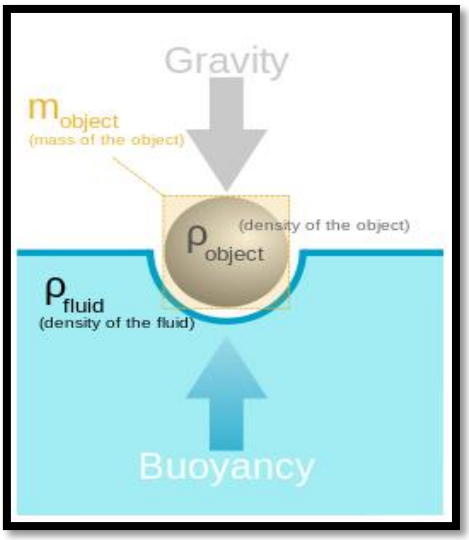


Figure 2: Archimedes Principle

RESULTS AND DISCUSSION.

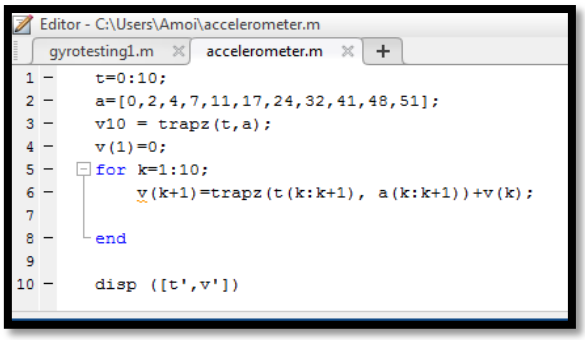


Figure 3: Accelerometer programming in MATLAB

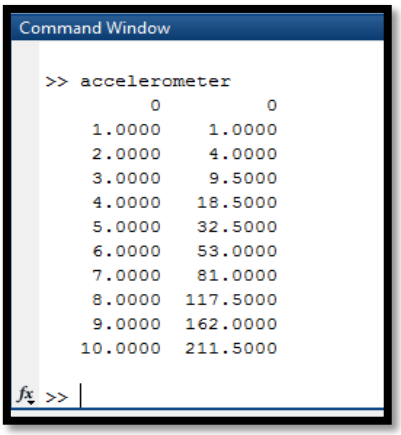


Figure 4: Result from MATLAB (time and displacement)

The equations (1) and (2) are the algorithm for accelerometer. The accelerometer integrates the acceleration signal to produce an estimate of the velocity, and it integrates the velocity estimate to produce the estimation value of displacement [1]. Figure 3 shows program interpretation to MATLAB from equation (2) and Figure 4 shows the results shown from MATLAB to be used in motor system programming. [4]

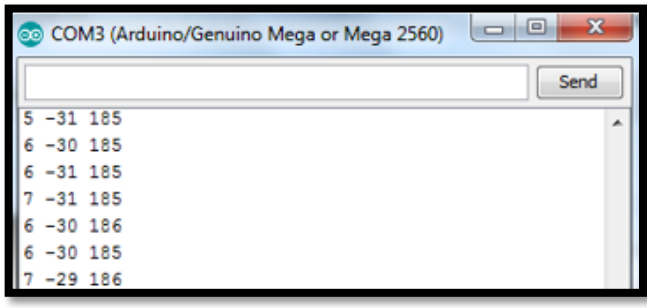


Figure 5: Initial condition from the gyro sensor (3DOF)

Fig 5 is the initial condition for gyroscope for X, Y and, Z axis for tilt-ness position. These values are used for motor counter values for stabilize. The connection of diagram between all the six motors will connect with Arduino Mega 2560 R3 in the Figure 6.

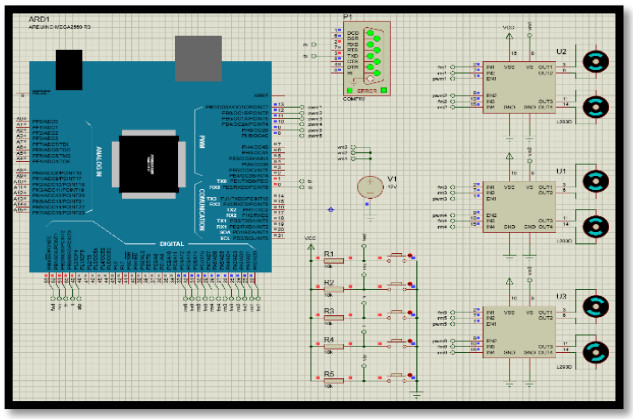


Figure 6: Circuit diagram connection in Proteus

ROV-IUV also runs with the help of gyroscope and accelerometers which is state in IMU sensor to maintain balance and direction control via Graphical User Interface. (GUI) in Figure 7. GUI will help the user for controlling the speed of motor and later on will display the vision of ROV.

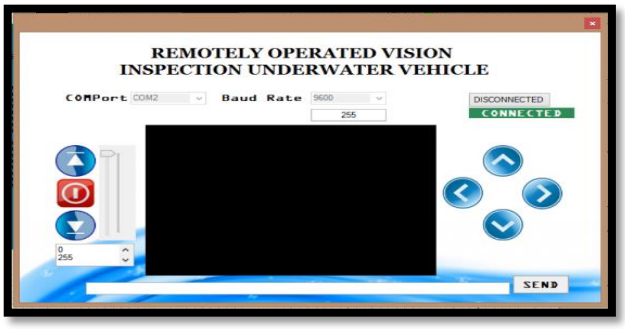


Figure 7: Graphical User Interface (GUI) for control ROV

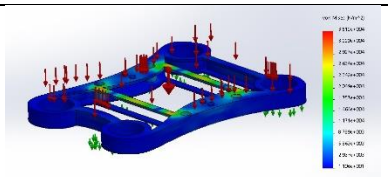
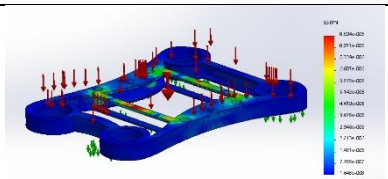
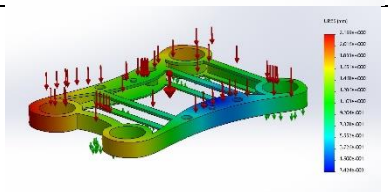
FEA	Results
Stress	
Strain	
Displacement	

Table 1: Finite Element Analysis of the Main Structure

Table 1 shows the Finite Element Analysis of the Main Structure that analyze the stress, strain and displacement with static in order to choose the fibers material. The force given is 10Nm and gravity is 9.81m/s^2. The result of deformation scale is 24.8072. Deformation scale is scale factor (or amplitude modulation) consists in scaling the maximum displacement amplitude for visualizing a deformed mesh image. The deformation scale is the ratio of deformation shown vs. reality.

CONCLUSION

In a nut shell, we conclude that, Remotely Operated Vision Inspection Underwater Vehicle (ROV-IUV) is complex but viable as it can controls the movement (left, right, forward, reverse, upward and downward) and automatically stabilize the ROV-IUV using microcontroller and gyro sensor. It even can live streaming and capture video underwater. It also able to

dive in range of 10m – 15m depth underwater. In order to achieve fully functional product, it requires detail research on motor and propeller system, pressure handled and buoyancy force, balancing system, vision system, design and materials.

ACKNOWLEDGEMENT

Praise is to Allah for giving the strength and spirit in completing the final year extended abstract. It is a great pleasure that our project thesis can be conclude in the final project report. The commitment and cooperation from other individual besides our group members lead the project to success. Appreciation need to be given to any organizations and individual direct or indirectly involved upon completing this project. The gratitude and acknowledgement to our supervisors Mr. Faizal Ismail and Mr. Mohd Hafiz Meh, project advisor Dr. Hadi Manap, our family and friends.

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“FISIOBOT” The Robotic Physiotherapy

Muhamad Syamim Salleh, Adib Riduan, Al Azim Ismail, Syafiq Baharom Dr. Abdull Zubi Ahmad and Mr. Kamal Othman, Mdm. Nurul Nadia

Abstract: “FISIOBOT” is a knee physiotherapy kit in helping to gain the range of motion (ROM) for patient that undergo Anterior Cruciate Ligament (ACL) or knee surgery. After the patient had undergo the surgery, they find it is hard for them to gain back the normal ROM as before. Some of them may take a long time to recover, some lasts for 6 months and some may prolong to one year. We also found that the existing equipment are lack of effectiveness and may require other equipment to fulfill the function ability. This kit specially designs to help patients after the knee surgery especially who involve in ACL cases. It also helps physiotherapist to ease their task in regaining the ROM in patient’s knee. The goal of this project is to fabricate a knee motion device by designing, fabricating and assembly the part to form a device. Next we want to actuate the knee motion device by varying the angle and speed of the motor. Furthermore, is to minimizing the time of post operation recovery stage. To achieve this objective, the team will optimize the function of stepper motor and program that has been created. After the fabrication and assembly process, we want to link the “FISIOBOT” to the Arduino Mega using Visual Basic (VB) to monitor the device. Last but not least, we want to analyze the human beat according to the motion of the device and speed of the motor. It can be a great achievement if we can perform all of the goals mentioned above.

INTRODUCTION

In recent years, sports had been a major contributor to knee injury. It includes sports like football, futsal, basketball, rugby and etc. The most common knee injury is related to the anterior cruciate ligament (ACL) tear. There are others tear in knee injury such as medial and lateral collateral ligament (MCL and LCL), medial and lateral meniscus tear and lastly posterior cruciate ligament. ACL tear is most fearsome injury to athlete even towards normal peoples.

Basically, the Anterior Cruciate Ligament (ACL) is one of four major ligaments (ligaments connect bone to bone) of the knee joint that coordinate function and promote stability of the knee joint. It runs in a notch at the end of the femur (intercondylar notch) and originates at the back part of the femur (Postero-medial aspect of the lateral femoral condyle) and attaches to the front part of the tibia (Tibial eminence). In an adult knee, the ACL prevents forward movement of the tibia. It also provides roughly 90% of stability in the knee joint.

The classic ACL injury occurs during a non-contact event usually when decelerating, stopping suddenly, twisting, cutting, or jumping. Oftentimes the patient will hear or feel a “pop” at the time of injury and sometimes they may report brief a hyperextension of the knee joint. Just after the injury patients may be able to continue activity, however most of the time the patient is unable to continue regular activity and a few hours after insult the knee swells considerably.
When the ACL is injured as a result of direct contact, football is often the associated sport. Most often, the knee is subjected to a direct blow to the lateral side and other ligaments are injured in addition to the ACL. The most common multi-ligament injury is the ‘unhappy triad’ that includes the ACL, medial collateral ligament (MCL), and the medial meniscus.

Normally, recovery stage can be divided into 3 phases (phase 1, 2 and 3). The most important phase is phase 1 which also known as early recovery phase after post-op. Phase 2 and 3 can be defined as strengthening (phase 2) and fieldwork stage (phase 3).

In phase 1, it focuses more on pain management, decreasing condition of swelling and ROM. Patient will have serious problem if they lack in their ROM for this phase. And they cannot proceed to the next phase, if they do continue with the next phase, it can generate pain in the strengthening muscle stage. So, our “FISIOBOT” will exactly focus on the early recovery phase. It will focus more on extension and flexion in shorter period.

Patient must achieve full extension and flexion is this early recovery stage. Which means they need to get 0° of flexion and the range of minimum 120° to maximum 140° of flexion. Although most of the knee rehab depends on patient condition, but the way of rehab also play an important role. If the procedure of rehab was wrong, it will bring more complication to the knee. Manually rehab fully depends on human effort.

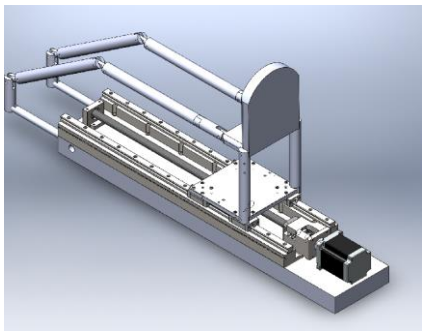

Fig 1: “FISIOBOT” 3D Model

METHODOLOGY

A. *Motor*

This device use NEMA 23 stepper motor with linear guide as the medium to move the joint in flexion and extension position. Stepper motor are DC motor that move in discrete steps. They have multiple coils that are organized in group called ‘phases’. By energizing each phase in sequence, the motor will rotate, one step at a time. With a computer controlled stepping you can achieve very precise positioning and speed control.

Fig 2: NEMA 23 Stepper Motor with Linear guide

Stepper motor are good for positioning, speed control and low speed torque. Since steppers motor move in precise repeatable steps, they excel in applications requiring precise positioning such as CNC, Camera Platforms and X, Y plotters. For speed control, the precise increments of movement also allow for excellent control of rotational speed for process automation and robotics. And for low speed torque as being used in “FISIOBOT”, stepper motor provides maximum torque at low speeds. So, they are a good choice for applications requiring low speed with high precision especially in medical and rehabilitation device.

The motor torque of the motor will determine the motor power. It will carry the load of the material and also the patient’s limb. The equation for the calculation of the motor are as follows:

$$T = \frac{1}{2\pi} P\,(F + \mu W g)$$

T = Torque (N-m), F = External force (N), W = Mass of load (kg), μ = Friction coefficient, g = gravity acceleration (m/s2), P = Ball screw lead (m)

B. *Material Selection*

The material selection also plays a big role in this project. We need material that has high corrosion resistance, high tensile and yield strength and etc.

After a careful and thorough discussion held among group members and the supervisors, we decided to choose Aluminium 6061 as the material to make our product. We choose Aluminium 6061 because of its mechanical properties that suits our product function the best. The mechanism of our product involve intricate movement with the load from the user. So, the material must have mechanical properties that make the product become durable and long lasting.

One of the best known properties of aluminium is that it is light, with a density one third that of steel, 2,700 kg/m3. The low density of aluminium accounts for it being lightweight but this does not affect its strength. Aluminium alloys commonly have tensile strengths of between 70 and 700 MPa. The range for alloys used in extrusion is 150 – 300 MPa. Unlike most steel grades, aluminium does not become brittle at low temperatures. Instead, its strength increases. At high temperatures, aluminium’s strength decreases. At temperatures continuously above 100°C, strength is affected to the extent that the weakening must be taken into account.

Aluminium is easily worked using most machining methods – milling, drilling, cutting, punching, bending, etc. Furthermore, the energy input during machining is low. Aluminium’s superior malleability is essential for extrusion. With the metal either hot or cold, this property is also exploited in the rolling of strips and foils, as well as in bending and other forming operations.

Aluminium oxide is impermeable and, unlike the oxide layers on many other metals, it adheres strongly to the parent metal. If damaged mechanically, aluminium’s oxide layer repairs itself immediately. Aluminium is a non-magnetic (actually paramagnetic) material. To avoid interference of magnetic fields aluminium is often used in magnet X-ray devices. After oxygen and silicon, aluminium is the most common element in the Earth’s crust. Aluminium compounds also occur naturally in our food. The characteristics will be explained more in the thesis.

C. *Machining Process*

There are several processes in fabricating this knee motion device. Such as milling, lathe, drilling, and few step of welding. All of the process are the example of material removing process which to convert raw material to product. Each of the process need to be done conventionally because of limited availability of machine.

The usage of some non-conventional (NC) and computer numerical control (CNC) machine need the short program to operate the machine. This method some time can consume time for the first time user. So, for our convenience the conventional machine was the preferable method. To ease our fabricating process, the process plan was made.

The machine that was used for milling process was Deckel AG FP4M. This machine can carry out process such as squaring, drilling, taping, boring and others. We use this machine to fabricate the base for foot and as attachment for the ball screw set. Some slot for the shaft also been made using this machine. There are some problems in fabricating the slot for the shaft as the shaft was in round shape. We need to clamp it using V-block which we never use before.

Fig 3: Deckel AG FP4M Milling Machine

While lathe process use Weiler Praktikant GS machine and can provide process such as facing, turning, drilling, boring and threading. The mention process was used in our fabrication and there was some other process in lathe such as grooving and tapering. Most of the shaft was machined using this machine. The diameter and length of the shaft was obtained by facing and turning process. The boring process was conducted on the Shaft 4.

Fig 4: Weiler Praktikant GS Lathe Machine

D. *Arduino Mega*

Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer (e.g. Flash, Processing, MaxMSP). The open-source IDE can be downloaded for free (currently for Mac OS X, Windows, and Linux). The Arduino Mega is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which

14 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. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

The Mega 2560 R3 also adds SDA and SCL pins next to the AREF. In addition, there are two new pins placed near the RESET pin. One is the IOREF that allow the shields to adapt to the voltage provided from the board. The other is a not connected and is reserved for future purposes. The Mega 2560 R3 works with all existing shields but can adapt to new shields which use these additional pins.

RESULTS AND DISCUSSION

Table 1: Data collect from an average male normal person

Fisiobot Angle of Inclination (°)	Angle of Knee (°)	Reach length (mm)/ (Ball screw)	Heart Rate (BPM)
0	180	30	73
40	140	231	73
60	120	333	72
80	100	430	73
90	90	452	73
100	80	535	73

Table 2: Data collect from an athlete male person

Fisiobot Angle of Inclination (°)	Angle of Knee (°)	Reach length (mm)/ (Ball screw)	Heart Rate (BPM)
0	180	35	55
40	140	238	55
60	120	339	55
80	100	435	54
90	90	456	54
100	80	539	55

Table 3: Data collect base on weekly basis from an athlete male person when perform flex-extent using FISIOBOT

Week	Resting Heart rate (BPM)	Heart rate during in Pain (BPM)	Time achieve (Min)

1	55	70	0.5
2	55	69	0.8
3	55	70	1.2
4	55	68	2.5
5	54	70	4.5
6	55	70	5.4

In the table for the results and discussion section, we relate between the data from the inclination/declination of knee angle and the reach length of ball screw. The data should show that the inclination angle will increase the reach length of ball screw and otherwise. Besides, we also include the data from the pulse sensor which measured the heart rate between an average normal male person and a male athlete.

The data will show the difference between heart rate both of them and hopefully will be a good monitoring system in the medical society. Furthermore, we expect that we can ease the tasks of the physiotherapist in doing the recovery session. In addition, we can say that an athlete male person has been improved from the time duration of using FISIOBOT increase every week before he felt the pain.

The pain is related to the change of heart rate during the flex-extent exercise. If the athlete in pain situation, we can see that the heart rate is in unusual BPM of his. This is because, during resting, heart rate of an athlete is at 54-55 BPM but during pain our brain stimulate the pain signal, but it also changes the blood pressure in our body.

CONCLUSION

After all of the design and program has been successfully matched, we hope that our "FISIOBOT" can be fully functional and can helps patient to achieve their ROM back after the post-op according to the normal timeline of recovery. We had successfully fabricate and actuate the knee device motion in the timeline given. We also manage to monitor the device by linking it to the Arduino Mega program. For the analysis part regarding the heart rate and blood pressure, we need to be more specific and must do clearer research to obtain precise information and result.

For the next research, we recommend that the next group can improve on the design and functionality of this device. They also can reduce the material utilization of the aluminium 6061 by minimizing the size of the device. As mention above, they also must do a better research for a better results and satisfaction.

ACKNOWLEDGEMENT

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Last but not least, our deepest gratitude goes to our beloved parents for their endless prayers, love and encouragement. Any omission in this acknowledgement brief does not mean lack of gratitude. Thank you.

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Prototype Of Anti Trap Escalator with Advance Sensing System and Smart Mechanism (SPREC)

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***Abstract* :** Accessing to give a safety for user or peoples from any harm or injuries when using the public transport which is an escalator was a big challenging to apply, by using a new method of design and operating system can surely reducing or eliminated any harm that can occur to the user of an escalator. The first objective for this project were to invent an anti-trap proof system to reduce harm to escalator user. The invention of anti-trap proof system was focused at the end and starting of the platform, by adding the roller to make sure the users does not had a chance to been trap. Second is by adding the sensor application to detect any accident occur. The PIR sensor, for detecting the motion, the sensor is been placed at the bottom of platform of escalator. The sensor is been program for stopping the escalator automatically when the sensor was been triggered. Third objective was design the new safety operating system data logging. The data logging of time date and voltage will be recorded to show the proof when the accident occurred. The data logging were be done by programmed by Arduino controller.

INTRODUCTION

Escalator is the device that help people to move between floors of the building which faster without using stairway. This device consists of motor driven, chain, roller and step treads to move up and down on tracks in horizontal position. Escalator is more suitable use in areas of usage include department stores, shopping malls airports, transit systems, convention centres hotels, arenas, stadiums, trains stations and public buildings. There have many benefits of using an escalator in example the ability to move large numbers of people in one time, no waiting interval, and used to guide people toward main exits. In recent years, with development of science and technology together with the increased of population, escalator safety is the most important point to discuss. In solving issues pertaining to escalator safety, many years of research and development about risk of escalator have been done with a lot of rooms for improvements. Lately, a lots of accident have happens in our real life related with escalator. In most cases, accidents occurred involving children which are not have a proper guidance during on board of escalator. This project is proposed with an intention to eliminate or at least can decrease potential accidents at escalator. There are various of area that can increase the safety of escalator such as create a new system mechanism for escalator to stop immediately when any object or faulty detect example detect motion in danger area of escalator equipment, also have data logging to record any happen at escalator which is why escalator suddenly stop with have time and date to review. All these system was developed to ensure user's regardless age can use this escalator with safe.

LITERATURE SURVEY

Accidents of data gets confirmed that accident caused by design failures, component breakdown and not maintenance well [1]. Conveyor systems comprising a train of consecutive carrier elements movable generally along a linear and curved pre-selected path and which may provide a forward and return motion, are widely used for a variety of applications, including the movement of Articles or people [2]. Many type of sensor can use such as electromechanical switches, photoelectric sensors and proximity sensors [3]. The control system is comprised of two major components, a main controller and a variable frequency drive [4]. The purpose of the escalator risk analysis is to achieve security system, using the principle and method of safety system engineering to identify and analysis the risk factors existed in the escalator system [5]. Currently the control system of escalator is by a microprocessor that based control system is highly propriety to each original equipment manufacturers [6]. Refinery industry and every other industry where data is of prime importance use wireless data acquisition, data processing and data logging equipment [7].

OBJECTIVES

The objective of this report are to exposed problems of the escalator and how to overcome the accidents. This report is intended:

- To invent an anti-trap proof systems to reduce harm to escalator user.
- To add the sensor application to detect any accident occur.
- To design new safety operating system data logging.

METHODOLOGY

The team members including the supervisors were meeting together for brainstorming session to come out with a good project title. The ideas from the meeting with team members were an incubator, the crane lifter, destroyer wiggler, and a safety smart mechanism prototype escalator. At the end of the discussion "safety smart mechanism prototype escalator are selected as the

title of the project. The selected project title has been agreed by the group members and supervisors because the main point on the discussion is to contribute, to solve problem or invent a new technology or system that contribute to the society.

After decided the project title, the project background are created to ensure the society understand why the project is selected. The next step was the literature view part where the research was been done from the previous inventor that related to the project or system. The research was done by gathering the journal, thesis, newspaper that related to escalator. The information from the journals are used to improve the loophole of the project. At the end, the final "safety smart mechanism prototype escalator", design and system are invented by a combination of mechanical design and electrical programming system.

The next step is to create the project model and it was invented by mechanical team members, while the electrical members created the circuit diagram. The design are sketched and improvised from time to time during the SDP 1. Each of the structure from the design influence the quality of the project model. The part are divided into two in mechanical design which is the comb cover and the side cover. For the comb cover, the ideas is to take advantage of flat surface during the rotating escalator moving to transmit movement of the smart design mechanism roller so the user can move straight to the land platform without stepping on the comb plate. The circuit diagram shown the main circuit and the subsystem like Arduino, sensoring device and data logging. The created project model will easier to reader how the project works generally and how the project appearance of the project model.

Revising the project model by performing the testing whether to the design or circuit diagram. The performing toward the circuit diagram was to make sure the components were suitable, sufficient, and can work properly when operating the system. The data will be collected and been revised to ensure the result can be analyses properly or accordingly the desired output.

A. Flowchart of SDP

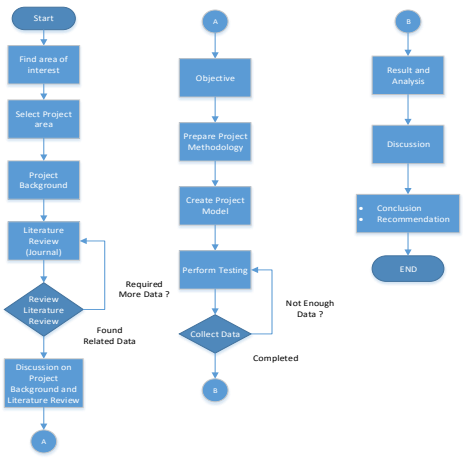

Figure 1 Project Flowchart of SDP 1

B. Electrical Wiring Diagram

Installing electrical wiring is an integral part of an electrician's job. Working with electrical wiring involves working with device boxes, raceways, conductors, and cables. Electrical wiring diagram is the important thing before start install the wiring, it is easy to determine which part have to use depend on equipment's type and as a reference when to install the wiring diagram. Figure 2 Shows the electrical wiring diagram for the escalator machine the input for the circuit is 240 VAC which is has main switch to switch on the circuit, after that have Earth-leakage circuit breaker (ELCB) function to prevent shock, detects small stray voltages on the metal enclosures of electrical equipment and interrupts the circuit if a dangerous voltage is detected. Miniature circuit breaker (MCB) function to protect electrical circuit from over current, can protect equipment. Power supply for arduino uno is adapter ac to dc 5V.

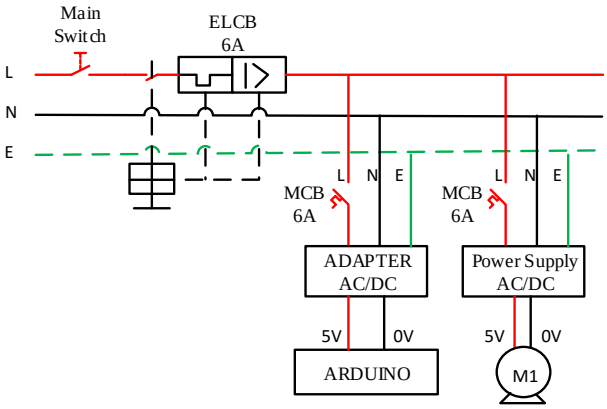

Figure 2 Electrical wiring diagram

C. Controller Wiring Diagram

Every operating system have a controller to guide the system what we want to do and measure, in this project we use controller arduino uno to manage the flow of the system. In the figure 3 below show the controller wiring diagram for the escalator system which is use PIR sensor, its act as switch to detect any accident occur inside the escalator which is has 3 connecter, for Vcc is connect with 5V to ON the sensor and for output will send signal trigger at the pin number 3 to arduino another connecter is connect at the ground. Arduino will take action send signal trigger to pin number 2 which is has connect with solid state relay and will cut the supply immediately. After has stop the escalator, data has been record and display in the computer and show the time, date and person incharge which is use real time clock (RTC) to save the time and date at pin number analog 4, 5 and 6, WiFi Serial Transceiver Module (ESP8266) to transmit data to computer at number pin 0 for Rx and number 1 Tx. Supply for ESP8266 is 3.3V which is have to use voltage divider to get the volt by using 2k and 1k resistor.

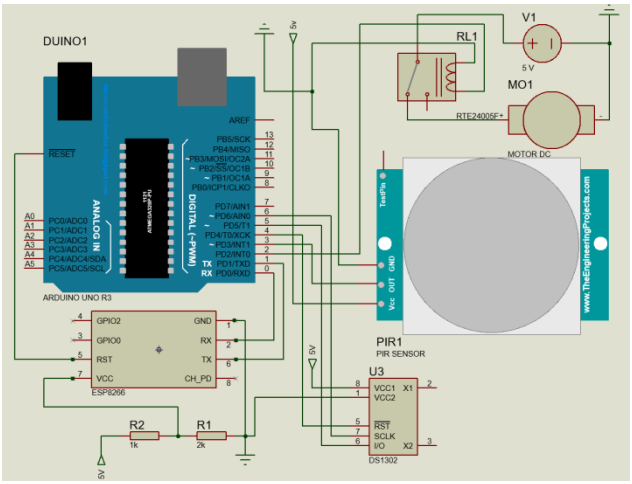

Figure 3 Arduino Wiring diagram

D. Data Logger or Recording Data System

A data logger is one of device that can record data over time in relation to location. Usually data logger were built in instrument sensor and via external instrument. Data logger generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer, and use software to activate the data logger and view and analyze the collected data, while others have a local interface device (keypad, LCD) and can be used as a stand-alone device.

The implementing of data logger system in Escalator system is one of the safety system for escalator as a proof of any accident occur. Basically the data logger is for recording the time date and the person in charge to controlling the escalator system if any accident occur. Figure 4 below show how the data logger is been done for gather an information such as time, date and person in charge.

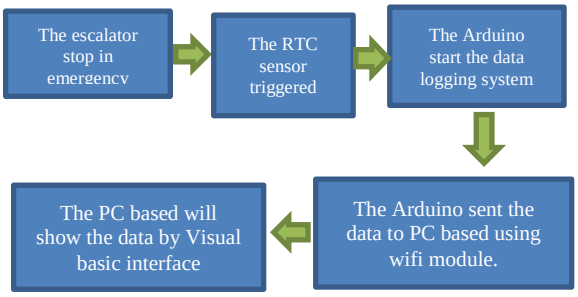

Figure 4 Process flow of data logger

The data logger for the escalator system is be done or controlled by Arduino programmed with addition data logger component like real time clock (RTC). The important components that were needed like Arduino Uno, Arduino shield card, and the SD card. As the knowledge that had been research about data logger, the program will be done in Arduino programmed and the data will be link to Microsoft excel and show the desired output. The choice can be made by choosing the suitable way to show the result or the data by using any interfacing software such as Microsoft excel and Visual Basic studio. The data will be saved in SD card memory that had been link with Arduino by using Arduino shield card. The table below show more detail the components that related to Data logger system.

E. The Project Design (Comb Plate Cover)

The concept of this design is using roller concept to transmit movement so that the user can move straight to the landing platform without stepping on the comb plate which usually being a major problem (people stuck their shoes or clothes on the comb plate). Figure 5 shows the latest invented comb plate cover that will be attached to the escalator comb plate area.

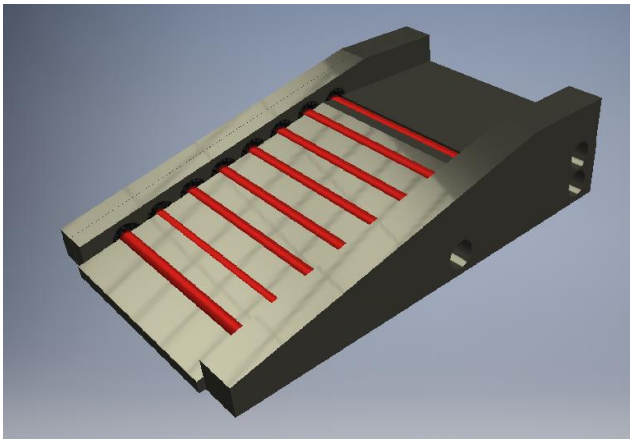

Figure 5 Smart Mechanism Comb Plate Cover

This design required a roller to transmit movement from the step plate condition (flat surface during rotating). As refer from Figure 5.1 the step plate will provided a movement force to activate the comb plate cover moving a person on the roller side. A flat rubber must be used to cover the roller and to grip while moving the passenger.

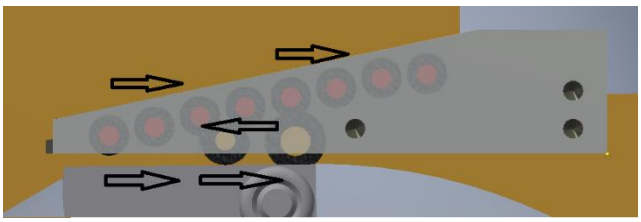

Figure 5.1 Side View Clear Model

As the Figure 5.1 above shown an arrow how the comb cover transmit the step plate movement into a rotation power to move the passenger.

F. The Project Design (Carousel Concept)

This carousel are actually idealize from the airport conveyor. From this project the user can safely ignore the side of the escalator, this is because the friction between step plates and the side of the escalator are been eliminated. The carousel will follow the step plate speed. The figure 6 show that the design of the carousel before

been attached with another carousel. When it have been attached it will look like caterpillar.

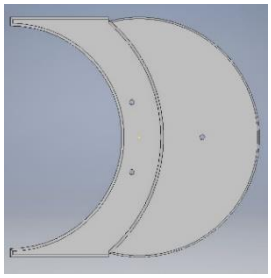

Figure 6 Top view of the carousel

RESULTS AND DISCUSSION

V. Figures and Tables

From the result of what we can observe that using this mechanism can save the user from injuries and reduce the fatality of the escalator. Figure 7 shows that the prototype of this project that apply the SPREC systems. The process of elimination of the friction between step plates and the siding of the escalator are totally eliminated. The operation system of SPREC can be expected reducing the accident on the step platform at the end and started. The automatically stopping escalator operation can eliminated when the platform was immediately breakdown.

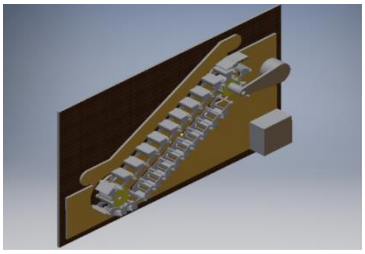

Figure 7 Assemble Escalator

CONCLUSION

In summary we hope this project will be accepted by all verifiers. In order to complete study in Universiti Malaysia Pahang – German Malaysian Institute, this senior design project subject must be done completely. This stage will make students to apply all knowledge that had been gained during study 2 and half years in UMP-GMI.

As a conclusion, we can say that it is very important for us to follow the objectives and everything else that we have listed out and thought in this proposal and make them as guidelines for our progress in completing the project because from that we can really achieve successfully in making this project complete and successful

- Improve the consistency in the escalator operating system
- Upgrading the comb plate design into trapped proof systems
- Design new safety operating system

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and the Most Merciful Alhamdulilah, all praises to Allah for the strengths and his blessing in completing in this project. Appreciation also goes to Majlis Amanah Rakyat (MARA) and Universiti Malaysia Pahang (UMP) that give opportunity for me to futher my studies in engineering field. We also like to convey thanks to the project supervisor Mr Ahmad Hafiz Bin Mohd Hashim and Mr Rashdin Ramli for his guidance and encouragement throughout this project, also to our project advisor Madam Nurul Nadia for their suggestion. Thanks to both Industrial Electrical and Production Technology Department, German-Malaysian Institute (GMI) for providing the laboratory facilities for this research. My sincere appreciation also extends to all friends, lecturers, teaching engineers and others who provided assistances and advices, including the crucial input for my planning and findings. The guidance and support received from all was vital for the success of this research.

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Automated Storage Retrieval System (ASRS)

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***Abstract*: The automated storage and retrieval systems (ASRS) are major material handling support systems that are commonly use in the automated factories, distribution centres, warehousing, and non-manufacturing environments. Their applications vary widely from a simple storage and retrieval system for small parts to central systems where production, assembly, and manufacturing operations are concentrically located around them. This report summarizes the literature study of technologies and materials used for, and development of a dedicated for technician room in German Malaysian Institute. The prototype developed consists of the control hardware and software communicating over a field bus network. This also includes study of literature for types of automated storage and retrieval system, study of literature for suitable environment for automated storage and retrieval system, order processing for automated storage and retrieval system. The development of physical prototype is highly beneficial to acquisition of tactic knowledge and greatly benefits the development of students by understanding the automated storage and retrieval system.**

Keyword: ASRS, German Malaysian Institute, prototype

INTRODUCTION

An automated storage and retrieval system (ASRS) consists of a variety of computer-controlled systems for automatically placing and retrieving load from defined storage locations. Inventory management systems are widely used in manufacturing facilities, distribution centres, and warehouse throughout the world. A combination of equipment and controls handles stores and retrieves materials with precision, accuracy and speed. It generally consists of machines that move up and down one or multiple parallel storage aisles, storing and retrieving products, and materials for dissemination to internal and external destinations alike. These systems automatically locate and deliver the required inventory to a conveyor system, manual out feed, or an ergonomic operator station. System can vary from relatively simple, manually controlled point of use storage structures to computer-controlled storage and retrieval system that are completely integrate into the manufacturing and distribution process.

A. Problem Statement

Every tools or components that available in a storehouse need to be sort accordingly to reduce the time wasted to search for standard part in a process hence reducing the efficiency of a process. Unfortunately, although the standard part or components may be well sorted and organized, due to the huge number of standard available, it consumes a lot of time to search for the specific tools. To encounter this problem, build this project to implement the ASRS.

B. Project Implementation

In the beginning before start the fabrication process, we have to complete the drawing of ASRS machines. After the design completed, we have to select the suitable materials to see whether the materials unable to support the load of the items on the ASRS machines. After received the materials from the store, we measured the materials according to the detail drawings and cut the materials using Band Saw Machines. Then we did deburring process and re-measure part by part after cutting process to achieve the length according to the detail drawing and to any injuries to human. After all the cutting process completed, the assembling part was done by using the L-bracket and tighten it using T-slotted screw and nuts .The process flow I shown in Fig.1 (a) until (f)

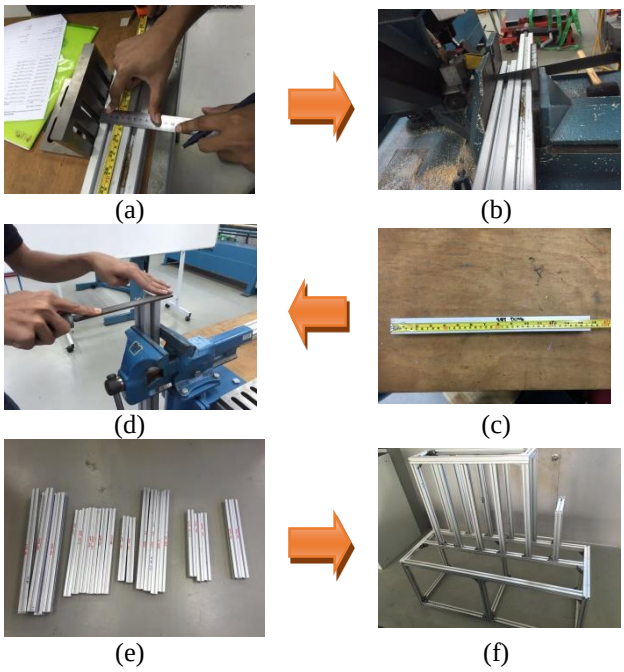

Fig.1 Project Implement Flow

METHODOLOGY

The mechanisms of Mini Load Automated Storage and Retrieval System (Mini Load ASRS) consist of three degree of freedoms (DOF) which are horizontal drive, vertical drive, and gripper drive. These mechanisms enable the system to move along X-axis and Y-axis directions powered by stepper motor. The gripper drive which is the z-axis functions to pick item from the rack and place item to storage rack powered by linear actuator.

In this project, the mechanisms of the Mini Load ASRS were designed in SOLIDWORK 3D computer aided design (CAD) software. The materials used to construct the mechanisms of the Mini Load ASRS are mostly Aluminium Extrusion Profile 30mm x 30mm. These materials were chosen due to their stiffness characteristic. The main advantages of Aluminium Extrusion Profile is ease to assembly and adjustable to construct the mechanisms.

A. Mechanism Design and Construction

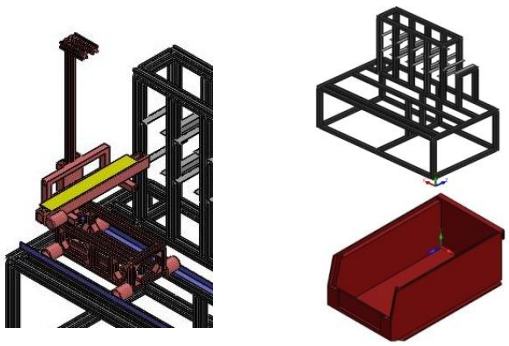

Fig.2 Project Design

W. Design Structure

This prototype consists of a rack consists of eight compartments and a loading area was designed in this project. The 3D design of the rack is shown in Fig.2. This rack was built to store container of dimension 11.8cm x 18cm x 8.2cm. The dimension of the rack is 1.4m x 1.3m x 0.8m. The dimension of the compartments is 152mm x 240mm x 198mm. Materials used for building this rack are aluminium profile 40x40mm and aluminium angle bar. The rack was constructed by using angle bracket and screw, nut for assembling the steel.

X. Finite Elements Analysis (FEA)

The Aluminium Extrusion Profile structure for the Automated Storage Retrieval System must possess sufficient strength and rigidity frame structures that can provide more stability and does not deflect significantly, due to our objective of project is to design ASRS that can transport maximum load of 4kg and determined the efficient factor in the design of building systems frame structures that have economical designs. The experimental setup for these tests consisted of Finite Element Analysis (FEA) concepts. The Finite Element Analysis (FEA) in term of mechanical, to determine the stress, strain and displacement detection and to gather the output, are using the efficiently optimize and validate each design step using fast solving, CAD integrated SOLIDWORKS. The simulation is used to ensure quality, performance, and safety. In terms of analyze the response of a component to an applied load, there three main parts which are frame structure, carrier and body structure of ASRS as shown in Fig.3.

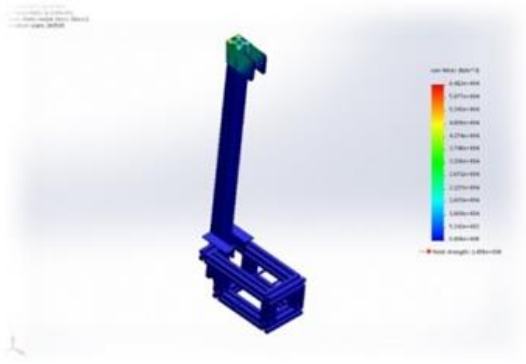

Fig.3 Final Element Analysis (FEA)

The grade material of Aluminum Extrusion Profile is Aluminum 6063-T5. The factors to consider when evaluating and to get the accurate results for an Automated Storage Retrieval System design, the result of analysis based on the output standard mechanical properties of Aluminum 6063-T5 data. The stress concentration must considered and not shock load or failure analysis. The SOLIDWORKS Simulation uses The Finite Element Analysis (FEA) methods to calculate the displacements, strain and stresses in ASRS design due to

operational loads such as forces, pressure and contact between components.

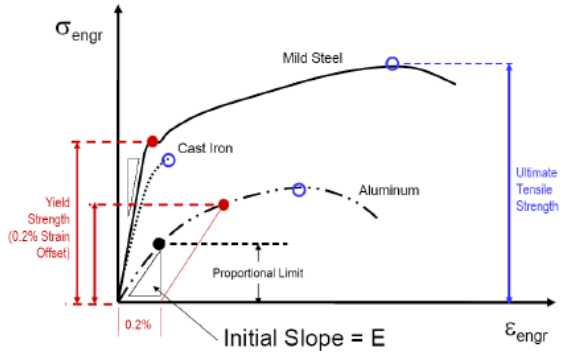

Fig. 4 Stress-strain elements experiment results

The strain or stress failure criteria are different depending on whether they are considered as brittle or ductile materials. The difference between brittle and ductile material behaviors is determined by their response to a uniaxial stress - strain test. Thus, in terms of structural component failure, the analysis the Aluminum 6063-T5 is very important to archive the one of objective goals for Senior Design Project (SDP), which is to transport maximum load of 4kg and to determine the most efficient and the strong frame structure of Automated Storage Retrieval System by analysis the design using SOLIDWORK software and factor of safety (FoS) is a common goal.

RESULTS AND DISCUSSION

A. Motor selected for our project

Motor which satisfied the specifications required by our equipment to build the ASRS was stepper motor. Our ASRS consist of three motor with direction X-axis, Y-axis and Z-axis. For both axis, the motor has a different torque, while the Z-axis used an electrical actuator to operate forward and reverse direction. Each of motor are connected with 24V dc with their driver. Meanwhile, each driver were connected with controller PLC 1200. Basically the each stepper motor had their own rotational force to turn things on load. These forces were measured in Newton meter (Nm). To analyse selection for stepper motor, we need to determine drive mechanism for the first step. By referring our ASRS design, we can determine dimension length for each mechanism. The next step was defined the mass of our load to get suitable force for our motors. By completing both steps, we proceed to the last step which calculated torque.

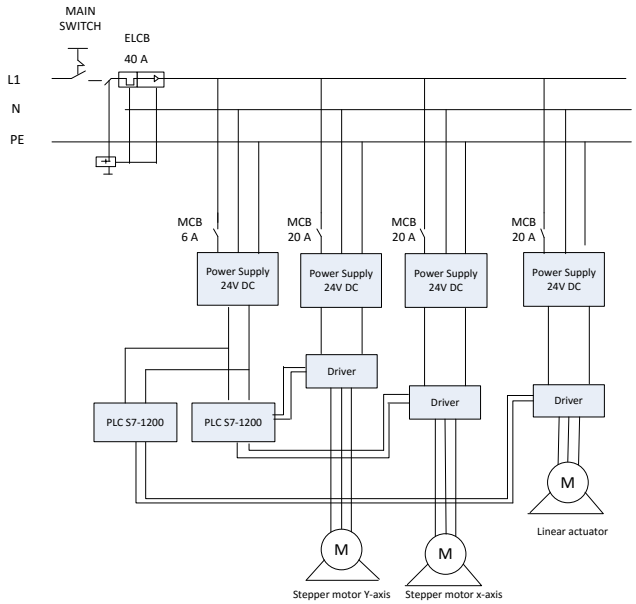

Fig.5 Main Circuit Design

Formula applied to get the torque for selection of motor is T=radius x force.

B. Software Used

We had been used Totally Integratd Automation (TIA) software to communicate with our PLC S7 1200.

C. Process Flow

Based on process flow, the user need to press start button before begin the process.Green light will indicated to show the programme start to run.Next, user need to enter the correct password.Then, press “ENTER” button and proceed with “CONFIRM”button after done.

This HMI was developed for more 4 sceens.Those screen contained the Initial, login,control panel and identity.

After the user done with mode selection and process selection, the user need to fill up the form either they want to storage or retrieval .Those form are made to avoid any missing item that had been stored in ASRS. Whatever process is happening,will be indicated in the process information display panel.

D. Totally Intergrated Automation (TIA)

Each stepper motor according to 3 directions, they need to be setting inside TIA.

Since we are using stepper motor as our actuator, therefor, we need to set on TIA portal for pulse and direction.We had choosed PTO instead PWM because the stepper motor move using pulse either in clockwise direction or anti-clockwise direction. This setting need to be done for the others 3 stepper motor.

E. Position Setting

After done with the setting on TIA portal, we need to do the others setting for positioning. Those setting must done to make sure the stepper motor will stop and move according to location of chamber while Storage or Retrieval process are running. Since we didn't use any hardware or limit switch to detect the positon,therefore, we choose on the settings, "Enable SW (software) limit swich.

CONCLUSION

As for our conclusion, we can conclude that, automated storage retrieval system (ASRS) is complex in design and control which we need to focus study on material selection, fabrication ,process control to control various movement which X,Y and Z and power circuitry for the whole system. These automated storage retrieval system development had been divide into a few layer such as designing process, fabrication for mechanical component and their assembly, the electrical circuitry, programming and interfacing for SCADA.

ACKNOWLEDGEMENT

Grateful to ALLAH "S.W.T" for giving us wisdom, strength, patience and assistance to complete our project work. Had it not been due to His will and favour, the completion of this study would not have been achievable.

First of all, thank you to deepest sense of Gratitude supervisor Mr Raja Azlan Bin Raja Abdullah, Mr Mohd Heidir bin Mohd Shah and Ms Sulastri binti Abdul Manap who offered their continuous advice and encouragement throughout the course of this thesis. We thank them for their patient, systematic guidance, comment, stimulating suggestions and encouragement which helped us in all the time of research guidance and great effort they put into training us in the manufacturing field.

Finally, we would like to thank you to all people that helping us built and implement ASRS.

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Laser Cutting Machine

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***Abstract*: The reason why we choose Laser Cutting Machine is because we have found the potential of the machine. The machine are able to cut any kind of material like metal, plastic and wood. The laser cutter is one of the most useful tools in a modern shop. Laser cutters work by directing a very powerful laser beam, at a precise focal length, onto a material which they either cut or etch, depending on how the laser cutter has been set up. Laser cutters cut materials similarly to other computer controlled tools, only they do so using a beam of light as opposed to a blade. When laser cutters are set up to etch something on the surface of a material, they operate like a printer, literally using their laser beam to etch an image onto something.**

After all the setup has be done, the machine will start cut the material, the user must be aware about safety during operate this machine because this machine relate with high voltage and some gases. Computer-aided design (CAD) or others application design can be used to design the cutting shape based on customer request.

Keyword: CAD, German Malaysian Institute

INTRODUCTION

Our group has choose the laser cutting machine as our final Project in senior design project 1 (SDP 1) we need to make a documentation all about this machine.

Laser cutting machines allow metal fabricators to create high-quality parts that require very little, if any, finishing work. As the high-powered laser is cutting, excess material is either melts, burns or vaporizes away. A high pressure jet of gas also blows away any debris, resulting in a highly finished surface cut, CO2 laser cutting machines were one of the first gas lasers and are the most common variety of laser cutting machine. They offer an excellent power input output ratio, as efficient as 20 percent they cut steel and other material in working industry.

PROJECT IMPLEMENTATION

In the beginning before we start the fabrication process, we have to complete the drawing of Laser Cutting Machines. After the design completed, we have to select the suitable materials to build the laser cutting machines. We have chosen Aluminium Extrusion Profile as a structure for this machines to operate. After we received the materials from the store, we measure the materials according to the detail drawings and cut the materials using Band Saw Machines. Then we did deburring process and re-measure part by part after cutting process to achieve the length according to the detail drawing and prevent injuries to human. After all the cutting process completed, we start to assemble the part using the L-bracket and tighten it using T-slotted screw and nuts.

Fig. 1 Measure the part

Fig. 2 Clamp and cut the part

Fig. 3 Deburr the part

Fig. 4 Arrange the part

Fig. 5Assemble the part

METHODOLOGY

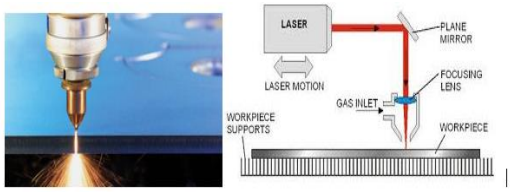
The Laser cut machine allow metal fabricator to create high quality parts that require very little work. Laser cutters work by directing a very powerful laser beam, at a precise focal length, onto a material which they either cut or etch.

Table 1 Machine Specification

Power Supply (Controller)	240VAC,12DC
Power Supply (Laser Tube)	220VAC/40W
Main Controller	Arduino Mega 2560
Sensor	Limit Switch
	Flow Rate Sensor
	TMP36
Actuator	Stepper Motor
Production time (cycle time)	
Estimate weight/size	240Kg
Raw input	CO2 Gas
Output	3D Model or Etch

A. Project Features

Laser Cut is an automated etch and cut machine. First we'll have the 3 dimensional drawing done using Solidwork software, after that the conversion of data will begin after the transferring of data. Next, the laser cut will start cut or etch the 3 dimensional model using laser beam CO2 while coolant system will control the temperature.



Example of how a 3D model cut and etch

B. System Layout

System layout is a plan, sketch, drawing, or outline designed to demonstrate or explain how something works or to clarify the relationship between the parts of a whole. In our machine, the drawing is made using Solidworks designing software which can also make a full simulation of whole machine after finish the design of the machine layout. Below are the overview pictures of the machine.

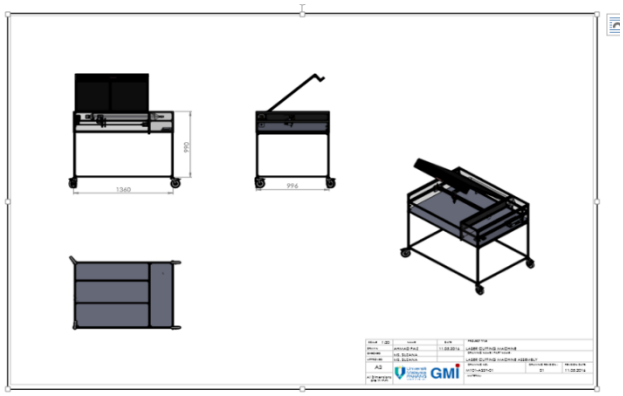


Figure 6 Design layout

C. Electrical Wiring Diagram

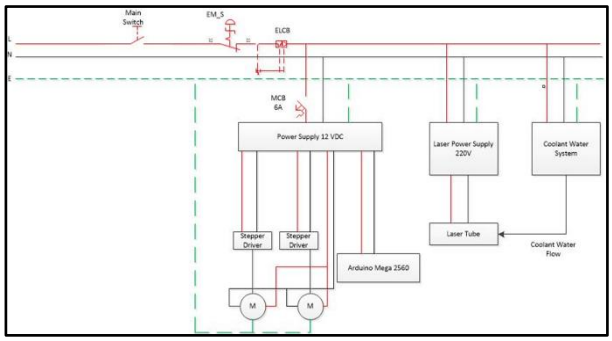
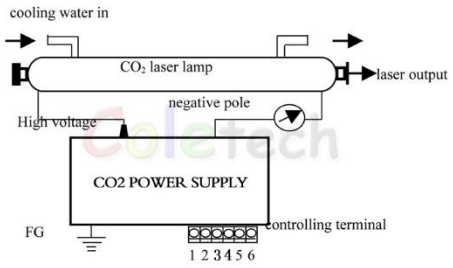


Figure 7 Electrical wiring diagram

D. Laser Tube Wiring

Connection between power supply and laser device:



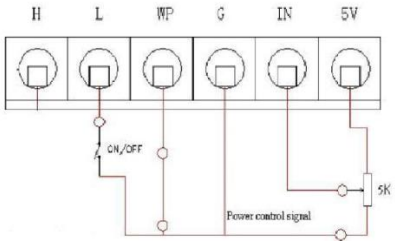


Figure 8 Laser Tube Wiring

E. Laser Power and Intensity

Lasers are usually described in terms of power, e.g. 1,000 watts or 6kW. Laser power is the total energy emitted in the form of laser light per second. The intensity of a laser beam is equal to its power divided by the area over which the power is concentrated. For example, focusing a 1kW laser beam over a diameter of 0.1mm (0.004 in) will result in a power density of approx. 125kW per mm2. The high intensity causes the material to heat up rapidly so that little time is available for heat to dissipate into the surrounding material. This produces high cutting rates and an excellent quality of cut.

$$\text{Intensity} = \frac{\text{Laser power}}{\text{Irradiated area}}$$

Equation 1 Intensity of Laser

A laser's intensity also determines the thickness that can be cut. The thicker the material to be cut, the higher the intensity needed. Higher intensities can be reached by increasing laser power or by using a focusing lens with a shorter focal length. However, focusing the beam on to a smaller spot also reduces the depth of focus and is therefore unsuitable for cutting thick materials. High intensity can be achieved both in pulsed and continuous beams. Accordingly, either the peak pulse power in pulsed cutting or the average power in continuous cutting determines the penetration.

F. Actuator Sizing

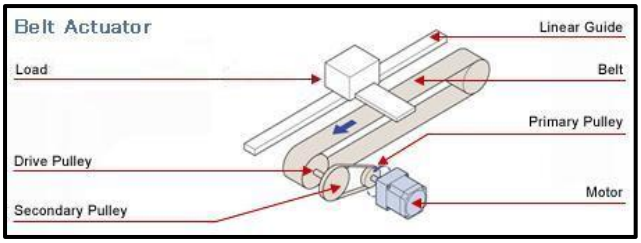


Figure 9 Calculation by using Oriental Motor

Load and linear guide,
Total mass of loads and table m = 0.172 [kg]
Friction coefficient of the guide μ = 0.5

Drive pulley specifications,
Drive pulley diameter DP = 15 [mm]
Drive pulley mass mP = 0.005 [kg/pc]
Number of drive pulleys n = 2 [pc]
Efficiency η = 90 [%]

External force,
FA = 0 [N]
Required Speed
Vm = V1 × (60 / π DP) = 500 × (60 / (3.14 × 15)) = 636.9 [r/min]

Required Torque,
T = (Ta + TL) × (Safety Factor) = (0.000 + 0.007023) × 2 = 0.01405[N·m]

Load Torque,
F = FA + (m × 9.8) × (sinα + μcosα) = 0 + (0.172 × 9.8) × (sin 0 + 0.5 × cos 0)
= 0.8428[N]

TL = (F × (DP × 103)) / (2 × η × 0.01) = (8.428e1× (15 × 103)) / (2 × 90 × 0.01)
=723 [N·m]

RESULT AND DISCUSSION

A. Main Flowchart

1. On Machine and Laser Safety system

This is how to turn on the machine and where laser safety system really takes the role to ensure the safety using laser cutter. What does laser safety system do actually: -

1. Monitor coolant flow and coolant temperature
2. If flow of coolant stops the laser is shut down and an alarm and buzzer will turn on to indicate no coolant flow while LCD will display "No Coolant Flow! Check Pump".
3. If the coolant temp rises over 21° C. The laser is shut down and an alarm sound, and LCD display "TEMP WARNING!!! Values Temperature Degrees Immediate Action Required! "
4. If the door is opened during running mode it will quickly shut down the laser.

2. Data Transfer

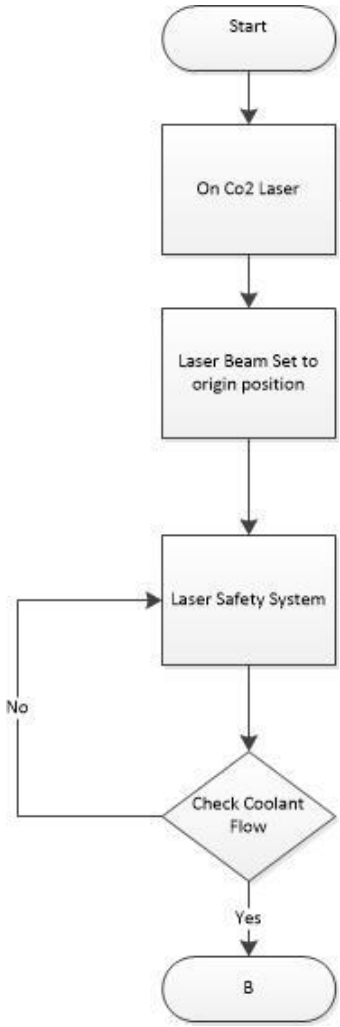
Here user will insert the drawing data that was created from the Solid Work software by using a SD card into the card reader where it is located on the machine.

3. Cut or Etch Process

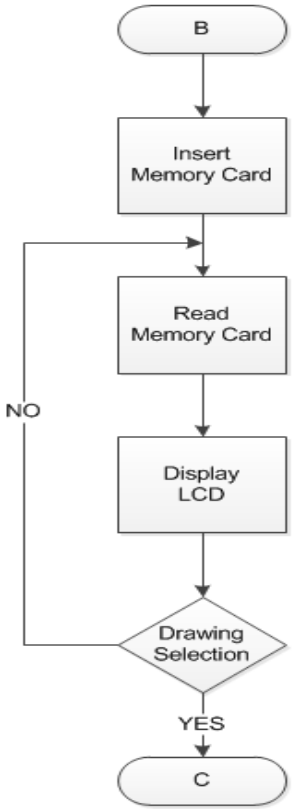
This is where the cutting and etching process start, the modelling will follow the software that used.

CONCLUSION

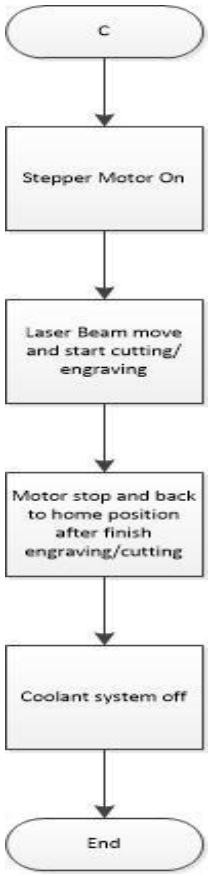
As a conclusion, we can conclude are the laser cutting machine can cut any material depending their power of machine and type of material used. Beside that using CO2 gases also make a cutting process more efficient because mostly laser cutting machine in world use the CO2 gases to make a cutting process and material cut more smoothly. We.re need to make more research about laser cutting machine and CO2 and their cutting speed cutting operation. So our objective will be achieve during implement this machine on SDP 2.



Main Flow Chart 1



Main Flow Chart 2



Main Flow Chart 3

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We would like to thank all the lecturer from University Malaysia Pahang (UMP) and German-Malaysian Institute (GMi) that have helped us throughout the process of preparing this proposal. Besides, a special thanks to our supervisor Madam Suzana for the advice and valuable guidance on our project and also Mr. Nazrin as our coordinator for BTE section for the advices and guidance on our documentation.

Apart from that, we would like to take an opportunity to thanks to our head of section, Ms. Sulastri for her dedication and willingness to support our group in the completion of our project.

Lastly, we would like to dedicate this project to our beloved parents. Without their support and understanding, the completion of this project would not be easy to complete. And also we would like to thanks to our friend and lecturers in University Malaysia Pahang (UMP) and German-Malaysian Institute (GMI) for helping us along the journey.

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Automatic Table Tennis Trainer with Player Position Detection

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***Abstract*: The Automatic Table Tennis is the innovative of the available table tennis robot in the market. The difference between our project and the other product is the feature that we added on which is why we think it is an important feature that can help many parties. The feature we provide is the player position detection. The position detection is needed so that player can change the difficulty that they desire.**

INTRODUCTION

Table tennis that we know nowadays has actually played widely late 19 century by wealth people in England. It was most likely to be played on winter season as indoor activities.

.The game is play with a ball made by rubber and a wooden paddle. It is well known as Ping Pong as the sound of the ball when hitting the table and the table sound like it.

In 1926, an institution which is the International Table Tennis Federation (ITTF) was created in Berlin and new laws were applied. [1]

The table tennis is play by 2 or 4 players. They need to hit the light ball across the table using the paddle. The player are only allowed to bounce the ball only once at their side or else the opponent will get the score. Ping pong is the sport where it was played with the fast tempo speed in short range. Only the minimum energy is needed to make respond or return ball to the opponent player.

Nowadays many tournaments have been conduct, such as Olympic Games in Rio, Brazil. The player comes from every corner of the world. They are likely to be seemed training with various ways, but most of them practice by using very high skill trainer. As we all know to hire such an incredible trainer you need spend a lot of money.

Some of them were trained using the technologies, with using the ping pong trainer robot. And for your information Our group has come out with an innovative idea to make the automatic table tennis trainer with player detection. We also decide to provide the trainer with 3 modes which is suitable with wide various level of player from beginner to professional.

LITERATURE SURVEY

Fig. 1 Robo-Pong 2040

Robo-Pong is the existing product in the market. This product features analog controls for ball speed. The user can choose their desired ball spin between spin, topspin, backspin and sidespin. Moreover, it has the shot selection such as push, chop, serve and lob. It is very suitable for the indoor recreation and can be also use as training purpose. Robo-Pong comes with built-in net as well, so that it is easier for collecting balls back to the launcher. [3]

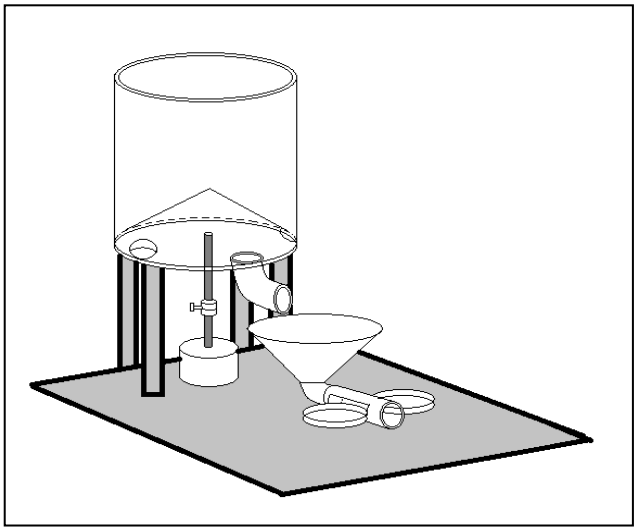

Fig. 2 Automatic Table Tennis Trainer with Player Position Detection

This project which we named Automatic Table Tennis Trainer with Player Position Detection provides the player position detection feature. We want to introduce the concept of detection so that this industry can evolve to the new level. With this feature we can glad people from various level to play the ping pong.

This project comes with ball tank and launcher. The launcher is critical part where it can provide spin, type of shot and also the speed of the ball.

DESIGN OBJECTIVE

This project was designed to be able to assist players to train on their own without the need of a trainer, as well as providing three modes suitable for the players' desired level of play. The ball launcher will react accordingly to the players' position with the use of the image processing system, very much representing a behavior of a trainer or an opponent for the player. So the purpose of this project is:

- to a create a system that can automatically launch table tennis balls, and
- to create a launcher that will move according to player position with the assistance of an image processing system provided by a Pixy Camera.

THEORY

The project design requires us to create a fully automatic table tennis trainer, complete with a ball feeding tank, a camera for image processing system, and the ball launcher.

Several calculations to determine theoretically our shooting rate speed, the force exerted by the two high-speed DC motors, the force and speed of the table tennis ball, what speed for the 3 modes.

A. Shooting Rate Speed

Use this formula to calculate the shooting rate per minute. [2]

$$\text{System Speed} = \frac{60}{\text{Total Time for one ball to shoot}} \qquad (1)$$

B. Force Exert by The Two High Speed DC Motor

Force can be defined as the external agency which makes the body change its state, size, position under strain. There are two types of force which is contact force and field force. Contact force involving physical contact with object, as example shooting ping pong ball and field force did not involve physical contact such as gravitational force which makes the ping pong ball bump to table.

As we are using two motor and two wheels, so we have two different forces. But we are using same method or formula to calculate the force exert to the ball.

This torque formula is applied to find the force for each motor

$$T = Fr \qquad (2)$$

C. Force & Speed of The Table Tennis Ball

$$F = ma \qquad (3)$$

Force can also define as mass time acceleration. Mass here is defining as the ping pong ball weight. The acceleration we can get it from the velocity

$$v = \frac{d}{t} \qquad (4)$$

The suitable rpm to shoot the ball is around 1000-2000 rpm. We can get the velocity from the rpm.

D. Studies on 3 Mode Speed

The 3 mode of our project will be explain in detail in the Methodology. The formula we use to find the velocity for each of the mode provide is

$$v = r \times RPM \times 0.10472 \qquad (2)$$

METHODOLOGY & PROJECT MANAGEMENT

This project uses three types of motors located in several parts for serving their specific purposes. The ball feeding tank is operated using a power window motor, while the direction of ball launcher is determined by the Pixy camera and operated by a servo motor. The ball launching process is done with the use of two high-speed DC motors located on both sides of the launcher. The programs to run this project are done in microprocessor coding using Arduino Mega 2560.

We also focused on optimizing the size and weight of our project, thus for that purpose, we used several different materials to make it compact and as light as possible. The plates were made from PVC, acrylics and thin metals, while the tank is made from plastic.

We decided to make the product into 2 parts which is the feeding part and the launcher part.

The feeding part is where we attach the Pixy camera that is used for the detection of the player, and the power window motor located below the ball tank.

The Pixy camera that we use is program to detect the colour of vest that the player wears. The Pixy camera action depends on what mode the player chooses whether beginner, intermediate or expert. The Pixy camera is well connected with the high-speed DC motors at the launcher. When the Pixy camera got the signal from the player, the signal is then sent to Arduino. The Arduino will process the information get to the launcher to make an action.

The launcher consists of two high-speed DC motors and a servo motor. The servo motor acts as the neck of the launcher which it can move about 30 degrees to the left and 30 degrees to the right. While the high-speed DC motors are used for 'shooting', it will run indefinitely unless the machine is switched off. The DC motor speed can varies from minimum to maximum speed depends on the mode selected by the user.

A. Beginner Mode

The table tennis trainer's launcher will follow the player wearing the vest. The Pixy camera will detect the colour of the vest and send the information to the Arduino to give the signal to the launcher. It is very suitable for the beginner player. Moreover, the speed of the ball is moderate.

It is recommended for the user to use this table tennis trainer indoors with white or black background (walls colour), so that the noise detection can be reduced and the detection will be more accurate.

B. Intermediate Mode

Intermediate mode help the player train to play the ball with the opposite direction as the launcher will shoot the ball inversely with the player position. It is more challenging as the player needs to play dynamically. The speed of the ball shoot out from launcher is also moderate.

C. Expert Mode

Here comes the hard mode of the table tennis launcher, where the ball is shooting to the player in random directions but still in the range of the table. This mode helps the player to train their reflexes and response to the next level. The player needs to focus more and act faster as the speed of the ball becomes faster.

RESEARCH PLANNING

Table 1 Project costing

No	Item	Price (RM)
1	Pixy CMUcam5 Sensor	426.00
2	Arduino Mega 2560	193.00
3	Servo Motor	41.00
4	Power Window Motor	172.00
5	DC Motor with Driver	490.00
6	Others (wires, pipes, screws, etc.)	2208.80
Total		3530.80

The table show the total up budget for this project. It is actually an expensive price for the user to buy because of add on of the Pixy camera and the Arduino. Moreover, our project's costing cover all the tool that we are use and I am sure if the product were produce with massive production it will greatly reduce the price for a unit of the table tennis trainer.

It is still a very good price if compare with the coaching system. The product is recommended for a professional player that only needs the partner to train and polish his/her skills because the coaching system needs one person time and energy to coach the player.

Table 2 Coach rate for Star Elite Table Tennis Centre Puchong

Coaching Rate
4 times package - RM125 per month with flexible group coaching sessions up to 4 sessions a month
8 times package - RM190 per month with flexible group coaching sessions up to 8 sessions a month
12 times package - RM230 per month with flexible group coaching sessions up to 12 sessions a month
Unlimited package - RM260 per month with flexible group coaching sessions with unlimited sessions a month

ıy	Morning Session	Afternoon Session	Evening Session
ınday	-	1:00pm - 3:00pm	4:00pm - 6:00pm
ɔnday	OFF DAY	-	-
ıesday	8:30am - 10:30am	5:00pm - 7:00pm	8:00pm - 10:00pm
ednesday	-	5:00pm - 7:00pm	8:00pm - 10:00pm
ıursday	8:30am - 10:30am	-	8:00pm - 10:00pm
iday	-	5:00pm - 7:00pm	8:00pm - 10:00pm
ıturday	9:30am - 11:30am	1:00pm - 3:00pm	4:00pm - 6:00pm

Fig. 3 Training schedule of Star Elite Table Tennis Centre Puchong

Table 3 Price comparison in 3 years

Price trained by coach		Price trained by Automated ping-pong trainer	
1st Year	RM260 x 12 = RM3120	1st Year	RM 3530
2nd Year	RM260 x 24 = RM6240	2nd Year	RM 3530 + RM 200 ~ 500 = RM 3730 ~ RM 4030 (maintenance fees)
3rd Year	RM260 x 36 = RM9360	3rd Year	RM 3530 + RM 400 ~ 1000 = RM 3930 ~ RM 4530 (maintenance fees)

When we come to price, there is quite a range between coach and robot. Table 3 shows the price/fees of the coach in 3 years is RM 9360, yet Automated Ping-Pong Trainer is only RM 3930 ~ 4530 (depends on the components/services maintenance). In this case, player can save up to RM 5430 in 3 years. In addition, Figure 3 shown the schedule of table tennis centre in Puchong, that's mean coaches are not flexible to provide 24 hours/day service to player. For example, player who wants to train on Monday is still a problem, but with Automated Ping-Pong Trainer, player can setup easily at anytime and anywhere.

ETHICAL CONSIDERATIONS

The ehtical issues that are related to our project is the assembly and mounting parts. It is very essential to give full concentration during the mounting of the Pixy camera, where if the camera position is misaligned, it will decrease the accuracy of the detection. Another important aspect is where the high-speed DC motors are being mounted. The motors must be mounted side by side equally to ensure that the balls passed straight and smoothly through the wheels.

Another possible ethical issue is the exposed wiring of the machine. Users must read the manual and take extra cautions while operating the table tennis trainer. While the Arduino is operated by low voltage supply, but it is very sensitive and easily malfunctioned if not handled with care.

RESULTS AND CONCLUSION

Y. Ball shooting rate

Based on our calculation, the expected result for ball shooting rate is maximum of 20 to 30 balls per minute. A ball is launched every 2 to 3 seconds.

Z. Player detection

The player detection system is working as intended. The player wearing the vest is succesfully detected by the camera and the position is precise.

The detection system is determined by the range between the player and the camera, in addition to colour of the background and also the lighting. If the player is closer to the camera, it is easier for him/her to be detected rather than if he/she is further. Next, if the background is almost the same tone with the colour to be detected (vest), it is harder for the camera to distinguish between them. When two objects with similar colour is present, the camera will detect the more dominant one, in other terms, the object with larger area of colour. Thus, it is advised for the player wearing the vest to be alone in front of the camera, and the background is either white or dark colour. The lighting also affect the effectiveness of the camera. So to say, the camera is more sensitive if used indoors instead of outdoors. [4]

AA. Recommendation

For future, this project can still be improved in several aspects. First, the player detection system can be improved by using a more advanced camera where the camera will no longer detect colour, but the player himself. Next, the project can be improved by adding the selection for shots desired, such as serve, smash, or lob. Another improvement includes the available selection for ball shooting speed, where the player can freely choose how fast the ball will be launched.

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