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Development of Mini Scale Automatic Portable Lifter for Luggage in *Kolej Kediaman Pagoh* Universiti Tun Hussein Onn Malaysia

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Abstract: Model scale project aimed to develop a prototype for an automatic portable lifter to transport students' belongings in public buildings. The problem addressed was the deficiency of elevators in student collage buildings makes it difficult for students, as many of them carry a lot of belongings to college. The objective was to design and develop a model-size portable automatic lifting system that could be easily implemented into these buildings without being permanently attached, and to analyze its performance in terms of practicality and reliability. The solution proposed was a pulley system with an electrical DC motor and motor driver, as well as a proximity sensor to control the movement of the cart. The control system used was a NodeMCU ESP32, connected to a Bylnk IoT system as a pushbutton. The prototype was powered by a 12V battery, which was charged using a 100-watt solar panel. Testing included function tests, load tests, practicality tests, and solar charging rate tests. Results showed that the prototype was successful in its movement but had some problems. A load of 5 kg was found to be the limit for the prototype. Results of the practicality test showed that the prototype could run for 8 cycles with different loads but had some problems. Finally, the solar charging rate test showed that it took 2 hours for the 12V battery to fully charge.

Keywords: Automatic Lifter, Pulley System, Guide Rails, Node

1. Introduction

Looking at the current situation in public universities, the trend of increasing the number of students can be seen in universities in Malaysia from 2020 to 2021 [1] where enrolment for student's bachelor's degree level was increase from 369,312 students to 378,806 students (data as of 30 November 2021). As a result, the trend for students' enrolment in Universiti Tun Hussein Onn Malaysia to stay at college also increased. In addition, in Student Collage Pagoh UTHM buildings were not equipped with lift

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facilities which make it harder for the students to carry their luggage to the room. This scenario will carry out other problems, to the students with asthma or students having a back pain problem. Moreover, Student collage resident building was the public infrastructure where any building cannot be attached permanently. To solve this problem, the outcome idea is to create a lift mechanism that can “plug and play” wherever that mechanism need be use.

The technology of lifting system had been developed in many years as the industry grows, the ways of handle product had been increased [2]. There are some studies been held to tackle this problem. The purpose of studies was to reduce the physical effort of labour and to protect the worker from repetitive strain injuries, overexertion etc. and to increase productivity [3]. Before the come of this technology, hook was commons be used to lift the load but it not suitable for every product. Due to that, the development of lifting system technology had been carried out widely for the different product [4]. In the manufacturing industry, lifter applications are already commonly used in many ways. For example, in some factories where there are many components to install and limited space for production, the first and second floors are used for production lines. To connect these production lines, an automatic lifter is used to transport products from the first floor to the second floor. Moreover, forklifts are also used to move products from one place to another, and they are often used in warehouses in the manufacturing industry. They consist of a mast, which is the vertical part that lifts and lowers the load, and interlocking rails that provide horizontal control. Lastly, in the manufacturing industry, the use of a good lift can be seen to transport components of a product from one department to another. It can only be used for loading and unloading.

2. Materials and Methods

From the overview of lifter system in manufacturing, it can be concluded that both forklift and cargo lifter have similarities in design which having load Infront of the system. Therefore, it be suitable design for the prototype which need to have load Infront the system. Moreover, based OSHA on Forklift Safety [5], factor such as the load on the forks and the terrain which the forklift is operating can also impact its stability.

2.1. Materials

the material selection is based on the purpose of the material and component toward the design being created. Each component that be selected was based on the previous study which include application, advantage, and limitation.

2.1.1. Mechanical component

System pulleys include with electric motor drive more acceptable than other system due to it cheaper and easier to maintenance than hydraulic and pneumatic system. From additional study, effect of increasing pulley diameter shown significant improvement toward mechanical advantage in pulley system [6]. For information, the prototype function was automatic which in this case the component electronic also included. Therefore, Figure 1 show prototype design with component include and Table 1 show component and hardware be used in prototype.

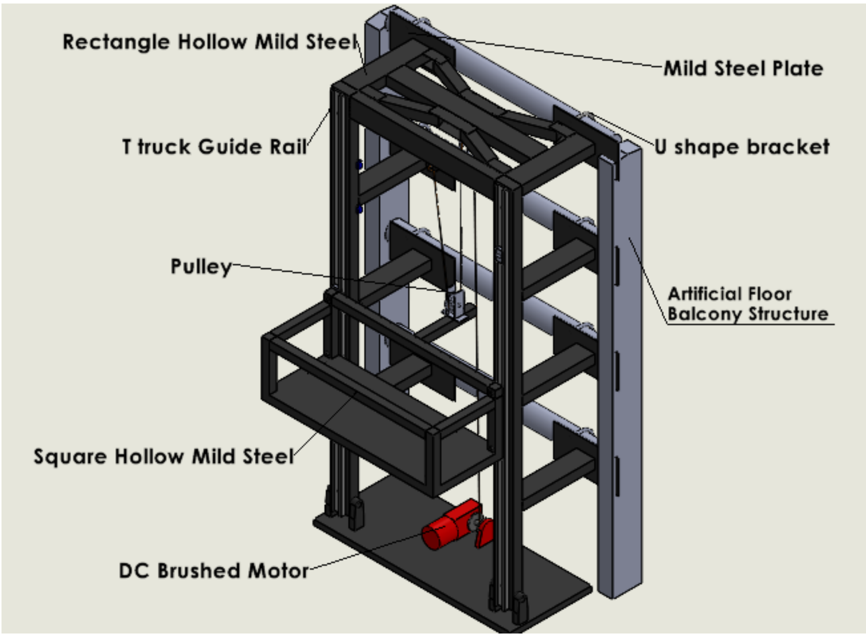

Figure 1: Mechanical component/Material in Prototype

Table 1: Components of hardware and materials

Bil.	Component
1	Mild steel square hollow 2inch x 1inch x 1.2 mm
2	Mild steel square hollow 1inch x 1inch x 1 mm
3	Pulley
4	Plate 153 cm x 153 cm x 1.2 mm
5	T-track Slot Guide Rail with slot
6	Nylon Wire Rope
7	Power Window Wira Brushed DC 12 V motor
8	NODEMCU ESP32
9	Proximity Sensor
10	Solar Panel (100 W 12 V)
11	Lead Acid Battery 12V
12	PWM Solar Charger Controller (20A 2160W 12V)

2.1.2. Electrical Component

From Figure 2 show a block diagram that representation of the components and their relationships in a system. It includes a solar panel that converts sunlight into electrical energy, a solar charger controller that regulates battery charging, 9 and 12-volt batteries that store the generated energy, a buck converter that adjusts voltage levels, a switch that activates the circuit, a microcontroller (NODEMCU ESP32) that controls a motor using Blynk IoT software and a proximity sensor to detect movement of a cart, and a motor driver that controls the motor's operation.

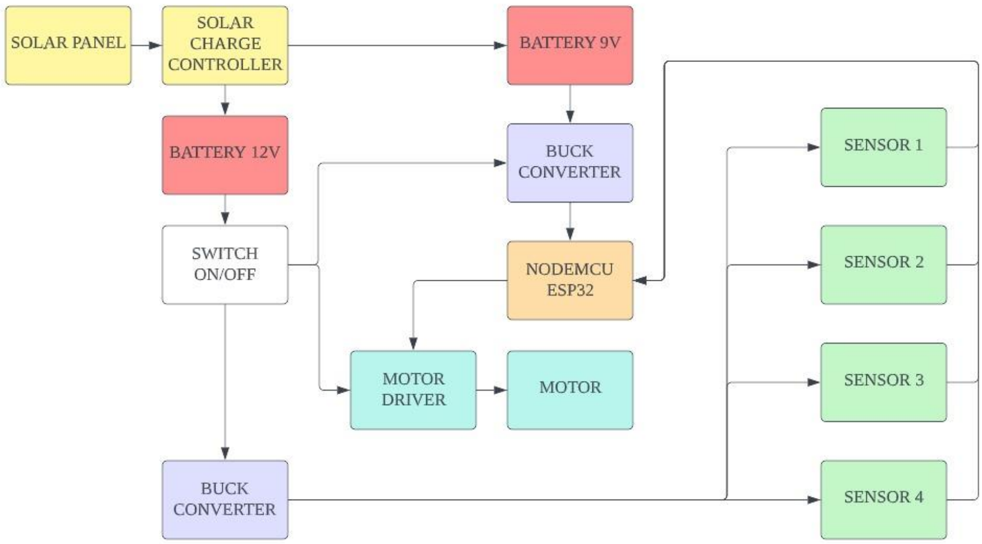

Figure 2: Block diagram of prototype

In Figure 3 show electrical schematic diagram for the system that translate from the block diagram Figure 2. From the Figure 3 showing that the system being powered up by using Battery which 12V 12Ah sealed lead-acid battery. It rechargeable where getting power from the solar panel with aid of solar charger panel which control the rate of battery charging. Battery 12 V supply the electricity to the Buck converter 5A which connect the NodeMCU ESP 32, also battery supply the power toward motor driver 43 amp for control the Power window 12V Motor DC movement. Moreover, the Motor driver 43amp received signal from the NodeMCU ESP32 to aid control the movement of motor DC. Meanwhile, sensor being used was proximity sensor that integrated as floors. The sensor will send the ping toward the NodeMCU esp32 to identify the desired floor.

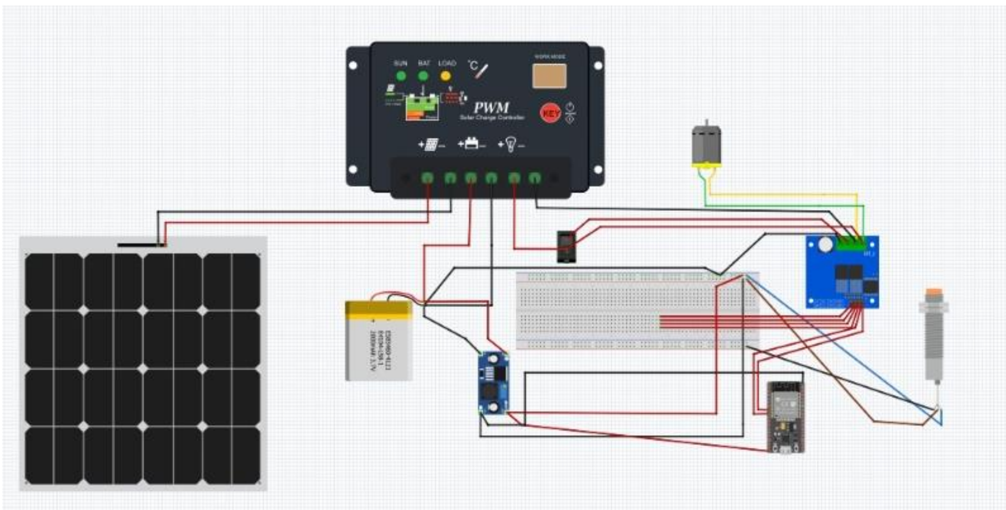

Figure 3: Electrical Schematic Diagram

2.2. Methods

The core aspect of mechanical design is creating detailed plans and blueprints for the dimensions, materials, and assembly of components in a mechanical system or machine. This process includes both conceptualization and detailed development, including the selection of components and creation of assembly drawings. Therefore, in this case the design that be selected based on the design of forklift [5] and cargo lift. Both of design having cart in front of the system where suitable to implement in high floor building. Both using guiderail mechanism to raise and lowering the cart which this import to keep cart in position when it moves.

The challenge is to making prototype portable and not be permanent attach to building. The design need be easy to assemble and at same time can functional properly when whole mechanism run. To tackle that problem, a design like ladder that can be seen attach at building be propose. The attachment from prototype to building can be seen at each structure at floor balcony. Moreover, the prototype can be disassembled by part, the part that can be disassemble is like cart, structure, base, and U shape bracket. Figure 4 show 3D design of prototype Automatic lifter while Figure 5 Show part that can be disassemble.

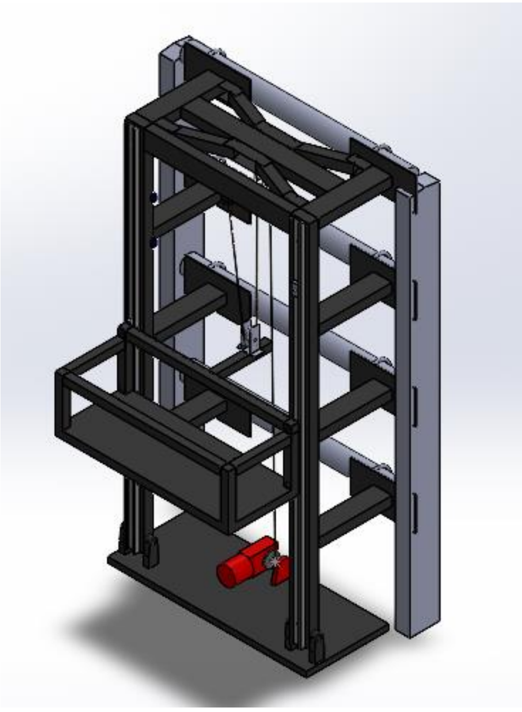

Figure 4: 3D design of prototype using SolidWorks Software

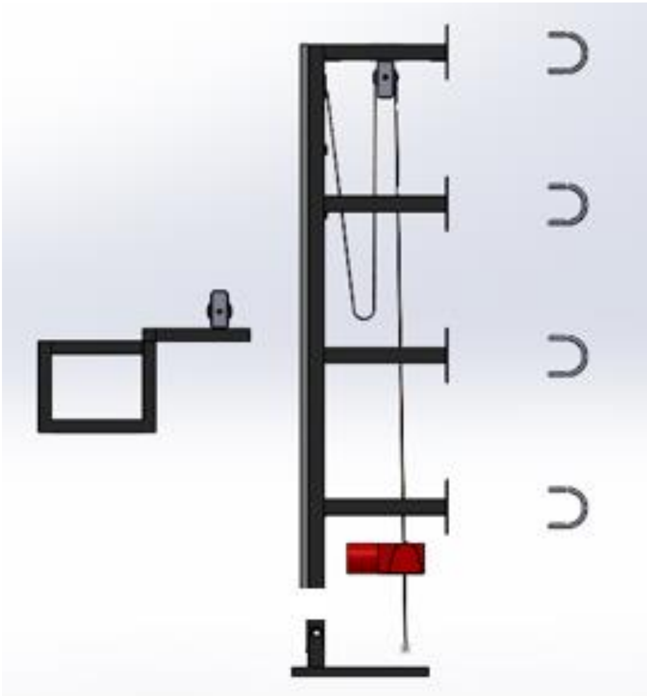

Figure 5: Part that can be disassmeble

Knowing that the motor be attach to drum to pull and release the wire rope that control the movement of cart, the initial torque needs to consider. As scope weight for the model scale was 49.05 N and using the drum radius was 0.0125 meter (from centre point of drum), the torque for pull the wire rope can be identified. The following *Eq.1* calculation be used to calculate initial torque need to pull the wire rope:

Eq.1

$$Torque = Load \times Radius$$

$$Torque = 49.05N \times 0.0125m$$

$$Torque = 613.125 \times 10^{-3} \mathrm{N.m}$$

Therefore, the rated torque for motor need to pull the wire rope more than 613.125×10^{-3} N.m. After consideration, the power window DC motor be selected because of the rating torque of power window was 2.9 N.m. Moreover, the selection of the power window due to the exceptional performance it offers at an affordable price and the design was easy to attach beside another type of DC motor.

2.2.1. Flowchart of system

From the flowchart in Figure 6 it can be guidance for creating the coding for the control the movement of DC motor. Meanwhile, from the flowchart shown it start with user select the floor. Users push the push button which in this prototype using Blynk IoT application. From this, the input from Blynk sent to microcontroller which NodeMCU ESP. Following that, the cart moving based on desire floor. If cart not moving, it will start back at floor selection. Remind that the cart moving based on the input from the proximity sensor which sent the input to NodeMCU and sending data to motor movement. Finally, the system will start again based on the selection floor before.

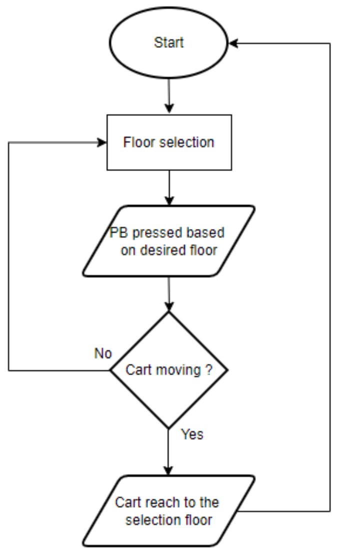

Figure 6: Flowchart of system in prototype.

3. Results and Discussion

This section examines the results and findings from testing a prototype automatic lifting system. For recall, the purposes of the project are to create a prototype automatic lifting system that enables controlling cart to move to a specific location autonomously with the aid of the proximity sensor. Next, is to use the Bylnk Iot software as a mean to communicate with the microcontroller and verify the cart movement. Moreover, using battery 12 V as power source and aid of solar panel for charging. The tests were conducted to evaluate the prototype's reliability and practicality, including functionality, and load. The results are presented in tables, graphs, and charts for easy understanding.

3.1. Final Prototype

The actual prototype can be seen in Figure 7 and Figure 8. the model scale sizing was height 1000mm with length 500mm and 300mm width. The electronic part being stored in white box for secure it from any hazardous. Meanwhile, from the box, having attachment solar panel for capturing the sun light. The model scale prototype using wire rope to pull and push the cart. Some of part of cart using aluminum sheet plate to making rectangular shape cart.

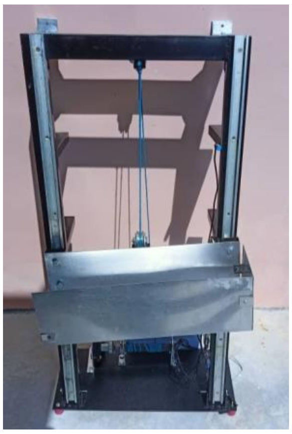

Figure 7: Front view of prototype

Figure 8: Side view of prototype

3.2. Function test

The function test purposed is to ensure the system function well during the testing period for 10 cycles. During this test, the prototype been run for 10 cycles which the movement of cart for each floor and each floor distance was 250 mm. From the test been done it can saw that Power Window motor with torque 2.9 Nm been used can pull the cart with help by pulleys. As the structure frame was rigid and durable enough to hold the force given from motor and not showing any defect at structure part after been run for 10 cycles. For the electronic and electric part working fine regarding the having some issue. From the Table 2 below showing the result observation of testing after 10 cycles run.

Table 2: Result of observation during ten cycle movements

Cycle	Observation
1	Successful
2	Cart not moving at 4th floor to 3rd floor
3	Successful
4	Successful
5	Successful
6	Successful
7	Cart not moving at 2nd floor to 3rd floor
8	Successful
9	Successful
10	successful

From the actual testing showing that the electronic part like motor driver, battery charging doing well. Regarding that some issue like WIFI connection to the NODEMCU ESP32 and the sensitivity of proximity may affect the flow of the system. The error of the proximity sensor can find out because of it detect twice when it moves downward. This case can be saw in cycle number 7 in Table 1, where push button need be press twice in blynk software for cart move from 2nd floor to 3rd floor. Moreover, mechanism for assembly cart may affect the movement of cart. This can be saw when run the test. By the observation, upward movement of cart being smooth, but cart tilted at left side when moving downward. Cart need tilted to the left side otherwise cannot moving. This scenario can be saw at cycle number 2 in Table 1. During that cycle, the cart cannot move from 4th floor to 3rd floor due to slider in guide rail been stuck when cart not tilted to left side.

3.3. Load Test

Load test be done by testing movement of cart for each section. There prototype being divided for four sections. Each section represents as floor for building. For this test being done to identify the optimum weight for prototype. Each movement been running by five time by changing the load (9.81N, 19.62 N, 29.43 N, 39.24 N, 49.05 N) and taking time taken data for analysis. The test also being redone if the cart movement having some problem. By doing this because to take the time taken for each success movement. From the Table 3 show a result of average time-taken for each load and Figure 6 show graph of load versus time for upward and downward movement.

Table 3: Time taken for each load

	time taken for lift move upward (s)			**Time taken for lift move downward (s)**		
load (N)	level1-level2	level2-level3	level3-level4	level2-level1	level3-level2	level 4-level3
9.81	2.72	6.22	6.16	2.46	4.31	4.12
19.62	2.86	6.28	6.42	2.51	4.35	4.23
29.43	2.99	6.35	6.65	2.36	4.14	4.39
39.24	3.33	6.78	7.18	2.44	4.33	4.38
49.05	3.46	7.11	7.64	2.65	4.31	4.23

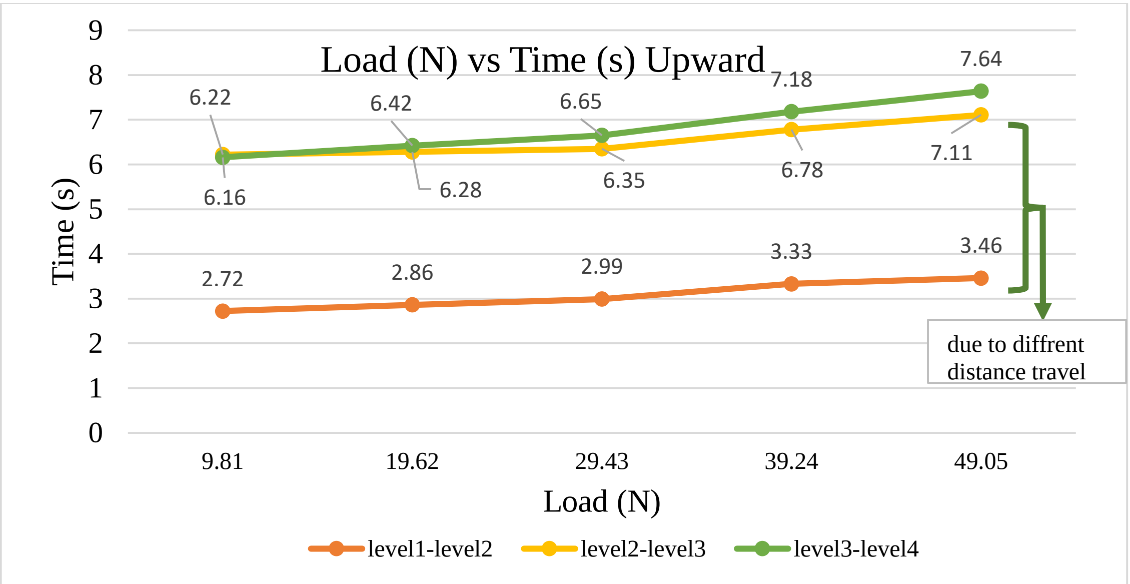

Figure 6: Graph Load vs time for upward

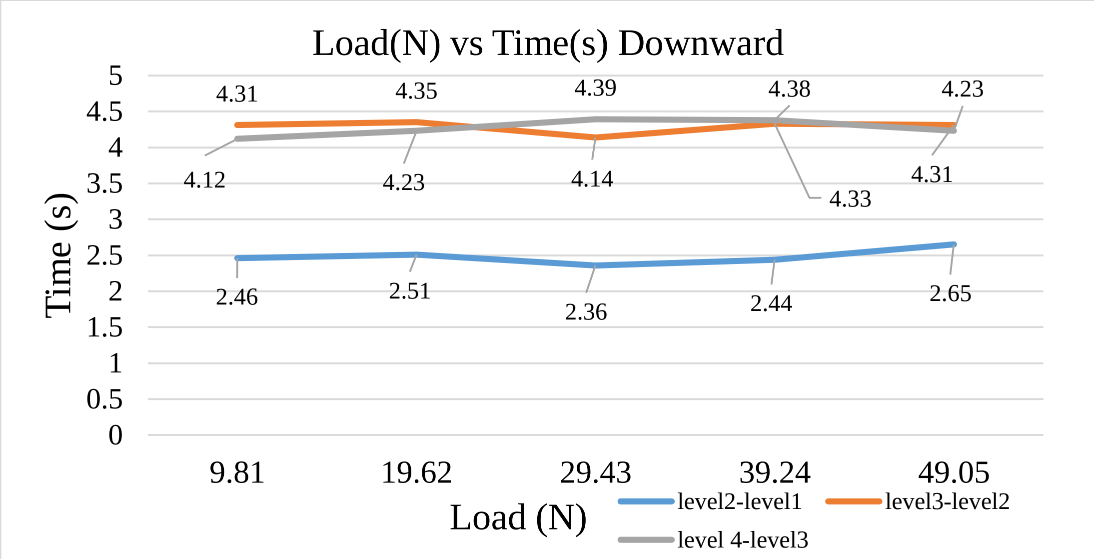

Figure 7: Graph Load vs time for downward

It can be observed that the time taken per floor is not consistent. This can be interpreted by the results of both movements, as the data shows a random pattern but for the context if the result being round up nearest tenth, the time taken for downward movement is precise but for upward movement was different after 39.24 N. Furthermore, From the result can be saw that the time taken for each load increase when load being increase and this happen when cart moving upward only. This is likely due to the added effort and energy required to lift and transport heavier loads. For ground floor to second floor was the quickest because the travel distance was smaller than another floor where distance travel was 140 mm, and another floor was 250 mm. For another floor, the total distance was same and the result time for each floor are different. From the observation, the major problem affects the reading of result due to the connection between guide rails and cart structure. Regarding that, from the observations the optimum load for prototype can be identify which when conducting load for 49.05 N the base being tilted upward and need to support for like Figure 8.

Figure 8: Base need support by leg

This scenario happen due to the design error which connection between the base and main structure was connected to bracket whick led it free movement. The base also not heavy enough to withstand total force given from the motor. Moreover, from the upward movement graph showing that time taken for below 29.43 N was consistence which 6 second each floor. From this can conclude that optimum weight for the prototype design was below 29.43 N.

4. Conclusion

The Prototype Portable Automatic Lifter performed well in its ability to move loads between 9.81 N and 49.05 N, but there are areas for improvement. The system functioned smoothly, and the connection between the NODEMSU ESP32, motor driver 43A, and proximity sensor was successful. The Blynk IoT was used as a push button to make it easy to run and reduce the load on the wiring system. Most issues observed were mechanical, which may have affected data accuracy and precision. The main structure was in good condition with no cracks or defects. The prototype was most accurate with a load of 3 kg and had an error rate of 10-20% during 10 cycles of testing. Recommendations for improvement include using a roller guide rail for less friction, a detailed plan during fabrication, prioritizing safety, using high-quality materials, and equipping it with safety features like overload protection and emergency stop buttons. Moreover, for the base design need to redesign either or to fully attached to the ground floor or making it heavy enough to withstand force from the motor.

Acknowledgement

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