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Proceeding for International Undergraduates Get Together 2024 (IUGeT 2024)

"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition

Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

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DEVELOPMENT OF AN AUTOMATED TECHNICAL DRAWING PLOTTER FOR ENHANCED ENGINEERING EDUCATION

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Abstract
Engineering drawing is a fundamental course in the Mechanical Engineering Diploma programme, encompassing both technical drawing and Computer-Aided Design (CAD). However, students at UiTM Cawangan Terengganu Kampus Bukit Besi face significant challenges with traditional hand-drawn techniques. This project aims to develop an automated technical drawing plotter to aid in learning by automatically drawing simple shapes. The methodology is divided into mechanical and electronic components. Mechanical parts, such as the gondola and brackets, are designed following a comprehensive engineering design process and fabricated using 3D printing. The electronic control system is developed using an Arduino UNO circuit board. The plotter successfully draws basic shapes, including diagonals and rectangles, demonstrating its potential as a teaching aid. This project addresses the learning difficulties in technical drawing, offering a practical solution that enhances students' understanding. Future enhancements could expand the plotter's capabilities to draw more complex shapes and integrate additional educational features.

Keywords: *Technical Drawing, Automated Plotter, Engineering Education, Arduino UNO, 3D Printing*

1. INTRODUCTION

Engineering drawing is a critical course in the Mechanical Engineering Diploma programme, involving both technical drawing and Computer-Aided Design (CAD). Students at UiTM Cawangan Terengganu Kampus Bukit Besi face significant challenges with traditional hand-drawn techniques in technical drawing, which hinders their ability to grasp fundamental engineering principles and progress in related subjects. This project aims to address these difficulties by designing, developing, and optimizing a technical drawing plotter capable of automatically drawing simple shapes. The plotter provides an accessible introduction to CNC technology, bridging the gap between manual drawing skills and digital tools, and aims to enhance the learning experience of students.

The project builds on the integration of robotics, engineering, and programming, focusing on the use of SolidWorks for 3D modeling and Arduino for controlling the plotter's movement. Previous studies have highlighted the importance of detailed 3D modeling and precise coding for the successful operation of plotter machines (Singh et al., 2021; Sharma, 2023). Similar projects have demonstrated the feasibility of using automated tools to aid in technical drawing education, but often face challenges with accuracy and usability (Trihono Sewoyo et al., 2022; Kaushal et al., 2018). The methodology involves designing and optimizing the gondola and bracket components using SolidWorks, fabricating these components via 3D printing, and developing the Arduino software to control stepper motors. The plotter uses an Arduino UNO board, motor drivers, a 9V 2A power adapter, and two stepper motors to control the X and Y axes, enabling the gondola to move and create drawings on a flat surface. The project successfully developed a technical drawing plotter capable of drawing simple shapes such as diagonals and rectangles.

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The 3D printing process produced parts that matched the design specifications, and the Arduino circuit design and simulation functioned well, with no significant issues in the code. However, accuracy issues were observed due to factors like the surface angle or the tension of the timing belt (Sharma, 2023). This innovative product simplifies the engineering drawing process, making it an essential tool for students, educators, and hobbyists. By automating technical drawings, it meets the growing demand for efficient and user-friendly drawing solutions in various fields and offers tremendous commercial potential in the educational and DIY markets. Future enhancements could enable the plotter to draw more complex shapes and integrate additional educational features.

2. METHODOLOGY

The methodology for developing the DIY Plotter Engineering Drawing Machine with Arduino is structured to achieve the goal of building a functional prototype, as depicted in Figure 1. This flowchart outlines the comprehensive process from initial concept to project completion. Material selection, including aluminum, wood, and PLA, is prioritized based on availability and suitability for structural integrity and ease of fabrication. The design phase commences with creating detailed 3D models of the gondola and brackets using SolidWorks software, serving as guides for fabrication.Control of the plotter's operations is managed through Arduino board source code, meticulously crafted to ensure precise movement of the drawing mechanism. Progress tracking is facilitated by a Gantt chart, aligning development milestones with project timelines. The assembly process encompasses wiring and final adjustments, culminating in a comprehensive project demonstration ("X-Y Plotter Robo Using MXY Board," 2023). Defining the problem involves a Product Design Specification that rigorously evaluates key factors such as performance, durability, maintenance, cost-effectiveness, component availability, size, weight, aesthetics, standards compliance, safety, and installation requirements. Each criterion is systematically analyzed to meet educational objectives. Concept generation employs Physical Decomposition to break down the system into manageable components and subsystems, facilitating design, assembly, and troubleshooting phases. The Morphological Chart organizes design parameters and options to optimize configurations, prioritizing design criteria effectively.

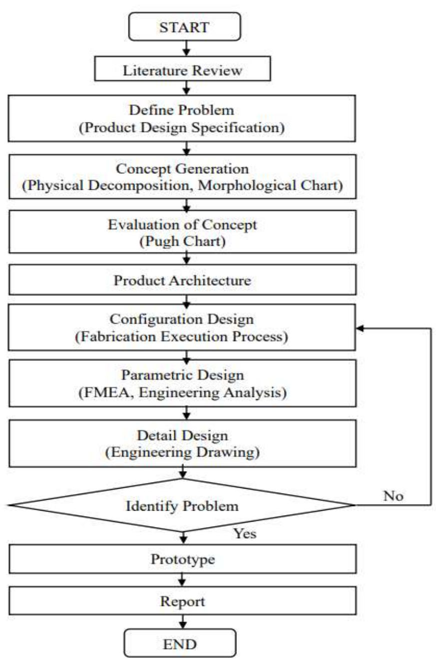

Figure 1. The flow chart for the mechanical design process

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The project utilized a structured approach including the Pugh Chart for decision-making, guiding the evaluation of design alternatives. Its integrated Product Architecture features an Arduino microcontroller managing stepper motors via belts, pulleys, and linear guides for automated drawing. Component procurement involved sourcing nine components online and producing four parts via 3D printing, ensuring adherence to specifications with contingency plans for materials. Engineering analysis rigorously tested the plotter's accuracy and versatility using SolidWorks for detailed design and iterative refinement, aiming to enhance educational experiences in mechanical engineering through the integration of traditional drawing techniques with advanced machining.

3. RESULTS AND DISCUSSION

The final design of the plotter, drafted using SolidWorks software as shown in Figure 2, represents the culmination of meticulous design and iterative refinement aimed at achieving optimal appearance and functionality. Arduino circuit testing, conducted through the Wokwi simulation website, affirmed the successful integration and error-free operation of critical components, particularly the precise synchronization of two stepper motors. The Arduino source code effectively managed motor commands, ensuring synchronized movements with other plotter components. Fabrication of the plotter involved converting SolidWorks designs into 3D-printed components. The Gondola and Brackets were fabricated with precision, adhering closely to original size specifications and fitting seamlessly into the assembly process. Detailed steps were followed to assemble all components, with additional adjustments made to optimize performance, such as balancing the gondola assembly with weights on the timing belts, as depicted in Figure 3.

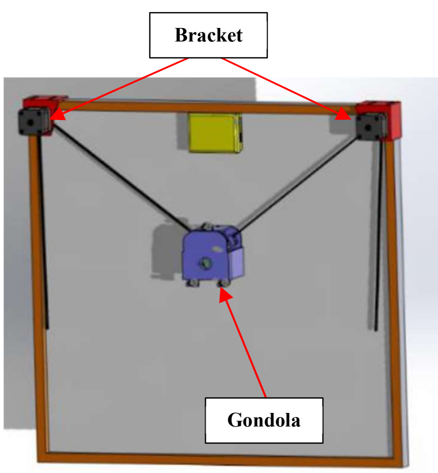

Figure 2. The drawing design using SolidWorks

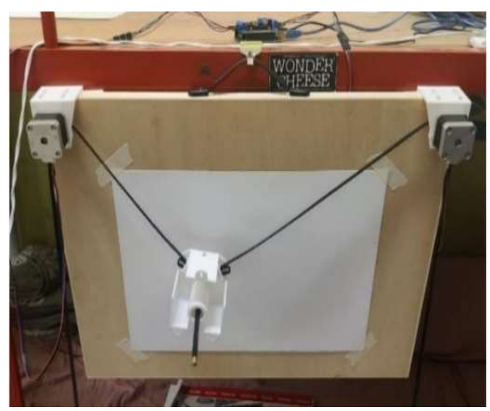

Figure 3. Full view of the project

Performance testing focused on executing a diagonal shape drawing task. Using Arduino IDE, a diamond shape test as depicted in Figure 4 was initiated, adjusting parameters including starting position, motor speed (set at 150 rpm), shape dimensions (60 mm per side), and employing a 1.0 mm marker pen. Upon execution, the stepper motors initiated XY-axis movements, resulting in the completion of a technical drawing as shown in Figure 5. However, observed inaccuracies in line straightness highlighted challenges in achieving precise drawing outcomes. The plotter functioned reliably with no coding errors, indicating robust operational capabilities despite encountered accuracy issues attributed to factors like surface angles and timing belt tension variations.

Discussion on the results underscores the successful integration of mechanical and electronic components in the plotter's design. While initial testing demonstrated functional adequacy, identified inaccuracies necessitate further refinement in mechanical calibration and software optimization to enhance drawing precision. Future iterations could focus on addressing these challenges through enhanced tensioning mechanisms or software adjustments, aiming for improved performance consistency across various drawing tasks. In summary, the results validate the effectiveness of the developed plotter in automating technical drawings, albeit with recognized areas for improvement. This iterative process underscores the project's commitment to advancing educational tools in engineering drawing, with implications for broader applications in CNC technology and educational robotics.

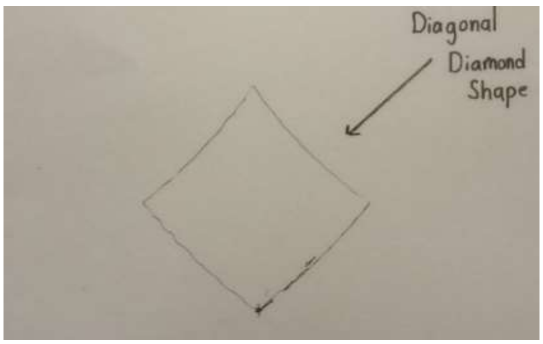

Figure 4. Expected diagonal shape

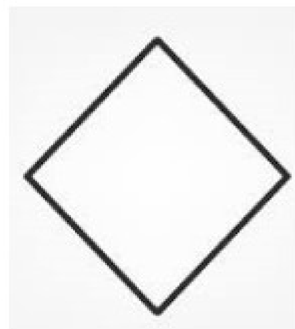

Figure 5. Actual Result

4. CONCLUSION

This study successfully developed an automated technical drawing plotter to aid in teaching engineering drawing concepts. While achieving functional reliability, ongoing refinement is crucial to optimize drawing precision and expand the plotter's educational utility. The project contributes to advancing technical drawing education by bridging manual and automated drawing techniques, paving the way for broader applications in engineering and educational robotics.

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