Investigating Usability in Enhancing User Comfort and Productivity through the Design and Development of Arduino Motorized Computer Monitor Arms.

MUHAMMAD NASRUL AIMAN BIN MOHD ZULKARNAIN
B092010221

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY WITH HONOURS

2024

Faculty of Mechanical Technology and Engineering

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology with Honours

Faculty of Mechanical Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

DECLARATION

I declare that this choose an item entitled " Investigating Usability in Enhancing User Comfort and Productivity through the Design and Development of Arduino Motorized Computer Monitor Arms." is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Muhammad Nasrul Aiman Bin Mohd Zulkarnain

Date : 1/2/2024

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering with Honours.

Signature : TS. MOHD FAEZ BIN ZAINOL
Jurutera Pengajar
Fakulti Teknologi Dan Kejuruteraan Mekanikal
Universiti Teknikal Malaysia Melaka (UTeM)

Supervisor Name : Mohd Faez Bin Zainol

Date : 7/2/2024

DEDICATION

I also dedicated this thesis to my respected supervisor, Mr Mohd Faez Bin Zainol, who unwaveringly supported me and played a main role assisting me in completing this project. As a mentor, he has not complained about any of my ideas, instead he generously gave the best opinion and extensive knowledge in every aspect. He is committed in providing guidance and assistance either through in-person meetings or online communication. This shows his dedication to my personal and professional development. I am immersed and grateful for his limitless support and knowledgeable inspiration, as his guidance is very valuable to me throughout this journey.

ABSTRACT

This project aims to improvise the existing product by develop a motorized monitor arm using Arduino as the part of the control system. The objective of this project is to fabricate an ergonomic motorized monitor arm for future development to become a part of upcoming project endeavors in monitor arm industries. Second, to enhance the functionality of manual (conventional) monitor arm operation, it is proposed to integrate a controller (Arduino) for automating various operations. Lastly, to analyze the product design criteria and selection by using SolidSim. As for the methodology used in this project consists of 4 phases which the phase 1 is defining phase to initiate research of existing monitor mount to generate or develop an improvement product. Phase 2 is planning phase which , the project's technical design, task list, resources plan, budget, and project timeline were assigned and prepared. Phase 3 is executing phase where the product with a new features improvement was fabricated. Utilizing Solidwork to execute strength analysis of the product. Phase 4 is the closure phase which the finding needed to be finalized in terms of actual expenditures in all areas such as material used, prototype analysis, and machine used. Gantt charts, budgeting and other related has been stated in the budgeting phase. As for the result, the conclusion and results documentation were defined and justified.

ABSTRAK

Projek ini bertujuan untuk menambah baik produk sedia ada dengan menciptakan *monitor arm* bermotor menggunakan Arduino sebagai sebahagian daripada sistem kawalan. Objektif projek ini adalah untuk mencipta *monitor arm* bermotor yang ergonomik untuk pembangunan masa depan untuk menjadi sebahagian daripada usaha projek yang akan datang dalam industri *monitor arm*. Kedua, untuk meningkatkan fungsi operasi *monitor arm* manual (konvensional), dicadangkan untuk menyepadukan pengawal (Arduino) untuk mengautomasikan pelbagai operasi. Akhir sekali, menganalisis kriteria dan pemilihan reka bentuk produk dengan menggunakan SolidSim. Bagi metodologi yang digunakan dalam projek ini terdiri daripada 4 fasa yang mana fasa 1 fasa penentuan, untuk memulakan penyelidikan pemasangan monitor sedia ada untuk menjana atau membangunkan produk penambahbaikan. Fasa 2 ialah fasa perancangan yang mana reka bentuk teknikal projek, senarai tugas, rancangan sumber, belanjawan dan garis masa projek telah ditetapkan dan disediakan. Fasa 3 ialah fasa pelaksanaan di mana produk dengan penambahbaikan ciri baharu dibuat. Menggunakan Solidwork untuk melaksanakan analisis kekuatan produk. Fasa 4 ialah fasa penutupan yang mana penemuan itu perlu dimuktamadkan dari segi perbelanjaan sebenar dalam semua bidang seperti bahan yang digunakan, analisis prototaip, dan mesin yang digunakan. Carta Gantt, belanjawan dan lain-lain yang berkaitan telah dinyatakan dalam fasa belanjawan. Bagi keputusan, kesimpulan dan dokumentasi keputusan telah ditakrifkan dan dibenarkan.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Ts. Mohd Faez Bin Zainol, Universiti Teknikal Malaysia Melaka (UTeM) who constantly supported my journey. Thank you for guiding me through all this research and sharing opinion upon completing this research.

Last but not least, from the bottom of my heart a gratitude to my beloved mother, Mrs Robiah Binti Abdul Samad, for her encouragement and who has been the pillar of strength in all my endeavors and inspiration to embark on my study. Her support and encouragement have been my constant source of inspiration and motivation, driving me on in the pursuit of my educational goals.

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CHAPTER 1

INTRODUCTION

1.1 Background

Flat-screen technology for display screen monitors is quickly advancing (Baertsch et al., 2023). Popular flat-screen devices include LCD, plasma screens and mobile displays. These flat displays may be put on a pedestal and conventionally fixed on a horizontal surface. Currently, mounting display screens on a wall is also very common. Ensuring that the flat screen remains level when mounting it on a wall might be challenging. Furthermore, a connection or cords attached to the flat-screen monitor's back can cause the spot to look disorganized. In addition, rotating support arms have the capability to get "sticky" and hinder the attached monitor's ability to rotate freely. Finally, the installation procedure itself might be challenging or irritating. An installer might never know if the mount is truly assembled correctly. An insecure mounting connection might occur if the parts are incorrectly installed.

The goal of the current innovation is to create a wall mount that addresses these and other limitations. There are three types of monitor mount installations, the first type is wall-mounted where the mount was attached to the wall. Next, clamping is one of the types of mount installation where the clamp hardware clamped or fastens to the edge of a desk.

Lastly, the third type of mount installation is called grommet. A grommet is a mount where the clamp was inserted through a hole in the desk and fastened underneath.

1.2 Problem Statement

Monitor mounts were invented in three types of mounting, each with its own set of challenges. The first type, wall mounting, involves installing the mount onto the wall, which can be messy as it requires drilling holes into the wall. The second type, grommet mounting, involves inserting the clamp through a hole in the desk. However, if the desk does not have a pre-existing hole, creating one can cause dust to fly everywhere. Lastly, clamping is considered the best option among all mounts due to its ergonomic design that takes up minimal desk space and allows the monitor to float freely around the desk. Unfortunately, this clamping mount can be quite heavy when supporting monitors in the range of 4kg to 10kg, and it can potentially cause the table to break due to the heavy load applied.

1.3 Research Objective

The main aim of this research is to fabricate an ergonomic motorized monitor arm for future development. Specifically, the objectives are as follows:

a) To fabricate an ergonomic motorized monitor arm for future development to become a part of upcoming project endeavors in monitor arm industries.

b) To enhance the functionality of manual (conventional) monitor arm operation, it is proposed to intergrate a controller (Arduino) for automating various operations.

c) To analyze the product design criteria and selection by using SolidSim.

1.4 Scope of Research

The scope of this research are as follows:

- Ergonomics: This research are focusing on the motorized monitor arm that could effect the user comfort, productivity, and health.
- Automation: As for the futuristic concept, an electric motor used to automate task such as adjusting display position in x (180 degrees), y (180 degrees) and z (180 degrees) axis based on user preferences.
- Manufacturing: Optimising the design and manufacture of motorised monitor arms, including the choice of materials (aluminum) and assembly procedures, could be the main goal of this research.
- Applications: Finally, researchers could investigate the potential applications of motorized monitor arms in various settings, such as offices, homes, and medical facilities.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter elaborates about the details and specifications used in the Motorized Monitor Arm using Arduino. In this chapter, this research will delve into the specific details and specifications of the Motorized Monitor Arm that is controlled using an Arduino microcontroller. This research will explore the various components, functionalities, and technical aspects of the system. The aim is to provide a comprehensive understanding of how the monitor arm operates and the technologies involved.

According to Rob Mossman & Andy Davis, monitor mount or monitor arm is a necessary invention where it has several benefits. Firstly, by enabling users to change the height, tilt, and location of their monitors, monitor mounts encourage ergonomic alignment. Users can prevent potential long-term health problems like neck pain and eye strain by setting the monitor up at eye level and adjusting it to a comfortable viewing angle. Monitor mounts allow for accurate monitor positioning, which enhances the viewing experience. Users no longer need to strain or constantly modify their posture because they may position the monitor at an appropriate eye level. This guarantees a cozy and engaging viewing experience, particularly while using a computer for a prolonged amount of time.

Nowadays, there are various designs of monitor mount such as fixed mounts, adjustable arms, wall mounts and desktop clamps. They can work with a wide range of monitor weights and sizes, supporting LCD, LED, and curved monitors, among other display technologies. Overall, the evolution of monitor mounts demonstrates the growing importance of ergonomics, productivity, and the demand for customized display setups in a variety of work and home environments.

2.1 Current Finding or Existing Product

Traditional monitor arms often have adjustable joints and hinges that let users customize the height, angle, and orientation of their monitors. For smooth and steady adjustments, these arms frequently have mechanical or gas spring mechanisms. Users must manually adjust them because they are manually operated.

Motorized monitor arms controlled by Arduino microcontrollers have been a popular DIY project for enthusiasts and makers. Arduino boards are commonly used due to their ease of programming and compatibility with various sensors and actuators. By utilizing stepper motors or servo motors, the monitor arm can be automated to move up, down, left, right, and tilt, providing adjustable positioning for the monitor.

Depending on projects and breakthroughs made within the maker community, the specific findings or improvements in motorized monitor arms with Arduino may vary. However, these systems frequently have the following characteristics and abilities:

- Remote control: Arduino-based motorized monitor arms can often be controlled remotely using additional components like Bluetooth modules or RF transmitters/receivers. This allows for wireless control of the arm's movements.

- Sensor integration: Sensors can be incorporated into the system to provide feedback and enable advanced features. For example, position sensors can be used to determine the arm's current position, allowing for precise control and automation.

- Programmability: Arduino boards provide a wide range of programming possibilities. Users can customize the movement patterns, create pre-sets, or implement automation based on specific conditions or inputs from other devices.

- Integration with other systems: Arduino's versatility allows for integration with other systems and technologies. For example, the motorized arm can be connected to a smart device or synchronized with home automation system.

These are just a few of the possibilities that Arduino-based motorized monitor arms offer. With its flexibility and programmability, Arduino is a powerful platform for creating custom solutions that meet the specific needs of users.

Here are some additional benefits of using Arduino for motorized monitor arms:

- Cost-effectiveness: Arduino boards are relatively inexpensive, making them a cost-effective option for building motorized monitor arms.

- Ease of use: Arduino boards are easy to use, even for beginners. There are several resources available online that can help users get started with Arduino.

- Open-source: Arduino is an open-source platform, which means that there is a large community of users who can share ideas and help each other troubleshoot problems.

2.2 Finding Outcome

Different types of monitor arm have their own pros and cons. The functionality of the specific monitor arm is referred to as ergonomic. The ergonomic is affected by some general considerations for such comparison as adjustability of motorized monitor arms offer motorized adjustments for height, tilt, and sometimes rotation, allowing for precise positioning of the monitor. This can provide greater flexibility and convenience compared to manual adjustment in traditional monitor arms.

In terms of ergonomics, both manual and motorized monitor arms aim to improve ergonomics by enabling users to adjust their monitor's height and tilt. However, motorized arms may provide a more effortless and precise adjustment experience, reducing strain and promoting better posture.

While motorized arms with an Arduino might require additional setup and programming, manual monitor arms tend to be simple to install and use. For those with expertise in technology or those seeking an innovative approach, Arduino-based solutions might be a better choice. Due to the additional motorized parts and technology required, motorized monitor arms are typically more expensive than manual monitor arms. Considering the cost of the Arduino board and any other components needed for customization, Arduino-based builds might raise the overall cost.

Motorized monitor arms may emit some noise when in usage, which might be an issue in peaceful surroundings. Furthermore, compared to manual monitor arms, motorized arms require a power supply for operation, which might have an impact on power usage. So, in conclusion, both system manual and motorized system have their benefits and flaws.

2.3 Technology in Motorized Monitor Arm with Arduino

In the motorized monitor arm setup described that the following technologies involved mechanical components which include the physical arm structure, joints, linkages, and motors that enable the movement of the monitor in various directions. The Arduino board serves as the central control unit, receiving input and sending commands to control the motor movements. Motor Drivers components interface between the Arduino and the motors, translating the control signals from the Arduino into appropriate electrical signals to drive the motors. The choice of motor drivers depends on the type of motors used (e.g., stepper motors or servo motors). A power source is required to drive the motors and power the Arduino board. The power supply can be a battery or a dedicated power adapter, depending on the power requirements of the motors and the Arduino.

2.3.1 180 Degree Servo Motor

A 180-degree servo motor as shown in figure 2.1 is a type of servo motor that can rotate or position itself within a 180-degree range. Unlike standard servo motors that typically have a 0 to 180-degree range, a 180-degree servo motor can move in a wider angular range, providing more flexibility in certain applications.

Servo motors are devices that incorporate a feedback mechanism to control the position or speed of a motor. They are commonly used in robotics, automation, and other applications where precise control of movement is required. In this project, servo motor was used to create an angular movement which is in y and x axis (180 degrees) that could allow the monitor arm to move to the user’s comfort level. This monitor arm used 4 servo motors that could create 4 degrees of freedom. The last axis is located near the base of the robot, and it provides the movement and the stability needed for the entire robotic arm to function correctly.

Generally speaking, the angular range that a "180-degree servo motor" may cover is indicated by its designation. The servo motor responds to a control signal and modifies its position within a predetermined range. Typically, the control signal is a pulse-width modulation (PWM) signal, which the servo motor uses to measure the intended position by interpreting the pulse's width.

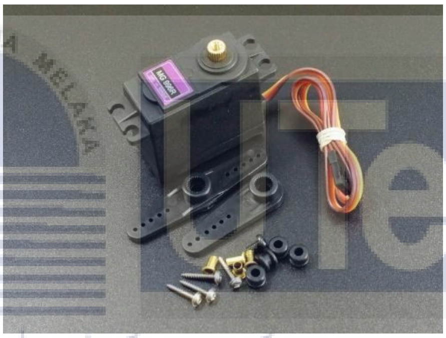


Figure 2.1: 180 Degree Servo Motor

2.3.2 Arduino Uno

Arduino Uno as shown in Figure 2.2, is an electrical component used to control the movement of the monitor arm. In the research conducted by Yusuf (2014), popular microcontroller boards like the Arduino Uno are used often in the electronics and prototyping industries. It relates to the Arduino board family and is well-known for its simplicity and adaptability. The ATmega328P microcontroller, on which the Arduino Uno is used in the Motorized Monitor Arm, has a set of digital and analogue input/output pins that can be used to connect and control the DC Motor.

The reason for using the Arduino Uno in the Motorized Monitor Arm is because of the simplicity of usage of its programming settings. Even beginners can use it because of its simple programming environment and user-friendly interface. The board's ability to be powered by an external power source via a USB connection offers versatility for the speed of DC motor settings. The Arduino Uno is a versatile board that features 14 digital input/output pins, 6 analogue inputs, and a few communication interfaces including UART, I2C, and SPI.

The Arduino programming language, which is based on a simplified form of C++, is used to program the Arduino Uno. A user-friendly interface is offered by the Arduino IDE (Integrated Development Environment) for authoring, compiling, and uploading code to the board. It is simpler for users to realize their ideas thanks to the abundance of tools, libraries, and example programs made accessible by the large Arduino community.

The Arduino Uno has fundamentally simplified the modification or improvement of the manual monitor arm to a highly innovative motorized monitor arm. It has enabled professionals, students, and amateurs to use their imagination to develop a variety of interactive projects, making it a mainstay in the maker community.

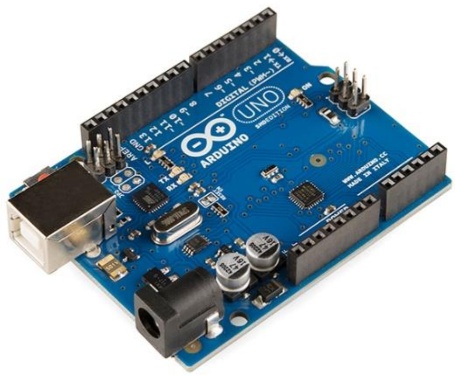


Figure 2.2: Arduino Uno

2.3.3 Bearing

A bearing is a mechanical component that makes it possible for machine parts to move smoothly and under control. It sustains weights and reduces friction between moving elements so that they can rotate or move in a certain direction. In many different uses, such as industrial equipment, automobiles, and machinery, bearings are essential.

There is one type of bearing used in Motorized Monitor Arm which is mini flanged bearing that were installed at the end of the aluminum plate. The function of the flanged bearing in the Motorized Monitor Arm is to enable smoother movement of the arm and reduce friction that could lead to tear and wear.

The flange provides a stable surface for the bearing to be mounted securely within the structure of the monitor arm. It often has holes or other features that allow the bearing to be bolted or otherwise attached firmly to the arm's frame. The flange helps in aligning and positioning the bearing within the structure of the monitor arm. This is crucial for ensuring smooth and precise movement of the arm, as misalignment can lead to increased friction, wear, and reduced performance. Bearings in a motorized monitor arm support the weight of the monitor and distribute loads evenly. The flange aids in this load distribution by providing a wider surface area, enhancing stability, and preventing the bearing from shifting under load.

In general, flanged bearings are essential parts of Motorized Monitor Arm because flanged bearings in the design contribute to the overall robustness, stability, and smooth movement of the arm. The flange plays a key role in ensuring that the bearings are securely attached, aligned correctly, and able to handle the loads and movements associated with adjusting the monitor's position.

Figure 2.3: Gear

2.4 Arduino IDE

The software program known as the Arduino IDE (Integrated Development Environment) enables to write, compile, and upload code to Arduino microcontroller boards. For creating and programming Arduino projects, it offers a user-friendly interface.

An open-source electronics platform called Arduino is made up of both hardware and software elements. The software includes the Arduino IDE, which is used to write and upload code to the numerous programmable microcontroller boards that make up the hardware. The Arduino IDE supports the Arduino programming language, a condensed version of C++ with extra libraries and features created especially for use with Arduino devices. It offers a selection of features and tools that make the development process easier, including a code editor, syntax highlighting, code suggestions, and a serial monitor for communication and debugging with the Arduino board.

Overall, the Arduino IDE was used in this Motorized Monitor Arm project for controlling the movement and rotation of the DC Motor that enables rotation of the monitor arm. Figure 2.4 shows the example steps of configuring the Arduino IDE.

Figure 2.4: Example of Arduino coding

2.5 Project Design

The process of planning and developing a project's structure is referred to as project design. It entails establishing the project's goals, specifying the actions needed to reach those goals, and estimating the time and resources required to execute the project successfully. Setting specific objectives, specifying project requirements, and offering a plan for project implementation all depend on project design. It ensures every individual involved in the project has a common knowledge of the goals and the steps needed to attain them. Effective project design enables improved control and management throughout the project lifetime and serves as the fundamental basis for effective project execution.

2.5.1 House of Quality

The Quality Function Deployment (QFD) matrix, commonly known as the House of Quality or the QFD House, is a visual tool used in product or service development to translate customer needs into particular design characteristics. Throughout the design and development process, it aids in making sure that client demands and expectations are met. The House of Quality (Hauser, n.d.) offers a structured method for aligning consumer needs with particular design elements and engineering options. It fosters effective communication between various teams, aligns the product or service development process with customer needs, and directs decision-making throughout the design phase. By utilizing the House of Quality can improve customer happiness, focus design efforts, and provide goods and services that more closely fit consumer expectations. Figure 2.5 shows the elements of House of Quality.

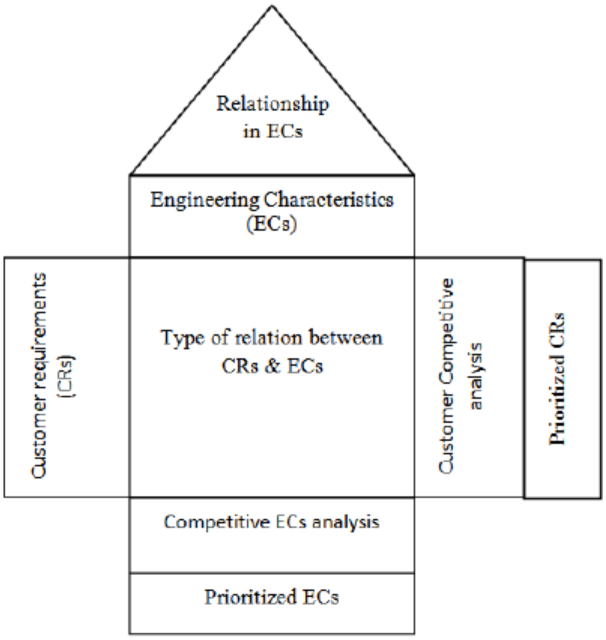


Figure 2.5: Elements of House of Quality (HOQ)

2.5.2 Design Selection

The process of selecting the best design concept or solution from a range of choices is referred to as design selection. It entails evaluating and comparing numerous design solutions based on a range of factors, including cost, practicality, viability, aesthetics, and user requirements. Design selection, which decides on which concept will be developed and implemented further, is an important step in the design process (Hall and Nauda, 1990, Martino, 1995, Wang et al., 2009). According to this research, the design selection was evaluated by using the Pugh Method that is shown in Figure 2.6.

Criteria	Alternative 1	Alternative 2	Alternative 3	Baseline	Weight
Safe	-1	-1	0	0	1
Durable	+2	0	-2	0	2
Weight	-1	-1	+1	0	1
Easy to assemble	+2	0	-2	0	2
Reliable	-1	-1	-1	0	1
Cost	+3	0	+3	0	3
NET SCORE	+4	-3	-1		
RANK	1	3	2		
CONTINUE?	Yes	No	No		

Figure 2.6: Example of Pugh Method

2.5.3 SolidWorks Software

The term "assembly design" describes the procedure used to develop and arrange the various parts of a system or product into an integrated and useful whole. It includes figuring out how the parts go together, the order in which assembly tasks should be performed, and making sure the finished assembly matches the required requirements and functioning (Huang et al., 2022). By minimizing assembly time, eliminating assembly errors, and increasing the overall quality and reliability of the finished product, effective assembly design seeks to optimize the assembly process. To ensure that the product can be constructed successfully and efficiently within the required manufacturing environment, it takes into account issues including ease of assembly, manufacturability, and maintenance requirements.

In order to develop virtual models of the components and simulate the assembly process, computer-aided design (CAD) software is frequently used in assembly design. Before physical production or manufacturing, this enables engineers to inspect the assembly, identify any potential interferences or problems, and make the necessary adjustments.

As for this product's assembly design, SolidWorks Software was used to develop virtual models and simulate the assembly process. Figure 2.7 shows the sample of SolidWorks Software.

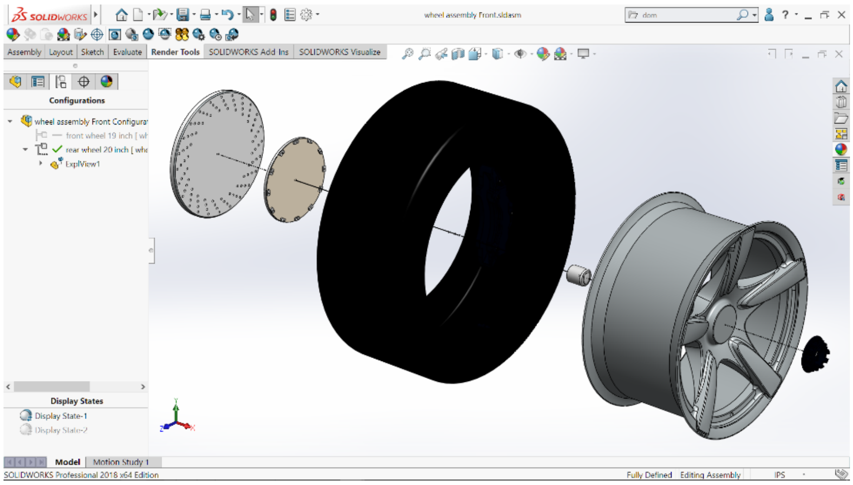


Figure 2.7: Sample of assembly process in SolidWorks Software.

2.6 Risk Analysis

Risk analysis is a methodical procedure for discovering, evaluating, and assessing potential risks or uncertainties related to a certain activity, project, or decision. It entails assessing the possibility and potential consequences of various risks and selecting the best management or mitigation solutions. The main objective of risk analysis is to get a thorough understanding of potential hazards in order to make wise decisions and implement the necessary measures to reduce or control those risks.

Table 2.1 shows the Bowtie Analysis of the risk analysis. There are 2 risk events that might occur. The first risk event is the occurrence of injuries during the fabrication process. This is because the student did not comply with the safety precautions in the laboratory. Next risk event is malfunction of the product. The cause of the event is because electrical components such as DC motor and Arduino are not functioning.

However, the preventive control and containment control are included in Table 2.1. To prevent the occurrence of injuries during the fabrication process, students should be familiar with the rules and regulations in the laboratory. By wearing proper PPE attire can avoid any injuries. Next, to overcome the malfunction of the product, students need to double check the electrical components such as Arduino and DC motor. By using a guaranteed well function component can avoid the risk of malfunctioning of the product.

Table 2.1: Bowtie Analysis

Causes	Preventive control	Risk event	Containment control	Impacts
Student did not comply with safety precaution in the laboratory.	Student should be familiar with the rules and regulations in laboratory.	Occurrence of injuries during fabrication.	Wearing proper PPE attire to avoid any injuries.	Overextended time of product completion.
Electrical component such as DC motor and Arduino not functioning.	Double check the electrical component.	Malfunction of the product.	Use a guaranteed well function component.	Fail to run the product.

2.7 Risk Assessment

The systematic process of determining, evaluation, and prioritizing any risks or hazards that might exist in any circumstance or context is known as risk assessment. It entails assessing the chance of a negative occurrence occurring as well as any potential effects it might have on people, organizations, or the environment. Risk assessment is primarily used to proactively manage risks and reduce their impact by spotting them before they emerge or become more serious issues. It is frequently used in a number of different industries, including business, finance, project management, healthcare, engineering, and safety.

Table 2.2: Risk Assessment

	Insignificant 1	Minor 2	Significant 3	Major 4	Severe 5
5 Almost certain	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
4 Likely	Medium 4	Medium 8	High 12	Very high 16	Extreme 20
3 Moderate	Low 3	Medium 6	Medium 9	High 12	Very high 15
2 Unlikely	Very low 2	Low 4	Medium 6	Medium 8	High 10
1 Rare	Very low 1	Very low 2	Low 3	Medium 4	Medium 5

2.8 Summary or Research Gap

Due to its versatility and enhanced ergonomics in computer workstations, motorized monitor arms have been rising in popularity in recent years. The open-source electronics platform Arduino provides a simple and adaptable method for managing motorized monitor arms. With an emphasis on their design, functioning, and prospective applications, this literature review intends to investigate the present research and advances in relation to motorized monitor arms with Arduino.

The design of motorized monitor arms has been the subject of several research. These take into consideration variables including the arm's structure, materials, actuation systems, and general resilience. To accomplish smooth and precise movements, researchers have investigated a variety of design configurations, including single-axis and multi-axis motorized arms. Due to its adaptability, cost, and simplicity of component integration, Arduino has become a commonly used control system.

Arduino enables the intelligent control and automation of motorized monitor arms in conjunction with the right sensors and feedback mechanisms. The use of PID (Proportional-Integral-Derivative) control algorithms to achieve precise positioning and stability has been described in the literature. The integration of additional functions like obstacle detection, collision avoidance, and user-friendly interfaces for intuitive operation is another area of research.

In the design of motorized monitor arms, ergonomics is crucial. Numerous arm configurations have been studied in relation to user comfort, posture, and productivity. Utilizing Arduino makes it possible to incorporate user-friendly features like automatic height adjustment, tilt, and swivel capabilities, fostering customized ergonomics and lowering the risk of musculoskeletal disorders.

The literature review indicates that Arduino-controlled motorized monitor arms provide an adaptable, individualized, and economically viable way to enhance ergonomics and user experience. The studies emphasize how crucial design factors, control mechanisms, ergonomics, and prospective applications are. This synthesis of prior research provides the foundation for future investigation and advancement in this area, resulting in improved motorized monitor arm designs and broader applicability in several areas.

CHAPTER 3

METHODOLOGY

3.0 Introduction

A set of guidelines, procedures, and techniques called project methodology are used to efficiently plan, carry out, and manage projects. It offers an organized system for finishing tasks on schedule, within budget, and with the required results. In order to assure consistency, efficiency, and effective project delivery, project managers and teams can refer to project methods as a reference. It is, in essence, a project management system similar to that shown in Figure 3.1.

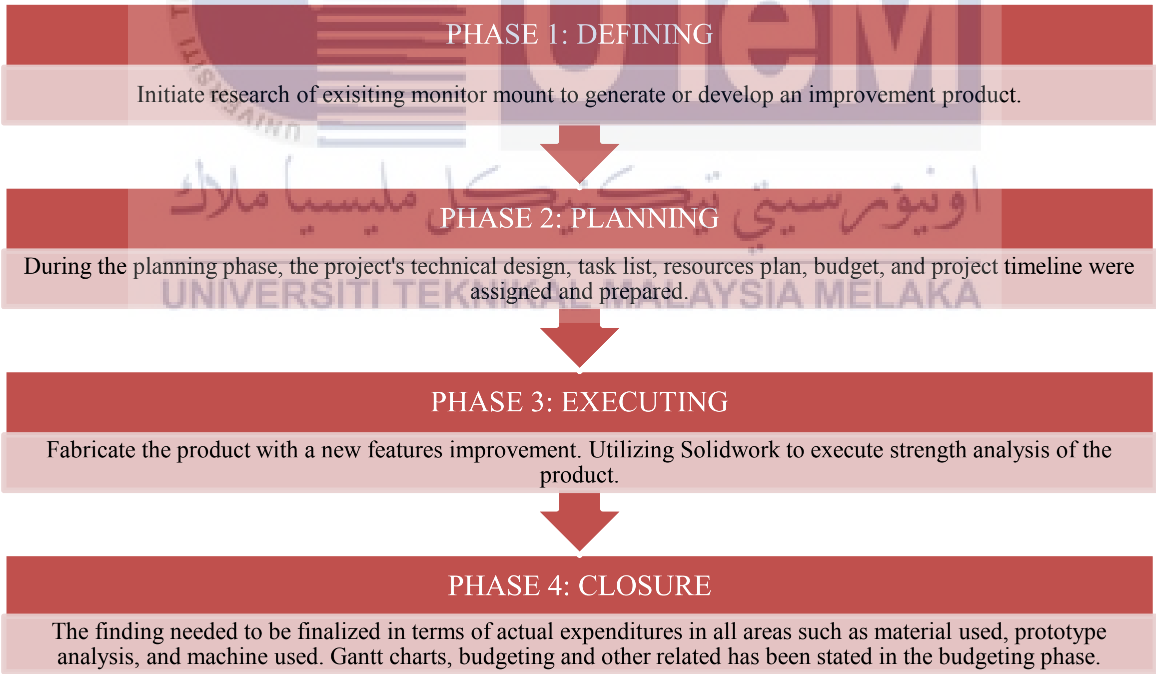


Figure 3.1: Phases of the project

3.1 Project Flow Chart

Project flow chart is a process flow of the tasks, decision, and dependencies throughout the project's lifecycle from initiation to completion. It also helps to guide the flow of the project which will be conducted according to the flow of this chart. Figure 3.2 shows the flow chart of this Ergonomic Arduino Motorized Monitor Arm.

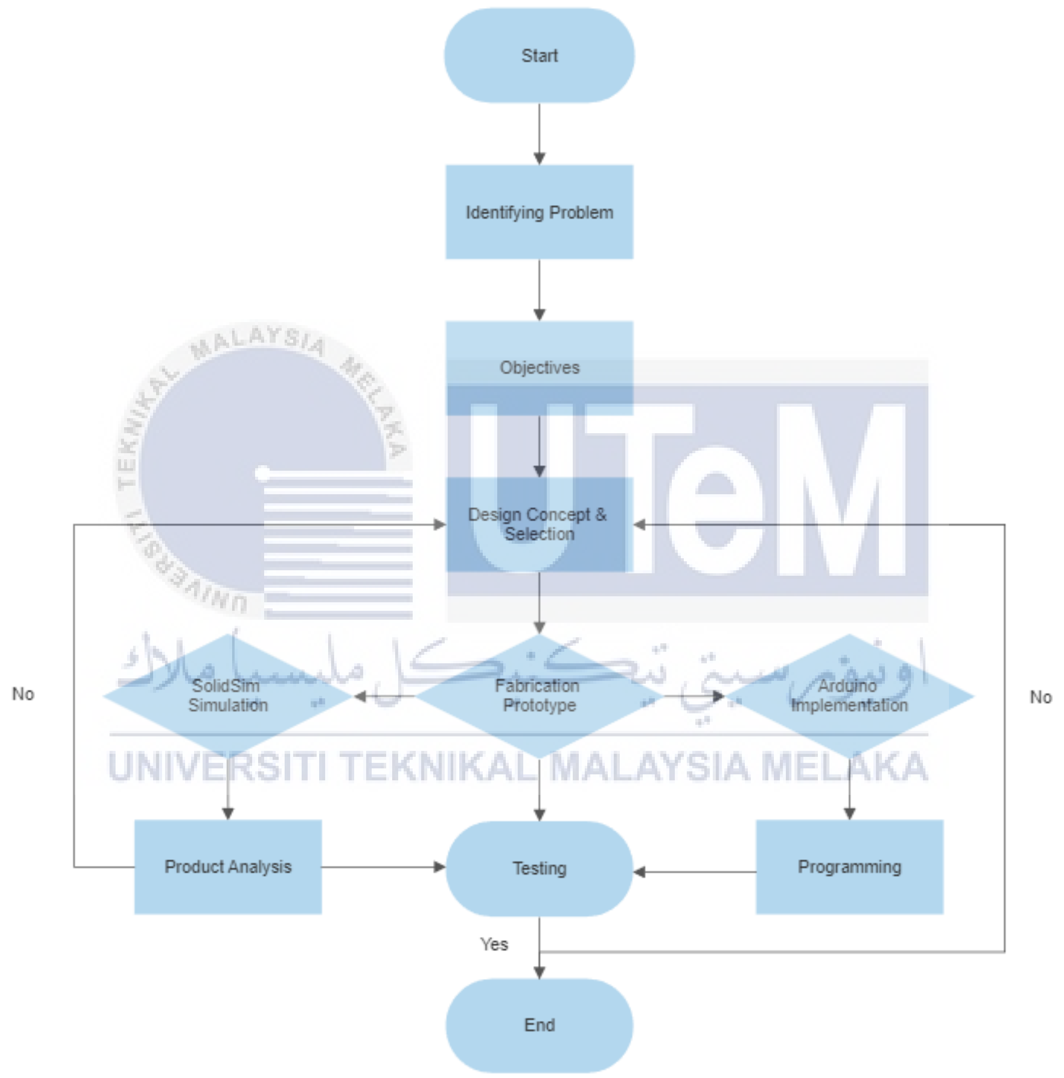


Figure 3.2: Project flow chart of the Ergonomic Arduino Motorized Monitor Arm

3.2 Project Gantt Chart

The Gantt chart in Appendix A, a quintessential project management tool, emerges as the unsung hero in the epic tale of the Design and Development of the Ergonomic Arduino Motorized Monitor Arm. With its graphical depiction of tasks, durations, and dependencies, this visual roadmap became the linchpin in orchestrating the project's journey from inception in November 2023 to its triumphant conclusion in January 2024. As the hands of time gracefully swept across the chart, it became a dynamic canvas, capturing not only the intricacies of task interdependencies but also serving as a strategic compass for project managers navigating the challenges that beset the development process.

The Gantt chart, more than a mere scheduling mechanism, transformed temporal constraints into a catalyst for innovation and efficiency. Challenges, rather than hindrances, became opportunities for strategic adaptation, each twist and turn documented with precision on the Gantt canvas. As milestones were reached and objectives achieved, the chart stood as a visual testament to the seamless alignment of planning, execution, and successful project completion.

Beyond the tangible manifestation of the Ergonomic Arduino Motorized Monitor Arm, the Gantt chart extended its influence into the academic sphere. The thesis report, a parallel endeavor running alongside the project development, mirrored the disciplined cadence set by the Gantt orchestration. The successful synchronization of deadlines not only ensured the timely completion of the report but also showcased the Gantt chart's transformative power in guiding complex projects through the intricate dance of time, tasks, and triumph.

3.3 Phase of Methodology

An organized approach or series of steps used to direct the completion of a project or process is referred to as "phase of methodology" in general. These stages often indicate separate steps that aid in making sure the ultimate objective is successfully accomplished. Here is a general illustration of a common approach for Design and Development of Ergonomic Arduino Motorized Monitor Arm. with its phases, although the precise phases can vary depending on the setting or field:

Table 3.1: Phase of Methodology for Design and Development of Ergonomic Arduino Motorized Monitor Arm

Initiation	Planning	Execution	Monitoring and Control	Closure
Identifying the purpose, goals, and scope, as well as conducting preliminary research.	Sketch product's design and identify components used.	Prototype and Arduino Uno development.	Run a test on the prototype.	Defining the conclusion and results documentation

3.4 Brainstorming Stage

The idea of Motorized Monitor Arm with Arduino was inspired by the combination of the existing monitor arm (Figure 3.5) and the industrial robot used for manufacturing as shown in Figure 3.4

Figure 3.3: Industrial Robot used for manufacturing.

Figure 3.4: Existing monitor arm.

3.5 Designing Prototype

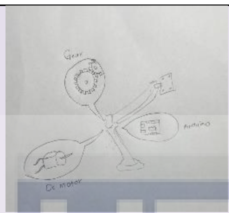
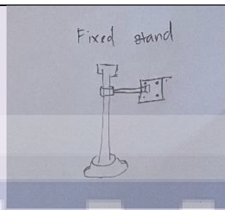
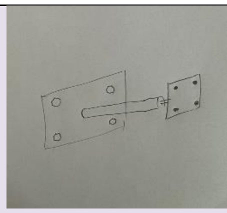
The design process of fabricating the Motorized Monitor Arm with Arduino was divided into two phases. The first phase is the Design Idea or Concept Design which in this research, the objectives, productivity and imagination needs to be considered. The second phase is Design Sketching in which the ideas of the designs are explored and translated into visual concepts. With the help of these sketches, the design team can clarify their notions and visualize alternative options. By completing the Pugh Method in Table 3.2, the final design sketch of the Motorized Monitor Arm with Arduino was shown in Figure 3.6.

Figure 3.5: Motorized Monitor Arm with Arduino's sketch.

3.5.1 Pugh Method

Selecting the best and most suitable design for the product requires careful consideration. The most suitable approach to choose the best design in accordance with the given criteria is to use the Pugh method. A scoring process will be used to evaluate the design at the meeting by the designers, who will also outline a few standards that the final product must meet. The Pugh method table is shown in Table 3.2.

Table 3.2: Pugh Method Table of the design sketching

Design Sketching			 	
-3 – (very bad) -2 – (bad) -1 – (better) 0 – (moderate)	1 – (good) 2 – (very good) 3 – (Excellence)	Adjustable Stand	Fixed Stand	Wall mount
Criteria	Weight	Design A	Design B	Design C
Easy to assemble	4	+1	+1	-2
Portability	5	+2	+1	-2
Cost	3	0	0	+1
Durability	4	+1	0	+1
Strength	5	0	0	+1
Ergonomic	4	+1	+2	0
Total Weight Score		30	29	24
Rank		1	2	3

3.5.2 3D Modelling

The finalized sketch was transferred to SolidWorks during the design phase using the computer-aided design (CAD) software. The purpose of implementing the design in the software is to make the fabrication process simpler for interpretation the specifications as it stated the dimensions information. Figure 3.7 shows the isometric view of the 3D model of the Motorized Monitor Arm with Arduino.

Figure 3.6: Isometric view of the Motorized Monitor Arm with Arduino.

3.6 Summary

This chapter presents the proposed methodology in order to develop a new improvement on existing monitor arm which is DC motors and Arduino were implemented in the product. Before the fabrication process started, problem identification was initiated. This included the objective of the project, goals, purposes as well as conducting preliminary research. Then, during the planning process, design sketches were developed for a better understanding of the product's view. Then, the sketches were implemented in the SolidWorks software for defining the dimensions and preparing for executing phase. As for the executing phase, the proposed methodology was using the cutting machine, bending machine and other related machine to fabricate the prototype according to the dimensions given in the SolidWorks design. As for the testing phase, a simulation needed to be run on SolidWorks software to identify the assembly process of the prototype before initiating the actual product. Then, an analysis test was conducted on the prototype to identify the strength of the prototype to achieve the requirement given. As for the closure phase, the conclusion and results documentation were defined and justified.

CHAPTER 4

RESULT AND DISCUSSION

4.0 CAD Modeling

In this chapter explained the process of the desired design to be executed and fabricated as a product. There are several stages involved which are started by CAD Modelling, Material Selection, Simulation Analysis, and Fabrication Method. The conceptual design of the product was defined based on Pugh Method (Table 3.2) in the SolidWorks software.

4.0.1 CAD Modeling in SolidWorks

The design model in Figure 4.1 is defined by the Pugh Method and the selected design then implemented in the SolidWorks software.

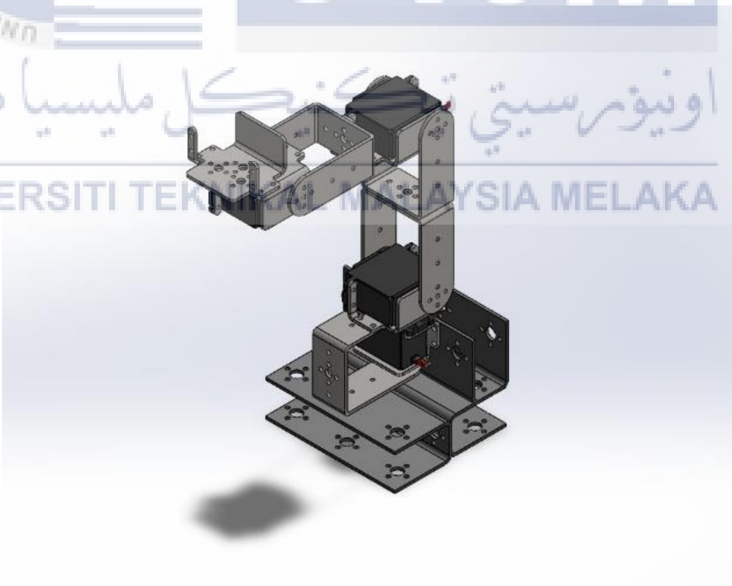


Figure 4.1: Isometric view

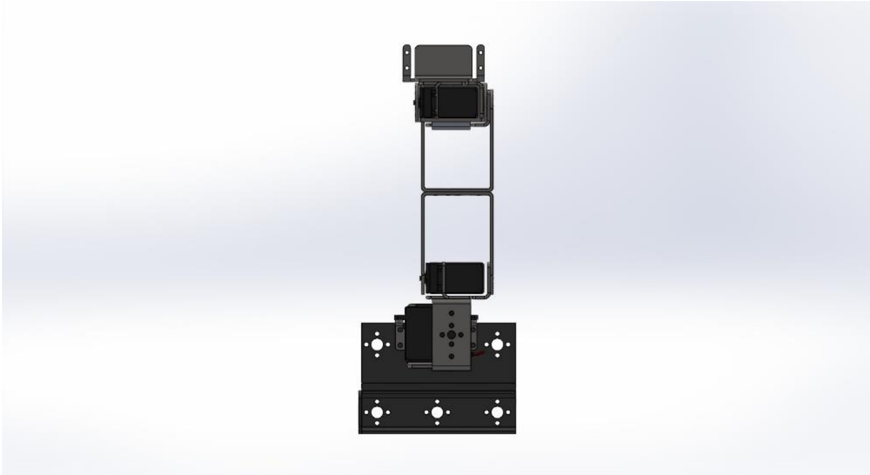


Figure 4.2: Front view

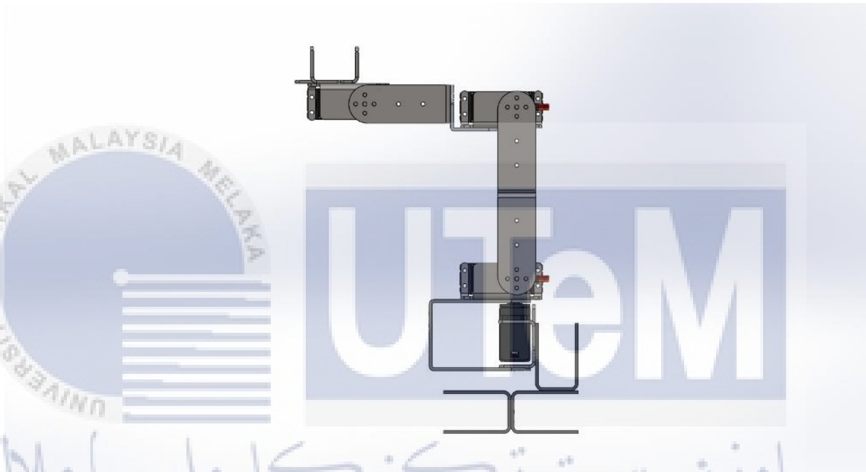


Figure 4.3: Side view

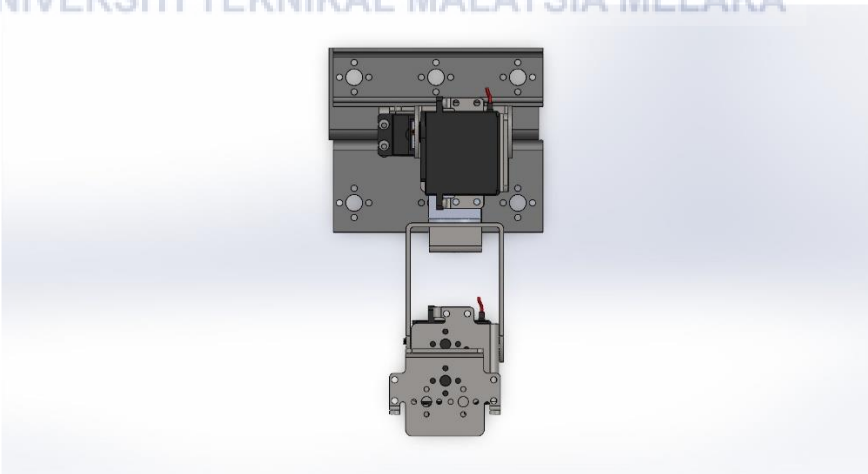
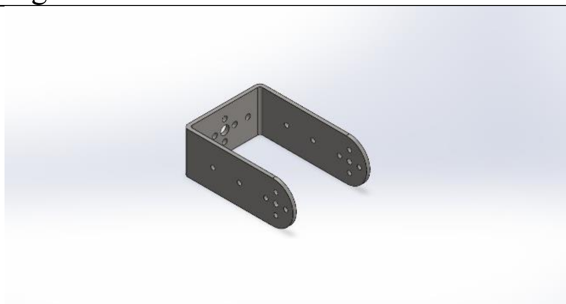
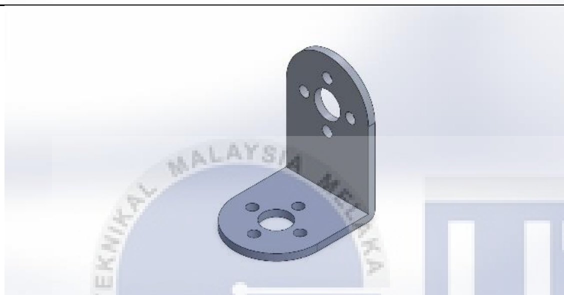
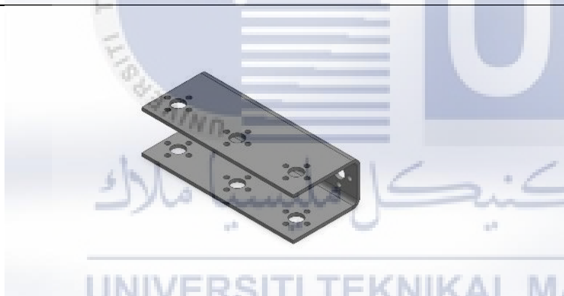
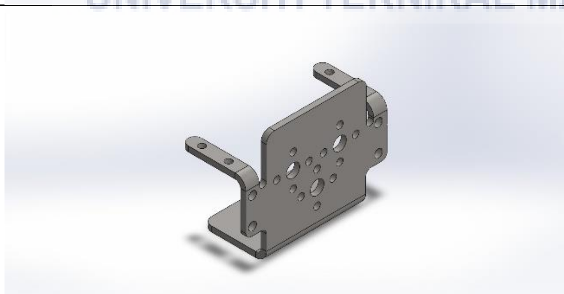
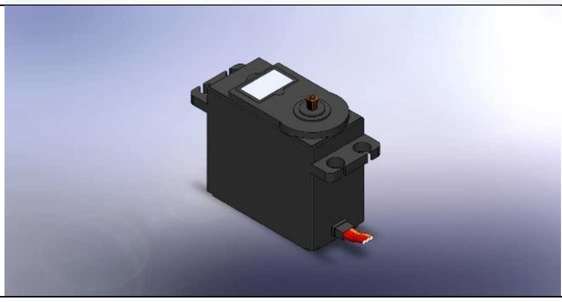


Figure 4.4: Top view

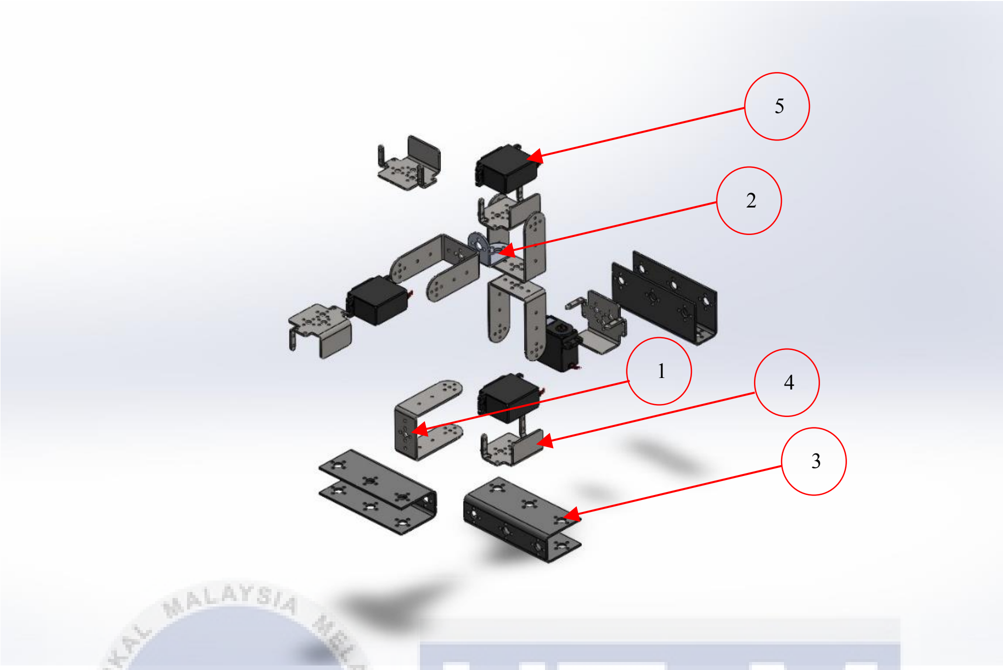
4.0.2 Detail Design

Table 4.1 shows the detail design for each part of the product from SolidWorks.

Table 4.1: Detail Design of each part of the product

No	Figure	Description
1		U-shape Bracket
2		Extension Bracket
3		L-shape Support Bracket
4		Servo Support Bracket
5		Servo Motor

4.0.3 Exploded View



No	Part	Quantity
1	U-shape Bracket	4
2	Extension Bracket	1
3	L-shape Support Bracket	3
4	Servo Support Bracket	5
5	Servo Motor	4

4.1 List of Material

As shown in Table 4.2 is a List of materials that were used as a versatile tool that plays a crucial role in the planning, execution, and management of various projects, ensuring that the right materials are obtained, used efficiently, and meet the necessary standards.

Table 4.2: List of Materials

No	Item	Product Detail	Price per unit (RM)	Quantity	Total (RM)
1	Aluminum Sheet	2mm thickness with size of 1ft x 1ft	28.00	3	84.00
2	Servo motor	Gear Type: All Metal Gears Rotation angle: 180 degrees Stall torque:12kg/cm(6V)	21.99	5	109.95
3	Arduino	Arduino Uno R3	42.90	1	42.90
4	Potentiometer	10k ohm	1.20	4	4.80
Total				241.65	

4.2 Project Fabrication

The success of the project relies heavily on the fabrication process, which is crucial for understanding product functionality and ensuring product quality. This project involves four primary processes, outlined as follows:

a. Cutting process

b. Drilling process

c. Bending process

d. Assembly process

4.2.1 Fabrication process

Table 4.3: Fabrication process

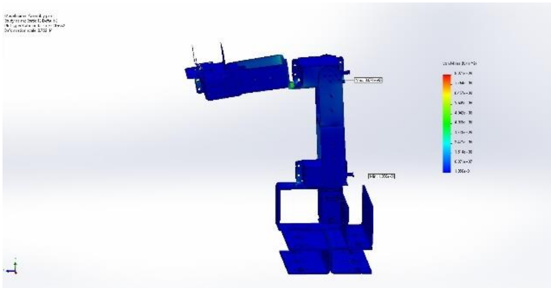
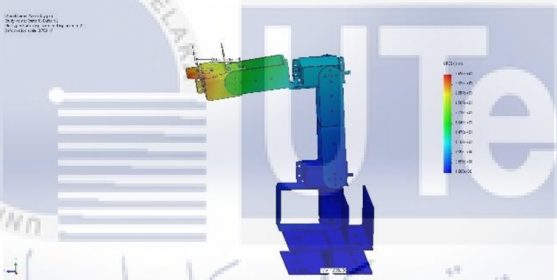
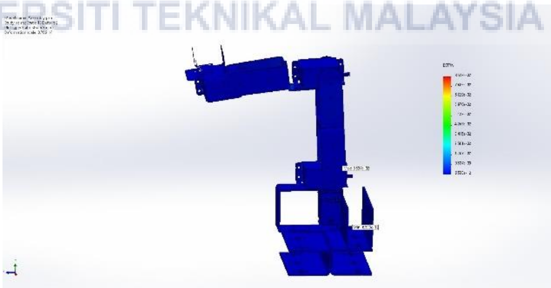
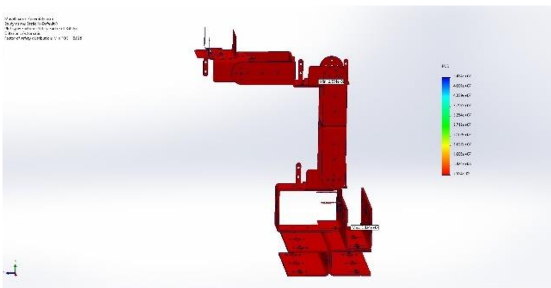
No	Activity	Description
1		• After measured the dimension of desired parameter to cut the plate, the plate was placed under the hand cutting machine and cut the unnecessary part.

2		• Then, measured the desired hole point to be drilled off. Placed the plate under the drill bit according to the point marked and drilled out the point.
3		• The plate then was placed on the hand bending machine to bend according to the desired angle.
4		• Lastly, the parts that have been fabricated will be assembled properly.

4.3 Analysis process

The analysis process involves data of stress, displacement, strain and safety of factors of the product. This simulation analysis is to justify the final product meets the objectives and desired standard. The product demonstrates its success from a technical standpoint, elucidating its inherent potential upon successful completion of rigorous quality testing. As the quality assessments conclude, the product unveils its sophisticated features and capabilities, showcasing a level of technical prowess that is bound to impress. The simulation analysis is being conducted by using SolidWorks software with the simulation features. Table 4.4 shows the type of analysis that has been performed onto the designed product.

Table 4.4: Type of Analysis

Type of Analysis	Figure	Description
Stress		Max = 8.071e+08 N/m^2 Min = 1.058e-01 N/m^2
Displacement		Max = 3.969e+01 N/m^2 Min = 1.000e-30 N/m^2
Strain		Max = 8.537e-02 Min = 6.533e-12
Safety of factors		Max = 5.424e+07 Min = 2.554e-02

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

As conclusion, the summary of the project development and the objective has been successfully achieved. The scope of the project to generate automation movement of the monitor arm using servo motor and controlled by Arduino has been successfully achieved. The monitor arm can be moved in x axis (180 degrees), y axis (180 degrees) and z axis (180 degrees). That shows the programming code is the correct code to instruct the monitor arm to move upon the desired angle by the users' preferences. In terms of simulation analysis, 100N load has been implemented and the data of the maximum stress is 8.071e + 08 N/m^2 and the maximum displacement is 3.969e + 01 N/m^2 while the maximum strain is 8.537e – 02. The data shows the product has achieved the criteria of strength of a typical monitor arm. In the context of this project, the highly ergonomic design greatly simplifies the assembly and disassembly procedures of the robotic arm. This technical refinement enhances user convenience, allowing for efficient and straightforward manipulation of the robotic arm as needed.

5.1 Recommendation

Throughout the project implementation, various significant challenges have surfaced, necessitating a thorough investigation for substantial enhancements. It is evident that a pivotal and comprehensive comprehension is imperative to facilitate the essential improvements for achieving optimal project functionality. These recognized issues serve as valuable learning experiences, offering essential insights into domains where improvements can notably enhance the overall performance and efficacy of the project.

First, I would like to recommend reinvestigating the selection of materials that could withstand a load of 10kg which is the average mass of a monitor. A lot of other materials that could withstand a load of 10kg, for example Polybenzoxazole (PBO), commercially known as Zylon, is often considered one of the strongest synthetic fibers and plastics. PBO has a 5 times greater tensile strength than steel which makes it the best selection of materials to reconsider for this project.

Next, I would like to propose the improvement of the torque of the motor that meets the criteria of the load placed on the product. By this improvement, it can carry a higher load which can be implemented in all scope of usage. To enhance the efficiency and user experience of a motorized monitor arm, potential improvements could involve optimizing joint mechanisms for smoother articulation, incorporating advanced sensors for precise positioning, and implementing intelligent automation features to adapt to user preferences seamlessly.

5.2 Project Potential

The Motorized Arduino Ergonomic Monitor Arm project holds immense potential, offering a groundbreaking solution at the intersection of ergonomic design and technology. Its integration of Arduino technology into a motorized monitor arm represents a paradigm shift in user experience, allowing for dynamic and personalized adjustments. This level of adaptability is crucial in addressing the diverse needs of users in contemporary workspaces, where the demand for ergonomic solutions is on the rise. The motorized feature enables users to effortlessly customize the height, tilt, and orientation of their monitors, promoting healthier postures and accommodating various work setups. This innovation not only enhances individual comfort but also has the potential to elevate overall productivity and well-being in office environments.

Beyond individual users, the project is strategically positioned to cater to the corporate sector's growing emphasis on employee well-being. Modern offices and co-working spaces increasingly recognize the importance of ergonomic solutions in fostering a conducive and efficient work environment. The Motorized Arduino Ergonomic Monitor Arm, with its technological sophistication and user-centric design, could become an integral part of such workplaces, contributing to employee satisfaction and overall productivity. Its potential to seamlessly integrate with other smart devices and its programmable features provide a forward-looking solution for businesses seeking innovative ways to enhance the ergonomic landscape of their workspaces.

Furthermore, the project's incorporation of IoT capabilities through Arduino technology adds another layer of potential. Remote monitoring, data analytics on usage patterns, and the ability to proactively manage and maintain monitor arms contribute to the project's versatility and long-term viability. As the workplace continues to evolve, the Motorized Arduino Ergonomic Monitor Arm emerges as not just a product but a transformative force, poised to shape the future of ergonomic solutions in the dynamic landscape of modern work environments.

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APPENDICES

APPENDIX A: Gantt Chart

ACTIVITY	WEEK (May 2023-Jan 2024)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Meeting and Discuss with Supervisor	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Project Background Research		■	■														
Objectives			■	■													
Literature Review			■	■													
Product Sketching				■	■												
Design Selection					■	■											
Material Preparation						■	■	■									
Product fabrication								■	■	■	■	■					
Arduino Programming												■	■	■			
Assembly Process														■	■		
Simulation Analysis															■		
Thesis Completion															■	■	

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: investigating Usability in Enhancing User Comfort and Productivity through the Design and Development of Arduino Motorized Computer Monitor Arms.

SESI PENGAJIAN: **2023/24 Semester 1**

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6%	3%	2%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

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2	Submitted to University College Birmingham Student Paper	1%
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4	www.evsint.com Internet Source	<1%
5	Submitted to CINEC Campus Student Paper	<1%
6	Submitted to Curtin University of Technology Student Paper	<1%
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