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Prototype of automatic goods moving equipment to multi-storey floor with Arduino

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ABSTRACT

The industrial world is currently growing and has become an important part of the world as a whole. An example is the process of grouping and moving goods over and over in the warehouse located on the upper floor becomes a problem if the process is still done manually. So shipping the goods requires a lot of energy needed and is still less efficient. This research made a prototype design of a freight elevator that can place goods automatically in a multi-storey floor storage warehouse, aiming to facilitate the performance of the arrangement of goods during the delivery process to the upper floor. The hardware consists of an Arduino Mega 2560 microcontroller, two 12 volt dc motors, an infrared sensor and a limit switch. Testing this system uses a package of goods from cardboard media, with a package thickness of 0.2 cm. The results of the testing of the classification of tool goods packages can work well so as to improve work effectiveness with the accuracy of the success of the tool in placing goods to 3 floors in sequence with an accuracy of 86.7%, then the placement of goods with 1 empty space 98.9% accuracy, and placement goods with 2 combined empty spaces are 84.47%.

1. Introduction

The development of the industrial world, especially in technology, makes humans required to develop fast, like today. Lots of companies are already using the latest technology. For example, in the production of packaged goods, the transfer will not only cover one size, but many sizes, starting from very small sizes, then medium sizes and very large sizes [1][2]. The transfers are still carried out manually, such as using goods trolleys and humans as movers who carry out the process. Relocations that are carried out require a relatively long time to complete the transfer process, and a lot of human labor is required. In a storage building, there are many levels of floors, therefore a better facility is needed than just stairs, such as an elevator [3]. Based on this, the author proposes the idea of creating a drive system that can work automatically to carry out the process of moving goods to the multilevel floors at the company according to the production goods that will be accommodated in the storage warehouse located on the multilevel floors. To fulfill these requirements, technology can be created that can function like laborers or human workers, but uses tools that can work automatically, such as elevators.

Elevator is a system that can be used to transport people or goods up and down using a set of mechanical devices, tools that can work automatically or work manually such as using buttons on a multi-storey building [4]. The elevator can work with the help of a relay or magnetic contactor [5].

The elevator control system has a very important role in determining whether the elevator works or not. Elevator control usually uses a PLC control system [6].

In terms of safety, the goods elevator is dangerous if it carries people because the goods elevator is made not to carry humans. The lack of air ventilation makes it very dangerous for humans to be in it [7]. Generally, elevators use motors as a driver and have space for placing goods. From here, a mini props system will be created, the system has the same function as an actual elevator in several high-rise buildings. This design will make it easier to understand how the system works and controls the elevator. In general, the actual control system in an elevator uses a PLC, but in this mini system the PLC controller is replaced by using another controller. One alternative that can be used to replace the work of the PLC is by using an Arduino microcontroller [8]. The Arduino and PLC microcontrollers have several similar functions, both devices can be programmed (in their own way), and have the same Pin/Port, namely input or output [9] [2]. Therefore, based on this understanding, an elevator was created with a control system using the Arduino Mega 2560 microcontroller which is an alternative to replace the PLC.

Arduino is used as the brain that carries out the process to then execute electronic circuits [10]. In the Arduino system circuits the aim is to read the input, process the input and then produce the output as desired [11]. Inside there is a main component, namely a microcontroller chip, Arduino itself is used because it is easy to learn [12]. Based on this background, the title "Design of an Automatic Goods Moving Equipment System to Multilevel Floors with Arduino" is taken with the author hoping to be able to create a more efficient and useful goods moving system.

2. Research Methods

The purpose of the research conducted is to create a tool that can assist in the process of moving goods to multilevel floors. The system created can work automatically using the Arduino Mega 2560 Microcontroller and a DC Motor. The microcontroller functions as the controller and the DC motor as the driving force.

2.1. System Design

The system design is presented in the form of a block diagram which can be seen in Fig. 1. The Arduino Mega 2560 acts as a controller and performs data processing that is read by each sensor and limit switch. Two 12 Volt DC motors are used to drive goods up and down besides that they are used to push goods. Infrared sensors are used to detect the presence or absence of goods. The L298N motor driver controls two motors. The limit switch acts as a sensor to stop the lift when it goes down, besides that it is used as a pusher off button when it returns to the garage.

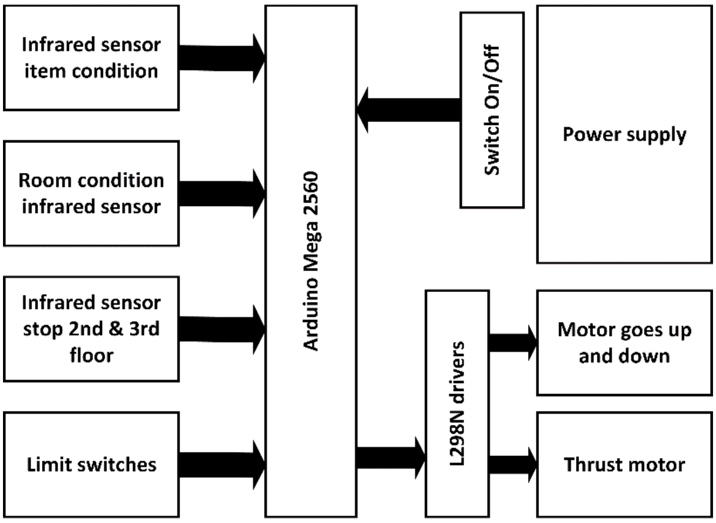

Fig. 1. System block diagram

While the overall system wiring diagram can be seen in Fig. 2. The two DC motors use 12 volts and the sensor uses 5 volts. The sensors used are 6 pieces consisting of 3 sensors in each room, 2 sensors to detect floors and 1 sensor to detect goods. Then, there are 2 limit switches. The sensor and limit switch are connected to the input data lines Pin 2, 3, 4, 5, 6, 7, 8 and 9 on the Arduino Mega microcontroller.

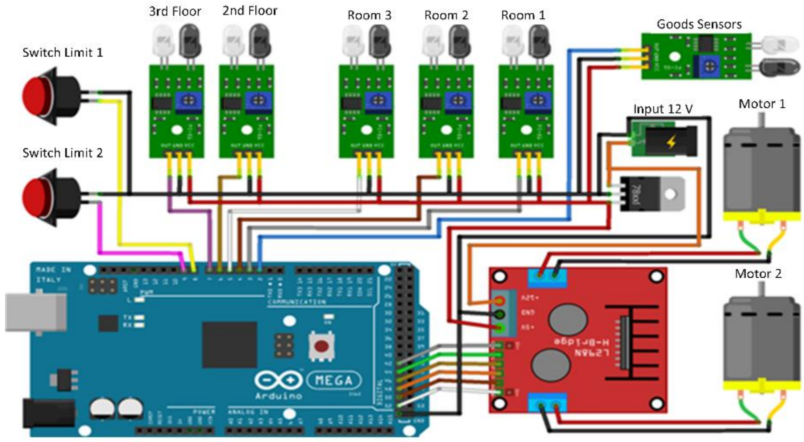

Fig. 2. Wiring diagram

2.2. Algorithm

After making the hardware design is complete, the next step is the software design (command program). The design of the software is made using the default software from Arduino, namely the Arduino IDE, which is then uploaded or downloaded on the Arduino Mega 2560. The first thing that needs to be done before making the program is to make a flowchart (flow chart) as a guide in writing the program. The flow chart can be seen in Fig. 3 and Fig. 4.

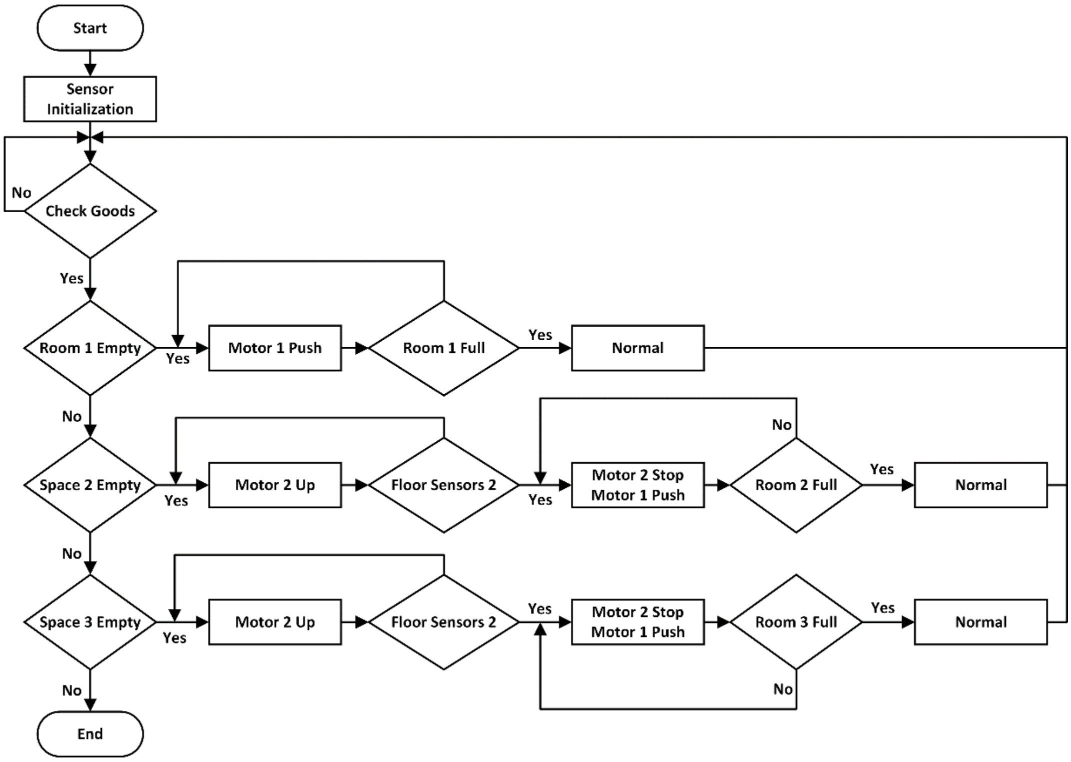

Fig. 3. Goods movement system flowchart

The information in Fig. 3 is that the sensor detects the goods will analyze whether the goods are read or not, if the sensor detects the presence of goods, the space sensor will carry out an analysis, if the analyzed space is empty, Arduino Mega will process the input data from the sensor and will move the motor to deliver the goods. according to free space detection. Fig. 4 is the process of returning the elevator cage to its initial position before sending goods. Starting from the tool moves backwards until the limit switch is pressed, then moves down until the limit switch is pressed.

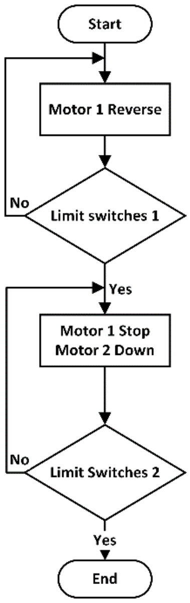

Fig. 4. Flowchart back to cage

2.3. Accuracy

Test results data can obtain the percentage of success or accuracy to determine whether the tool made is suitable or not with the purpose of manufacture. The percentage of success of the system of placing goods to the multilevel floor designed in carrying out orders is calculated by Equation (1).

$$Accuracy\ (\%) = \frac{\sum Space\ 1 + \sum Space 1 + \sum Space\ 3}{\sum Experimental\ x \sum Space}\ X\ 100\% \quad (1)$$

The Room 1 variable is the number of successes in room 1, Room 2 variable is the number of successes in room 2, Room 3 variable is the number of successes on the 3rd floor. Then, the experimental variable is the number of trials and the Room variable is the number of trial rooms.

3. Results and Discussion

Testing the placement of goods packages is done by 3 methods. The first method tests the placement of goods to 3 floors sequentially with the goods being tested sequentially starting from the 1st floor to the 3rd floor. The second method tests the placement of goods with 1 empty floor. While the third method is testing the placement of goods with 2 combination empty floors.

3.1. Testing the placement of goods to 3 floors sequentially

In the placement of goods to 3 floors sequentially carried out 10 times. The data on the results of the item placement test are shown in Table 1. There were failures in trials 5, 6 and 9 so that the accuracy did not reach 100 percent.

Table 1. Results of placing goods on 3 floors sequentially

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	√	√	√	100 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	×	√	×	33.3 %
6	√	√	×	66.7 %
7	√	√	√	100 %
8	√	√	√	100 %
9	√	√	x	66.7 %
10	√	√	√	100 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 2. In room 1 there were 9 successes, in room 2 there were 10 successes and in room 3 there were 7 successes. Therefore, an accuracy of 86.7 percent is obtained.

Table 2. Results of placing goods on 3 floors sequentially

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	9	10	7	86.7 %

The percentage of successful tools in executing commands is calculated by Equation (2).

$$Accuracy\ (\%)\ = \frac{9+10+7}{10\ \times\ 3} \times\ 100\%\ = 86.7\% \tag{2}$$

From testing 30 attempts to place goods on 3 floors sequentially, there were 4 failures. Failure occurs when items pushed into the room fall without hitting the space sensor readings. Space sensors are at the front of each room. The percentage of successful testing of the tool in carrying out orders is 86.7%, items can be placed according to space.

3.2. Goods Placement with 1 Empty Floor

Placement of goods with this method is carried out with 3 placement classes, namely the first placement in room 1 with the goods to be sent to room 1, then room 2, and room 3. with the order of taking from the goods in room 1 to the goods in room 3. Then from the data collected obtained will be calculated the percentage level of success.

3.2.1. Empty Room 1st Floor

The 1st floor free room test is carried out when all the spaces are filled with goods, then on the 1st floor it is detected as empty because there are no goods. Data from the test results are shown in Table 3. There was 1 failure in the experiment, namely in the 7th trial.

Table 3. The results of the placement of goods 1 empty space on the 1st floor

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	√	√	√	100 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	√	√	√	100 %
6	√	√	√	100 %
7	×	√	√	66.7 %
8	√	√	√	100 %
9	√	√	√	100 %
10	√	√	√	100 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 4. In room 1 there are 10 successes, in room 2 there are 10 successes and in room 3 there are 10 successes. Therefore, an accuracy of 96.7 percent is obtained.

Table 4. The percentage of successful placement of goods in 1 empty space on the 1st floor

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	9	10	10	96.7 %

The percentage of successful tools in executing commands is calculated by Equation (3).

$$Accuracy\ (\%)\ = \frac{9+10+10}{10\ \times\ 3} \times\ 100\%\ = 96.7\% \tag{3}$$

In the room on the 1st floor, 10 trials were carried out, there was 1 failure in the 7th test because the falling object did not hit the sensor reading so that the accuracy result was 96.7%.

3.2.2. Empty Room Floor 2

The second test, the empty space on the 2nd floor is carried out when all the space is filled with goods. Then on the 2nd floor it was detected as empty because there were no goods. The test results data are shown in Table 5.

Table 5. The results of the placement of goods 1 empty space on the 2nd floor

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	√	√	√	100 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	√	√	√	100 %
6	√	√	√	100 %
7	√	√	√	100 %
8	√	√	√	100 %
9	√	√	√	100 %
10	√	√	√	100 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 6. In room 1 there are 10 successes, in room 2 there are 10 successes and in room 3 there are 10 successes. Therefore, obtained accuracy of 100 percent.

Table 6. Percentage of successful placement of goods 1 empty space on the 2nd floor

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	10	10	10	100 %

The percentage of successful tools in executing commands is calculated by Equation (4)

$$Accuracy\ (\%) = \frac{10 + 10 + 10}{10 \times 3} \times 100\% = 100\% \quad (4)$$

In the room on the 2nd floor, the same test was carried out, namely 10 trials. In this test there were no failures in the test so that 100% success accuracy was obtained without any failure.

3.2.3. Empty Room Floor 3

Testing the empty space on the 3rd floor is carried out when all the spaces are filled with goods, then on the 3rd floor it is detected as empty because there are no goods. The test results data are shown in Table 7.

Table 7. The results of the placement of goods 1 empty space on the 3rd floor

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	√	√	√	100 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	√	√	√	100 %
6	√	√	√	100 %
7	√	√	√	100 %
8	√	√	√	100 %
9	√	√	√	100 %
10	√	√	√	100 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 8. In room 1 there are 10 successes, in room 2 there are 10 successes and in room 3 there are 10 successes. Therefore, obtained accuracy of 100 percent.

Table 8. The percentage of successful placement of goods in 1 empty room on the 3rd floor

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	10	10	10	100 %

The percentage of successful tools in executing commands is calculated by Equation (5).

$$Accuracy\ (\%) = \frac{10 + 10 + 10}{10 \times 3} \times 100\% = 100\% \quad (5)$$

In 10 attempts in the room on the 3rd floor, the results obtained an accuracy of 100% success without any failure.

In the overall test results of placing items with 1 empty space, the average accuracy of the success of the tool is shown in Table 9.

Table 9. Accuracy of the total success of placing 1 empty space

Space Testing	Results
1	96.7 %
2	100 %
3	100 %
Amount (∑)	98.9 %

Based on the three experiments, the results obtained an accuracy of 98.9%, there were several failures, the failure occurred on the 1st floor, this was because the goods pushed into the destination space did not hit the space reading sensor. The position of the floor of the elevator cage is higher than the floor of room 1. In the case of floors 2 and 3, the position of the floor of the cage is also higher, but on the 1st floor there is a limit switch that makes the position of the cage rise above the position on floors 2 and 3.

3.3. Goods Placement With 2 Empty Floors

In placing goods with 2 empty floors, 3 types of tests are carried out. The first test is that empty space is on floors 1 and 2, the second test is empty space on floors 1 and 3, and the third test is empty space on floors 2 and 3. The combination room is detected as empty at the same time without turning off the system. Then from the data obtained, the percentage of success is calculated.

3.3.1. Empty Combination Room 1st and 2nd Floor

Testing the empty space on floors 1 and 2 was carried out with the condition that room 3 was filled with goods, then floors 1 and 2 were detected as empty because there were no goods. The test results data are shown in Table 10.

Table 10. The results of the placement of goods on 2 empty floors, a combination of rooms 1 and 2

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	√	√	√	100 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	√	√	√	100 %
6	√	√	√	100 %
7	×	×	√	33.3 %
8	×	×	√	33.3 %
9	√	√	√	100 %
10	√	√	√	100 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 11. In room 1 there were 8 successes, in room 2 there were 8 successes and in room 3 there were 10 successes. Therefore, an accuracy of 86.7 percent is obtained.

Table 11. The percentage of successful placement of goods on 2 empty floors, a combination of rooms 1 and 2

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	8	8	10	86.7 %

The percentage of successful tools in carrying out orders for placing goods is calculated by Equation (6)

$$Accuracy\ (\%) = \frac{8+8+10}{10 \times 3} \times 100\% = 86.7\% \quad (6)$$

So, the percentage of success of testing the tool in executing commands is 86.7%. There were several failures in the 7th and 8th trials because if the 1st floor failed, the 2nd floor failed.

3.3.2. Empty Combination Room 1st and 3rd Floor

Testing the empty space on floors 1 and 3 was carried out with the condition that room 2 was filled with goods, then on floors 1 and 3 it was detected as empty because there were no goods. The test results data are shown in Table 12.

Table 12. The results of the placement of goods on 2 empty floors, a combination of rooms 1 and 3

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	×	√	×	33.3 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	√	√	√	100 %
6	√	√	√	100 %
7	√	√	√	100 %
8	×	√	×	33.3 %
9	√	√	√	100 %
10	×	√	×	33.3 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 13. In room 1 there were 7 successes, in room 2 there were 10 successes and in room 3 there were 7 successes. Therefore, obtained accuracy of 100 percent.

Table 13. The percentage of successful placement of goods on 2 empty floors, a combination of rooms 1 and 3

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	7	10	7	80 %

The percentage of successful tools in carrying out orders for placing goods can be calculated by Equation (7)

$$Accuracy\ (\%) = \frac{7+10+7}{10 \times 3} \times 100\% = 80\% \quad (7)$$

The percentage of success of testing the tool in executing commands is 80%. Failures occurred in experiments 1, 8 and 10. Failures occurred as in testing on 2 empty floors, a combination of rooms 1 and 2 with the 1st floor failing to execute placement. On the 3rd floor it will also fail to execute the 2nd item which will be sent to the 3rd floor sent to the 1st floor.

3.3.3. Empty Combination Room 2nd and 3rd Floor

Testing the empty space on the 2nd and 3rd floors was carried out with the condition that room 1 was filled with goods, then on the 2nd and 3rd floors it was detected as empty because there were no goods. The test results data are shown in Table 14.

Table 14. The results of the placement of goods on 2 empty floors, a combination of rooms 2 and 3

Experiment to-	Room 1	Room 2	Room 3	Accuracy %
1	√	√	√	33.3 %
2	√	√	√	100 %
3	√	√	√	100 %
4	√	√	√	100 %
5	√	×	×	33.3 %
6	√	√	√	100 %
7	√	√	√	100 %
8	√	√	√	100 %
9	√	×	×	33.3 %
10	√	√	√	100 %

*Remarks sign √ = successful placing of goods, × = failed to place goods

The percentage of success can be seen in Table 15. In room 1 there were 10 successes, in room 2 there were 8 successes and in room 3 there were 8 successes. Therefore, an accuracy of 86.7 percent is obtained.

Table 15. The percentage of successful placement of goods on 2 empty floors, a combination of rooms 2 and 3

	Room 1	Room 2	Room 3	Accuracy
Total (∑)	10	8	8	86.7 %

The percentage of successful tools in executing commands is calculated by Equation (8)

$$Accuracy\ (\%)\ = \frac{10+8+8}{10\ \times\ 3} \times\ 100\%\ = 86.7\% \tag{8}$$

Failed on the 5th and 9th trials because the items pushed into the space were not perfect. The item falls without hitting the item detection sensor. The percentage of success of testing the tool in executing commands is 86.7%.

The average test results for the overall placement of goods in 2 empty spaces are shown in Table 16. The accuracy of the test success of the three combination rooms was 84.47% and there were several failures in the combination trials, failures occurred because the system executed imperfectly, when executing goods If the first item fails to be placed, the second item will also fail, but if the first item is successful, the execution does not necessarily mean that the second item is successful. This is because the goods that are pushed into the destination space do not fall on the space reading sensor. Room reading sensors are located at the end of the room on each floor 1, 2 and 3. Meanwhile, other failures are found on the elevator cage floor which is higher than the floor. In the case of the 2nd and 3rd floor the cage floor position is also higher, but on the 1st floor there is a limit switch that makes the cage position rise above the position on the 2nd and 3rd floor.

Table 16. Accuracy of total placement of goods in 2 combined empty spaces

Combination Room Testing	Results
1 and 2	86.7 %
1 and 3	80 %
2 and 3	86.7 %
Amount (∑)	84.47 %

4. Conclusion

Based on the results of the research that has been done, it can be concluded that the lift simulator design can work as expected. Using the Arduino Mega 2560 microcontroller as the control brain of the elevator, infrared sensors and limit switches as system control inputs, then a 12V DC motor as a driver of goods and driving the elevator cage up and down. This simulator work system by moving goods that have been packed to the multilevel floor as a storage area (warehouse). Besides that, the simulator that has been made is good and feasible. The system can execute orders to place goods to 3 floors sequentially with a success accuracy of 86.7%, then place goods with 1 empty space with a success accuracy of 98.9%, and place goods with 2 combined empty spaces with a success accuracy of 84.47%.

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