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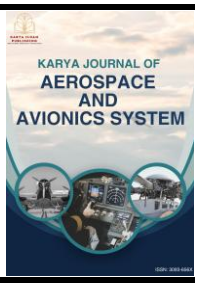

Development of a Miniature Landing Gear Simulation Controlled via Mobile Application

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ABSTRACT

Theoretical concepts can be challenging for students as they require intense focus and lack visual representation. Studies show that visual learning improves comprehension and retention, making it a more effective approach for complex subjects like aviation systems. This miniature landing gear simulation serves as an interactive learning aid at UniKL MIAT, helping students better visualize and understand landing gear mechanisms. By bridging the gap between theory and practice, it enhances the overall learning experience. From the planning stage, the goal was to develop a practical and innovative tool that simplifies complex concepts. The project successfully meets this objective, demonstrating reliable functionality while providing opportunities for further improvements.

1. Introduction

Landing gear is one of the most critical components of an aircraft, serving as a suspension system that facilitates taxiing, takeoff, and landing. It is designed to absorb and dissipate impact forces through an integrated system of struts, wheels, brakes, and hydraulics, ensuring safe and stable ground operations. The design of a landing gear system is a complex process that requires balancing multiple competing factors, including weight minimization, compactness, short development time, and cost efficiency. Additionally, various performance criteria—such as ground clearance, stability, structural rigidity, controllability, and impact force absorption—must be carefully evaluated to accommodate different landing scenarios.

Aerodynamic efficiency plays a significant role in landing gear design, particularly in reducing drag and weight. While retractable landing gear substantially lowers aerodynamic drag, the addition of fairings can further minimize drag but at the cost of increased weight and mechanical complexity [1].

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1.1 Problem Statement and Objective

Numerous studies on organizational learning have been conducted worldwide; however, there is a lack of research linking organizational learning processes to the successful performance of the Malaysian aviation industry [2]. Despite the high costs and limited availability of modern learning aids, many aviation schools have yet to equip their training programs with up-to-date instructional tools. A study by Natalia Dużmańska-Misiaeczyk [3], revealed that 75% of students prefer visual learning over traditional theoretical lectures. This highlights the need for innovative educational tools to enhance student engagement and comprehension in aviation training.

Effective learning, whether conducted virtually or in a physical classroom, demands a high level of focus from students. Relying solely on theoretical instruction can lead to disengagement and reduced retention of information. Therefore, developing interactive and visually engaging learning aids is crucial to fostering a deeper understanding of complex aviation concepts, such as landing gear systems. This project aims to improve the quality of aviation education, particularly at UniKL MIAT, by developing a compact and functional landing gear simulation model while integrating a wireless monitoring system to enhance hands-on training and improve students' understanding of landing gear mechanisms.

2. Methodology

2.1 Flowchart

The development process for the Miniature Simulation of Landing Gear Controlled by Mobile Phone follows a structured plan to ensure efficient and effective project execution. Proper planning is essential for successful development, as it helps streamline the process, minimize complexity, and prevent unnecessary confusion. Without a well-defined approach, the project would face significant challenges in organization and implementation. Figure 1 shows the planning phase of the project.

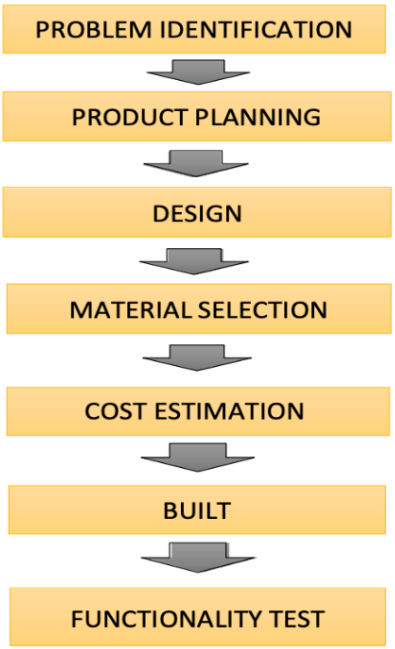

Fig. 1. Project planning

2.2 Product Design

CATIA (Computer-Aided Three-Dimensional Interactive Application) is a comprehensive multi-platform software suite developed by Dassault Systèmes and marketed globally by IBM. It is widely used for CAD (Computer-Aided Design), CAM (Computer-Aided Manufacturing), and CAE (Computer-Aided Engineering) applications.

In CATIA, the Sketcher toolset provides essential features for dimensioning and applying constraints, ensuring precise geometry while offering a range of tools for creating profiles and performing sketch-based operations. The Assembly Design module enables users to construct complex products by integrating individual components designed in the Part Design module, ensuring proper fit and functional interaction between parts. This advanced integration makes CATIA a powerful solution for designing, simulating, and validating intricate engineering systems across various industries.Figure 2 shows the product design using CATIA.

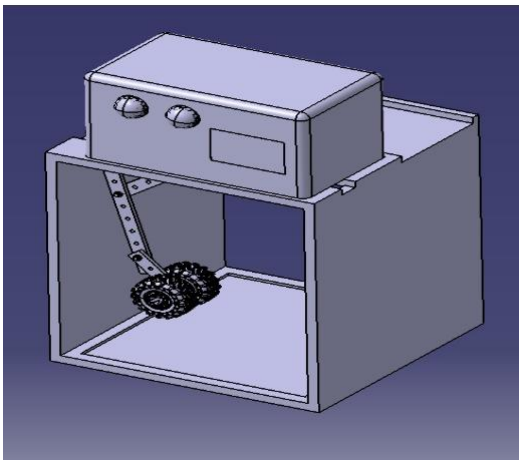

Fig. 2. Design of product using CATIA

2.3 Simulation Circuit

As illustrated in Figure 3, the design process serves as the foundation for developing any product or system. For this project, the system must be user-friendly, efficient, and practical for both students and lecturers. It should feature an intuitive interface and incorporate power-saving mechanisms to ensure long-term usability. Additionally, the design requirements for the management unit emphasize the need for a stable Wi-Fi connection and seamless integration with an online monitoring system.

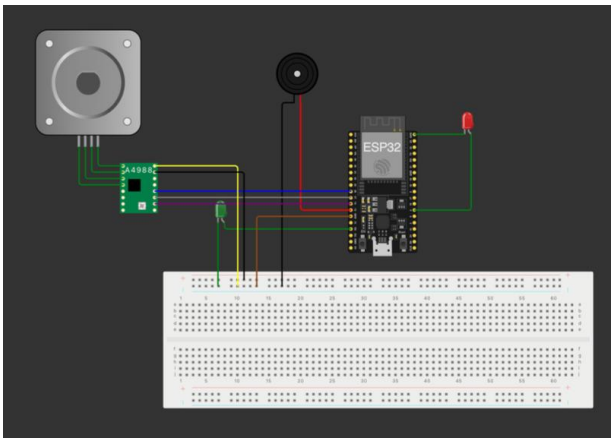

Fig. 3. Simulation circuit of the product

The Arduino Wi-Fi Shield ESP32 [4] plays a crucial role in this project by enabling Wi-Fi and Bluetooth connectivity within the circuit. Its high-speed data processing capabilities allow seamless connections to mobile devices and laptops, making it an ideal component for Internet of Things (IoT) applications. With support from the Arduino ecosystem, developers can write and upload custom code directly to the ESP32, tailoring its functionality to meet specific project needs.

Designed for low power consumption, the ESP32 is well-suited for battery-powered applications, ensuring both sustainability and extended component longevity. It operates within a voltage range of 5V to 12V and is powered via a built-in Micro USB port. The ESP32 is compatible with multiple development platforms, including LeetCode, Mongoose OS, and Arduino IDE, making it highly versatile. An Arduino IDE add-on is available to facilitate ESP32 programming, allowing developers to upload code in approximately 10 minutes.

With an ESP32 module, a Micro USB cable, a laptop, and the Arduino IDE, developers can easily begin programming and customizing their projects. Proper handling of components is essential—ensure hands are dry when assembling, refer to the component manuals for correct usage, and handle fragile pins with care to prevent damage. Figure 4 shows the landing gear simulator.

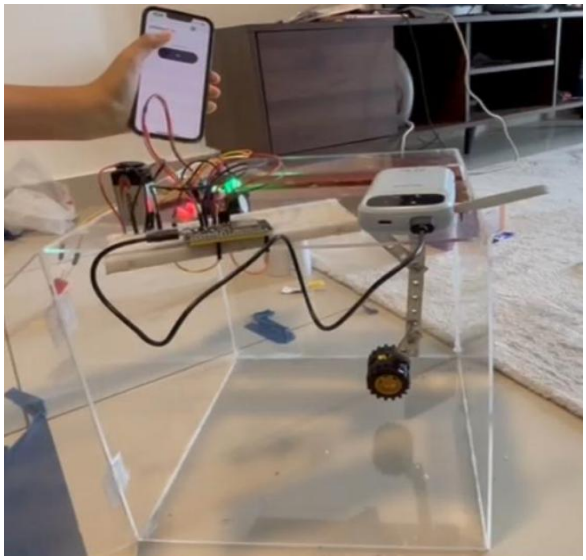

Fig. 4. Product outcome

3. Results

3.1 Functionality Test

Upon completing the coding, construction, and programming phases, the final stage of the project involves testing the overall system's functionality and performance. This includes assessing the system’s operation, mobility, and responsiveness when controlled via a mobile phone, ensuring smooth and efficient performance.

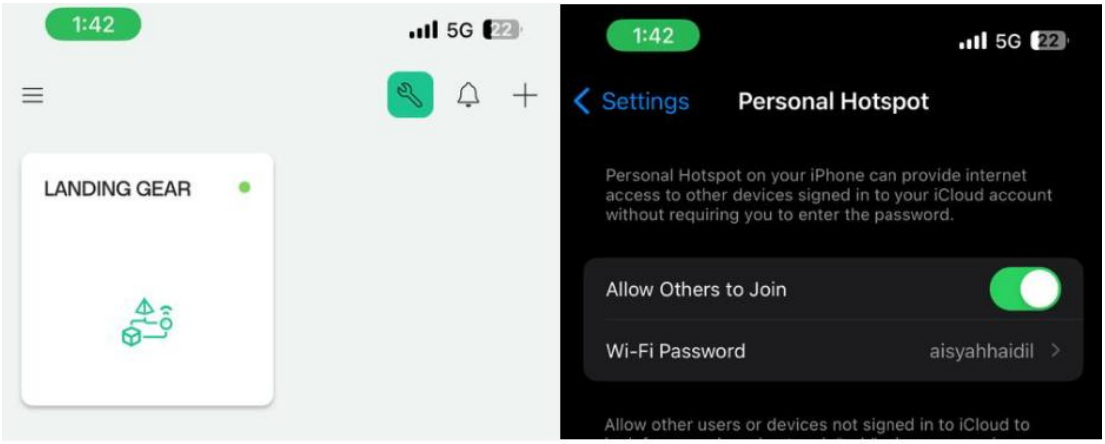

Fig. 5. Blynk App to ESP32 connectivity test

A green indicator in the top left corner signifies that the ESP32 has successfully connected as soon as the assigned mobile phone enables its personal hotspot. The Blynk app displays a green light, confirming a stable connection between the mobile device and the ESP32, allowing seamless control with a single touch.

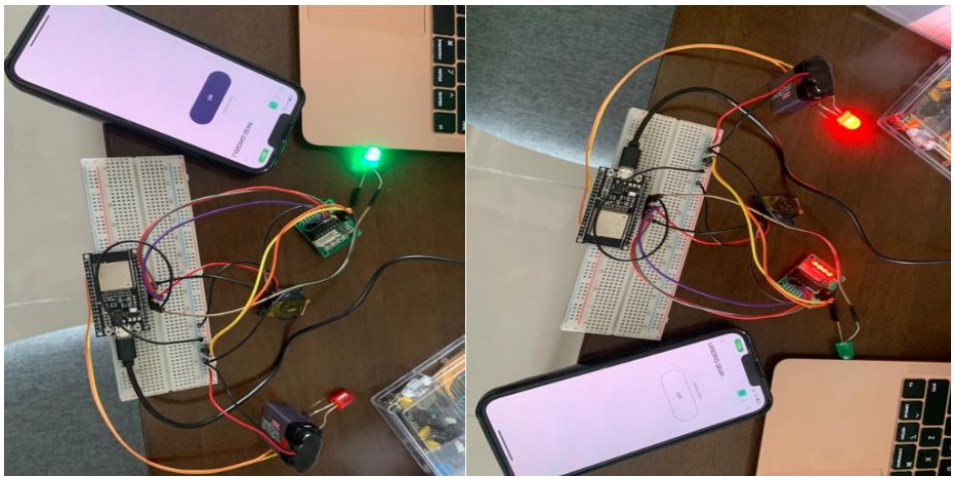

Fig. 6. LED lights green and red functionality test

Following comprehensive functionality testing, the results align precisely with the expected outcomes, including the smooth operation of the landing gear mechanism. This project effectively serves as a learning aid, helping students gain a deeper understanding of landing gear functionality and its control system. A detailed explanation of the system's operation is provided in Table 1.

Table 1
Circuit functionality explained

ACTION	RESPOND
When project is turned "ON" on Blynk app	Buzzer will ring twice to imitate the sound of alarm like real life aircraft is about to extend its landing gear and motor will start rotating for 5.5 seconds and green LED will turn on.
When project is turned "OFF"on Blynk app	Motor will rotate back to retract landing gear for 5.5 seconds nad red LED will turn on.
Operating voltage required for the project is 5V to 12V. If voltage supply is less than 5V or more than 12V.	Possibilities of component damage will be seen like overheating or incorrect operation.

4. Conclusions

The successful development of a mock-up landing gear system controlled via a mobile phone using Arduino ESP32 demonstrates the project's effectiveness in enhancing aviation education. The system functions reliably, allowing for seamless retraction and deployment of the landing gear, thereby providing students with a practical understanding of its operation. Research has shown that hands-on learning significantly improves student engagement and comprehension compared to traditional theoretical instruction. By incorporating an interactive approach, this project serves as an effective educational tool, bridging the gap between theory and practical application. Additionally, it offers a cost-efficient solution for aviation training institutions, reducing the need for full-scale landing gear models, which are considerably more expensive. Moreover, the system's portability and accessibility allow it to be utilized in various learning environments, provided there is a mobile network connection. This flexibility ensures that students and instructors can benefit from an interactive and immersive learning experience, ultimately contributing to a more comprehensive understanding of landing gear systems.

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