AIP Conference Proceedings

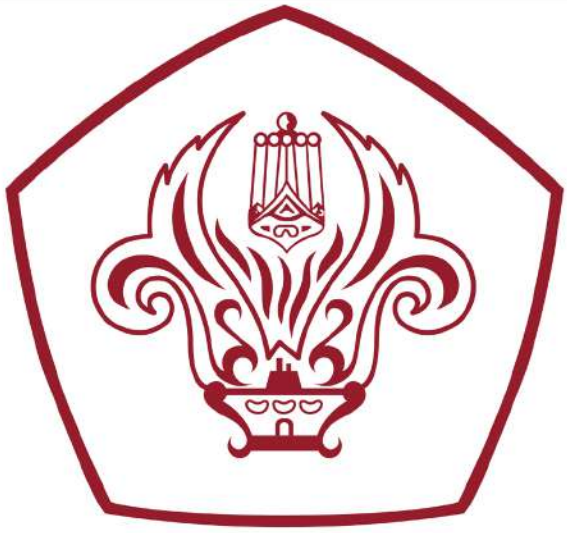
AIP Publishing

Volume 2680

Proceedings of the 4th Tarumanagara International Conference of the Applications of Technology and Engineering (TICATE) 2021

Jakarta, Indonesia • 5–6 August 2021

Editors • Benny Tjahjono, Soh Sie Teng, A. Ruggeri Toni Liang, Lenin Gopal, Hugeng Hugeng, Channing Chuang and Tresna Priyana Soemardi



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Online ISSN 1551-7616 Print ISSN 0094-243X

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RESEARCH ARTICLE | DECEMBER 07 2023

Design of automatic shoebox sorter based on color

Inoki Chandra; Wahidin Wahab; Endah Setyaningsih

AIP Conf. Proc. 2680, 020038 (2023)
https://doi.org/10.1063/5.0128004

Design of Automatic Shoebox Sorter Based on Color

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Abstract. Most small shoe industry are still using traditional machineries to conduct their day-to-day operations. However, there is an increasing need to improve its production line in the hopes of meeting the demand and improving the quality of the product at the same time. By doing so, competing with the other competitors around Jakarta in the long run will be possible. Therefore the 200 cm x 39 cm x 45.5 cm conveyor belt is designed to sort shoebox according to its color. When the system figures out the color of the box, then it will automatically count the number of the box with that particular color. Hence, this paper concludes that it can conduct automated color sorting and also calculating the number of shoebox that went throught the conveyor belt, while being able to see the updates remotely through a smartphone application.

Keywords: Industry, conveyor, color, shoebox, a smartphone application.

INTRODUCTION

The development of the industrial world today is growing rapidly. This is indicated by the number of various kinds of Industries. Competition continues to increase regardless of which industries have been able to survive or which are just starting. Moreover, the industry involves significant challenges for SMEs because large companies are not always willing to share information about their by-products to create industrial symbiosis flows [1].

Most manufacturers used humans, animals, or resources such as wind and hydropower to operate their productions. However, the disadvantage of human/animal labor were that they only able to exert small amounts of energy, which will hinder production process since manufacturers were only able to operate during working hours. In overcoming this problem, machineries were created to reduce production time while improving the overall efficiency within the production process, that eventually leads to the reduction of production cost. The first industrial revolution is considered as one of the important advancements in humanity, which started by using mechanical manufacturing facilities [2].

Currently, the industrial revolution has entered the era of 4.0, this era is implanted with intelligent technology that can be connected to various areas of human life or what is commonly called the Internet of Things (IoT). Industrial revolution (Industry 4.0) refers to the confluence of technologies ranging from a variety of digital technologies [3].

The small shoe industry is still traditional because in working on production goods it still uses technology/tools that are still simple. From the existing shoe industry, there are various obstacles, one of which is cost, to get a profit, usually small or home-based industries take the initiative to seek minimal profit to buy raw materials from the industry. In addition, in an industry that has quite high competitors in the city of Jakarta, shoes are a products that are often used by the community and are a necessity for most people in Jakarta. The shoe industry will

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Published by AIP Publishing. 978-0-7354-4698-4/$30.00

not be able to compete if it does not improve and catch up with its competitors products, it is necessary to improve the production process and other innovations that can help the competitiveness of the shoe industry.

In other words, innovations are required for these small-scaled manufacturers to survive the competition. Therefore, an Android-based shoebox sorter is created as one of the ways to automate the production line. This is a conveyor belt that is designed to sort shoebox according to its particular color. Besides that, it can show the number of shoebox that went into the conveyor belt based on its color and it can be seen remotely through a smartphone.

THE DESIGN CONCEPT

This automatic shoebox sorter uses several components such as: an Arduino MEGA 2560, a Wi-Fi module ESP-01, a TCS3200 color sensor, a FC-51 infrared sensor, an MG996R servo micro, a 20 x 4 Liquid Crystal Display (LCD), a 4-channel relay, a 24V DC motor, a 24V power supply switching, an XL4015 step-down converter module, and an Android-based application called Blynk.

Arduino MEGA 2560 is an Arduino-based microcontroller using the Atmega2560 chip. The Arduino MEGA can be powered via a USB connection or by an external power supply. Arduino MEGA operates with a working voltage of 5 volts to 20 volts. The board has multiple I/O pins that consists of 54 digital I/O pins (15 of which are PWM), 16 analog input pins, and 4 UART pins (serial hardware port) [4]. Arduino MEGA has several facilities to communicate with computers, other Arduino modules, and other microcontrollers. The Arduino MEGA 2560 microcontroller is used in this design because it has many I/O pins to connect to each module used in this design and can be used as the main program manager. An integrated development environment (IDE) is a piece of software whose role is to write programs, compile programs into binary code and load the program into memory.

ESP-01 is a module that allows access to the microcontroller via the internet. This module uses AT-Command for its configuration. ESP-01 has a ESP8266 chipset in it that allows microcontrollers to communicate wirelessly [5]. The ESP-01 Wi-Fi module is used as a connector for devices designed with android applications so that they can connect or communicate with smartphone devices.

TCS3200 is an IC (Integrated Circuit) to convert the color to be detected into a frequency that will be processed by the microcontroller. The color sensor can also be used as a motion sensor, the sensor can detect the movement of an object based on the color changes received by the sensor. The color sensor works with each LED emitting light, the light will be reflected by the detected object, the amount of light intensity of each LED color reflected from the detected object will vary depending on the color of the object to be detected. This TCS3200 color sensor module is used as a color detector on each shoebox. Basically TCS3200 color sensor is a light sensor that equipped with a light filter for basic color like RGB (RedGreen-Blue) [6].

The FC-51 infrared sensor is used to detect each shoebox using reflected infrared light. This sensor has two main parts, namely IR emitter and IR receiver. To emit infrared light, an Infrared Light Emitting Diode (IR LED) is used while to receive reflected light from red light (infrared) a photodiode is needed. Infrared sensors detect the object's distance with infrared radiation [7].

Servo micro MG99R is a device or motor designed with a feedback system (closed-loop). The use of a feedback system (closed-loop) on the servo motor is useful for controlling the rotation and final position of the servo motor shaft. This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package [8]. Servo micro MG996R is used as a sorter to show the place of each color on each shoebox that has been detected by color and infrared sensors.

Liquid Crystal Display (LCD) is a type of display unit that uses liquid crystals as the main display. Two principle components of LCD is mercury and liquid crystals [9]. This LCD is used as a display consisting of 4 lines, each line consisting of 20 characters, the contents of each line are the results of color detection from each shoebox.

Relay is a switch that opens and closes ciruits by receiving electrical signals from outside sources. It consists of two main parts, the coil and switch. Relay Module is a module that is very practical for use as a main switch with electronic circuits [10]. The 4-channel relay module is used to trigger the DC motor, adjust the direction motor (clockwise or counterclockwise), and turn the indicator lights on.

The DC motor consists of several elements, namely magnets, rotors, brushes, and axles [11]. The DC motor was configured to be under simple closed-loop speed control configuration, and using the PWM method to set the reference speed such that it could be easily controlled to reach the desired position using the microcontroller [12]. This 24V DC motor is used to drive the movement of conveyor line from input position to output position.

Voltage regulators can be broadly divided into 3 types, namely linear regulators, switching, and in the form of an Integrated Circuit (IC). A Power Supply Unit, or PSU, is a power supply that uses switching technology, instead

of the traditional iron-core transformer. This PSU serves to convert AC voltage into DC voltage and also as a power supply. Meanwhile the XL4015 step-down converter module is used to reduce the DC voltage from the power supply to the desired DC voltage.

Smartphone applications are ready-made programs that carry out certain functions installed on mobile devices. This Blynk application is used to design android applications as desired. Blynk application using various layouts and components available as desired and to display data from each shoe production in each color from the shoebox in this design.

Diagram block of automatic shoebox sorter based on color is shown in **FIGURE 1**.

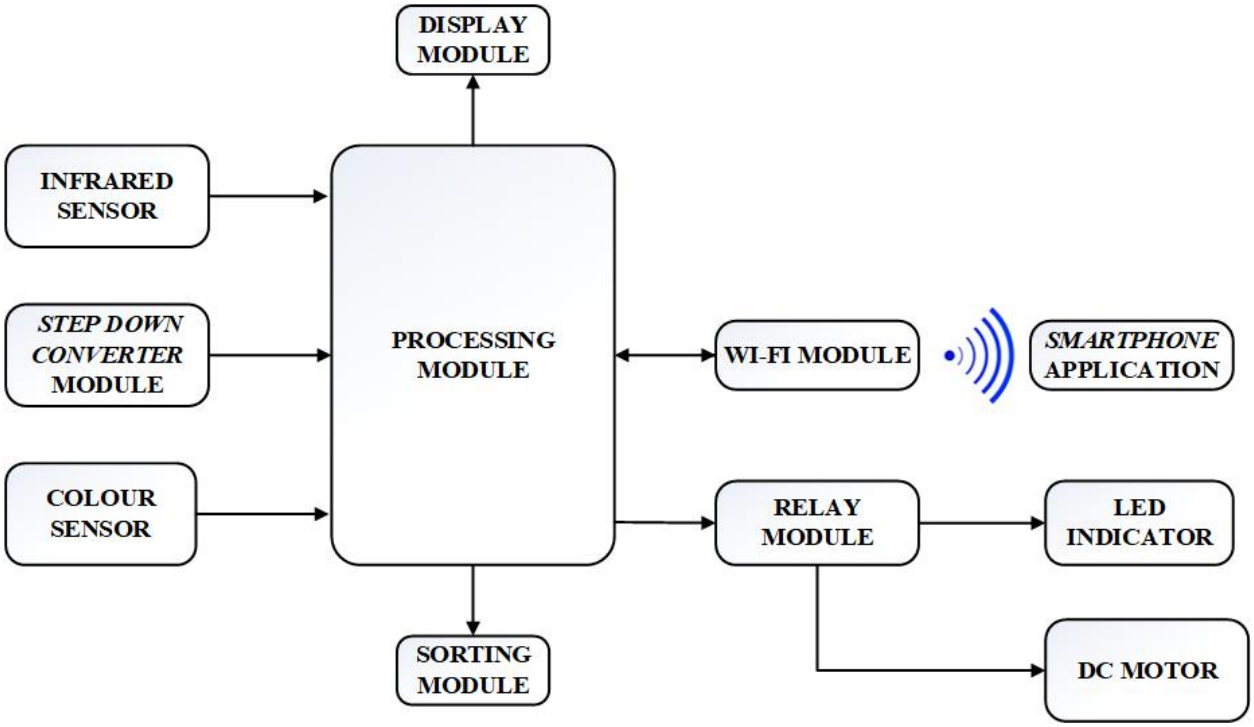

FIGURE 1. Diagram Block of Automatic Shoes Box Sorter Based On Color

THE CONSTRUCTION AND DISCUSSION

Based on the diagram block on **FIGURE 1**. The system is made out of several modules, that are both designed from scratch and also purchased off-the-shelves. Starting from the power supply module that provides input voltage that can start this design. The processing module acts as a data processor from input to output in this design. The processing module is the core of the entire module which can be adjusted starting from the sensor module to detect objects, the display module is used to display the detection results from the sensor module, the sorting module will sort objects according to their respective color locations, the relay module will stop the system when the button is clicked when the emergency button is pressed. The DC motor can turn the direction of movement of the conveyor forward or backward, and the Wi-Fi module can be connected by an internet connection. The sketch of the tool for sorting the type of shoe production based on this color can be seen in **FIGURE 2** and **FIGURE 3**. **FIGURE 2** shows a side view of the shoe production sorter tool based on the color, and **FIGURE 3** shows the realization of the overall system design.

The results of testing and analysis are aimed to ensure that each module used in this design will be working well. Testing and analysis are also useful for knowing the performance of the designed module, the module that is not designed, and the whole system. The test plan consists of testing the infrared sensors, color sensors, dc motors, step-down modules, and the realization of the overall system. Testing is done by using each module in the test plan to find out that each module used in this design can function properly according to its function, such as infrared sensors can detect objects that are in front of the sensor range, color sensors can detect colors on each object, the dc motor can

move clockwise and counter clockwise, the step-down converter module can reduce the voltage as desired, and every whole system can function properly.

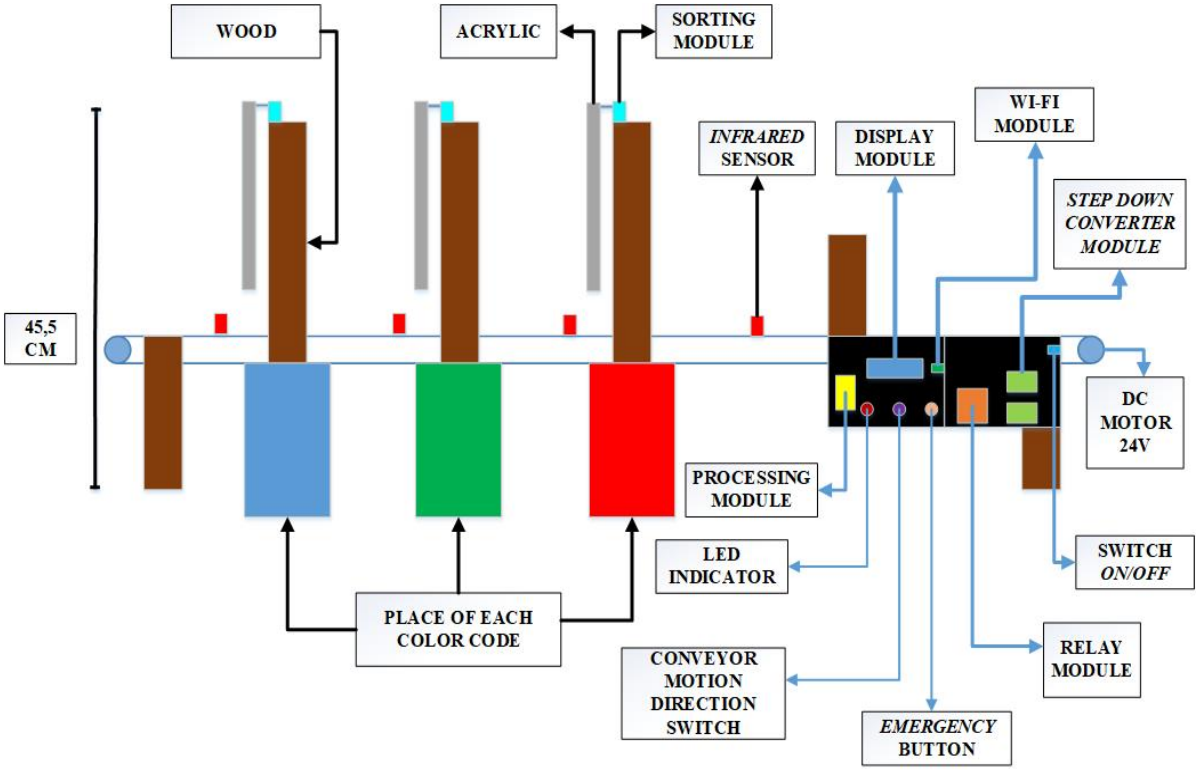

FIGURE 2. Side View Sketch of Shoebox Production Sorting Tool Based on Color

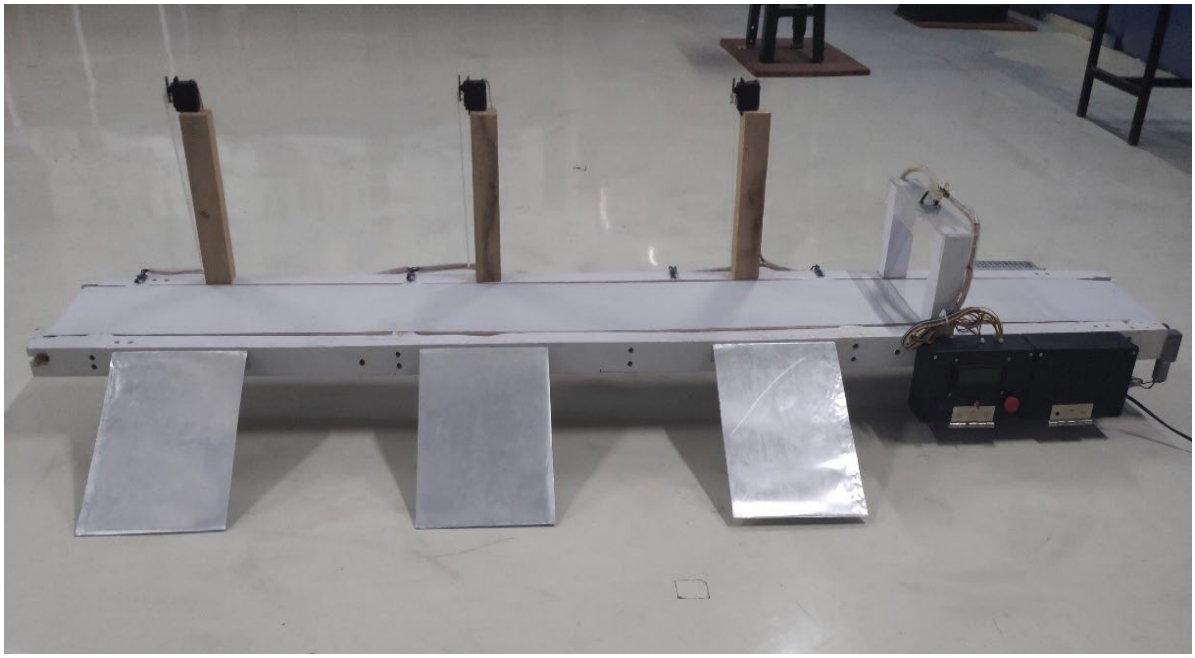

FIGURE 3. The Design Results of Automatic Shoebox Sorter Based On Color

The results of testing the infrared sensor module is shown in **TABLE 1**. It can be said that the infrared sensor can only measure a maximum distance of up to 12 cm and if the object passes over a distance of 12 cm it will not be detected.

TABLE 1. Test Result Of Infrared Sensor

The Distance Measured By The Sensors	Result Measured By Infrared Sensors
1 cm	Detected
4 cm	Detected
8 cm	Detected
12 cm	Detected
16 cm	Not Detected
20 cm	Not Detected

The result of testing the color sensor is shown in **TABLE 2**. It can be seen in **TABLE 2**. that the color sensor can detect three different colors, namely red, green, and blue. Each color is measured with a maximum distance of 5 cm. The maximum distance from the detection of the color sensor to red and green is 4 cm, while the maximum detection of blue is 5 cm.

TABLE 2. Test Result Of Color Sensor

The Distance Measured By The Sensors	Color On Object		
	Red	Green	Blue
1 cm	Detected	Detected	Detected
2 cm	Detected	Detected	Detected
3 cm	Detected	Detected	Detected
4 cm	Detected	Detected	Detected
5 cm	Not Detected	Not Detected	Detected

DC motor testing is done by testing the rotation of the DC motor to be able to move clockwise and counter clockwise. This test can be seen on a conveyor that has been made in this design to see the movement of the conveyor. The test results of the DC motor can be seen in **TABLE 3**.

TABLE 3. Test Result Of DC Motor

Voltage Source	Input	Motor Direction	Conveyor
Power Supply	+24V	Clockwise	Move forward
Power Supply	-24V	Counter Clockwise	Move backward

Testing the step-down module is done by providing a voltage input using a 24V switching power supply as the input voltage from the step-down module. This test is conducted to determine the output voltage of the step-down module resulting from the measurement results of the step-down module. Measurement of the output voltage on the step-down module is done using a multimeter. The results of the step-down module test can be seen in **TABLE 4.**

TABLE 4. Test Result Of Step-down Converter

Voltage Indicator	Input Voltage Of Power Supply	Output Voltage Of Step Down Module
Maximum	+24,35V	24,35V
Minimum	+24,35V	1,23V

Testing the whole system is done by testing the entire module used in this design. The test is done by looking at the results of the number of shoe production on the smartphone application, namely Blynk. The Blynk application shows results from the detection of each color from each shoe production. Test results is shown in **TABLE 5**.

The second test was carried out on the power supply system, which is the power source for the entire module. It also to make sure that when the power supply is on, the entire system can run properly, which includes: the processing module is the core module used to run all modules starting from the sensor module to be able to detect objects. The LCD displays the detection results from the sensor module, the sorting module to be able to sort shoebox to its designated place. Besides that making sure that the relay module is able to stop the system when the emergency button is pressed. Then the driver module should be able to move the conveyor belt either clockwise or counterclockwise and finally, ensuring that the Wi-Fi module is able to connect to an internet connection. Test results is shown in **TABLE 6.**

TABLE 5. The Results of Testing the Whole System with Smartphone Application

Testing	Color on shoebox	Color Read on LCD	Shoebox Placement By Sorting Module	Number of Items on LCD Screen	Number of Items on the Blynk App
1	Red	Red	Red	1	1
	Red	Red	Red	2	2
	Blue	Blue	Blue	1	1
2	Green	Green	Green	1	1
	Red	Red	Red	3	3
	Green	Green	Green	2	2
3	Blue	Blue	Blue	2	2
	Blue	Blue	Blue	3	3
	Green	Green	Green	3	3
4	Yellow	Green	Green	4	4
	Brown	Green	Green	5	5
	Purple	Blue	Blue	4	4

TABLE 6. Results Of Testing for Entire System On Each System

No.	Testing	Test Result
1.	Power Supply System can Power Entire Module	successful
2.	The relay module can stop the system when the emergency button is pressed	successful
3.	DC Motor can run the direction of movement of the conveyor (Clock Wise) and (Counter Clock Wise) when the toggle switch is moved	successful
4.	Wifi Module can Connect Device with Smartphone Application	connected
5.	Processing Module can Run Entire system	successful

CONCLUSION

Based on the test results of each module that is in the design automatic shoebox sorter based on color, it is concluded that:

From the results of the design of automatic shoebox sorter based on color, it has been successfully implemented using the TCS3200 color sensor as a color detector for each shoebox, 3 sorting modules as a place to sort each color on the shoebox, and a dc motor as a conveyor driver. The colors that were successfully sorted on the shoebox were red, green, and blue.

ACKNOWLEDGEMENT

The authors would like to thank the Dean of Engineering Faculty and Program Head for Electrical Engineering for supporting our Subject Program. We would extend our gratitude and thank to Directorate of Research and Community Engagement Universitas Tarumanagara for supporting part of our research funding.

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by Endah Setyaningsih

Submission date: 11-Dec-2023 09:15AM (UTC+0700)
Submission ID: 2254898006
File name: 020038_1_5.0128004_1.pdf (449.45K)
Word count: 3288
Character count: 16343

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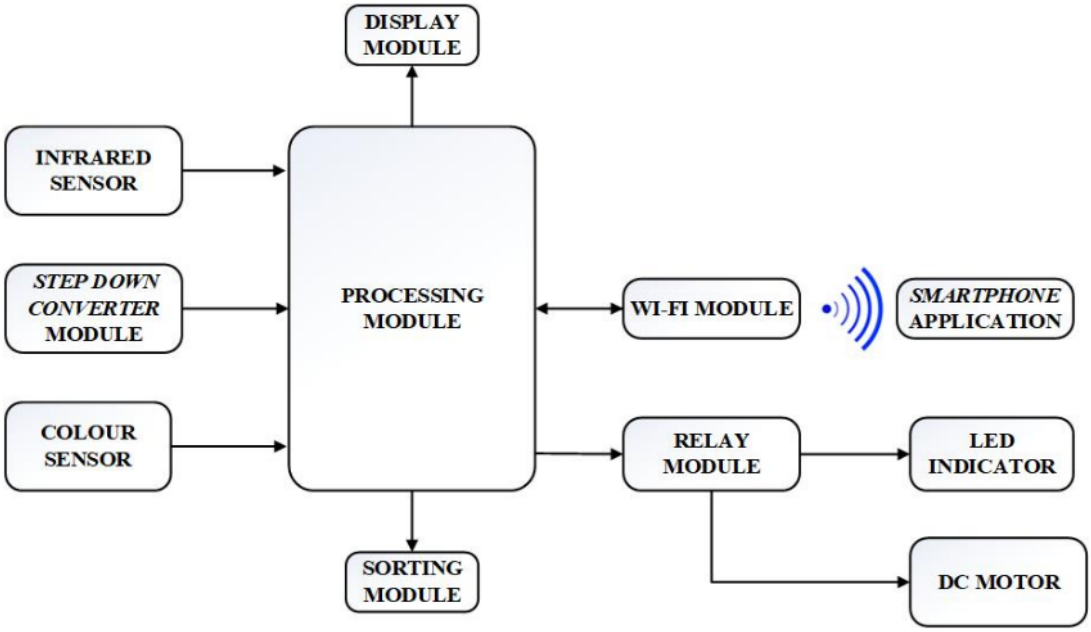

FIGURE 1. Diagram Block of Automatic Shoes Box Sorter Based On Color

THE CONSTRUCTION AND DISCUSSION

Based on the diagram block on **FIGURE 1**. The system is made out of several modules, that are both designed from scratch and also purchased off-the-shelves. Starting from the power supply module that provides input voltage that can start this design. The processing module acts as a data processor from input to output in this design. The processing module is the core of the entire module which can be adjusted starting from the sensor module to detect objects, the display module is used to display the detection results from the sensor module, the sorting module will sort objects according to their respective color locations, the relay module will stop the system when the button is clicked when the emergency button is pressed. The DC motor can turn the direction of movement of the conveyor forward or backward, and the Wi-Fi module can be connected by an internet connection. The sketch of the tool for sorting the type of shoe production based on this color can be seen in **FIGURE 2** and **FIGURE 3**. **FIGURE 2** shows a side view of the shoe production sorter tool based on the color, and **FIGURE 3** shows the realization of the overall system design.

The results of testing and analysis are aimed to ensure that each module used in this design will be working well. Testing and analysis are also useful for knowing the performance of the designed module, the module that is not designed, and the whole system. The test plan consists of testing the infrared sensors, color sensors, dc motors, step-down modules, and the realization of the overall system. Testing is done by using each module in the test plan to find out that each module used in this design can function properly according to its function, such as infrared sensors can detect objects that are in front of the sensor range, color sensors can detect colors on each object, the dc motor can

move clockwise and counter clockwise, the step-down converter module can reduce the voltage as desired, and every whole system can function properly.

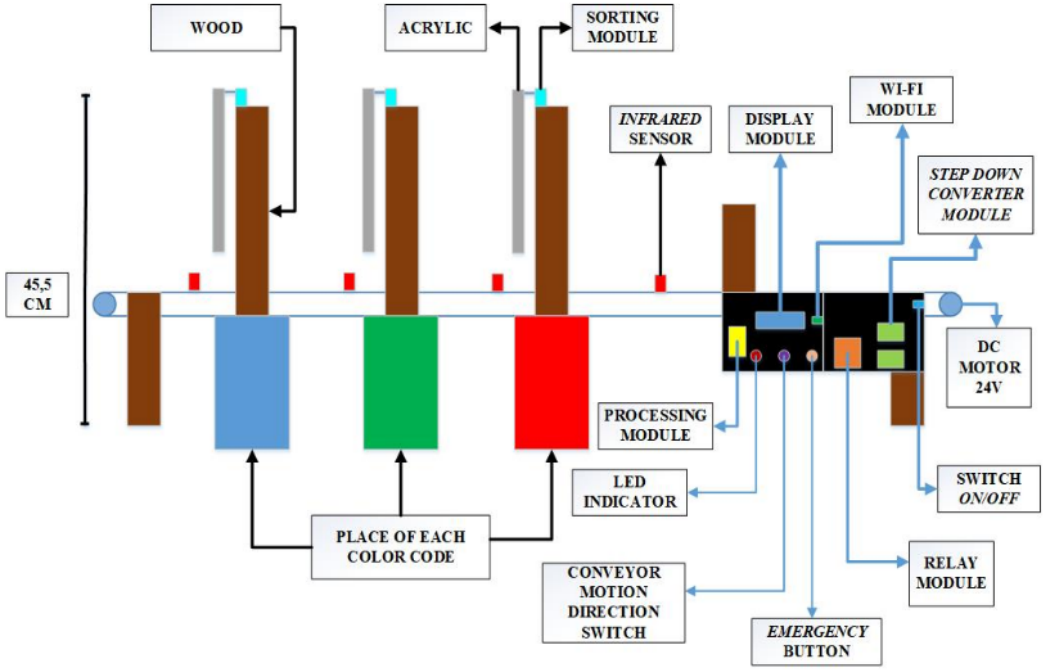

FIGURE 2. Side View Sketch of Shoebox Production Sorting Tool Based on Color

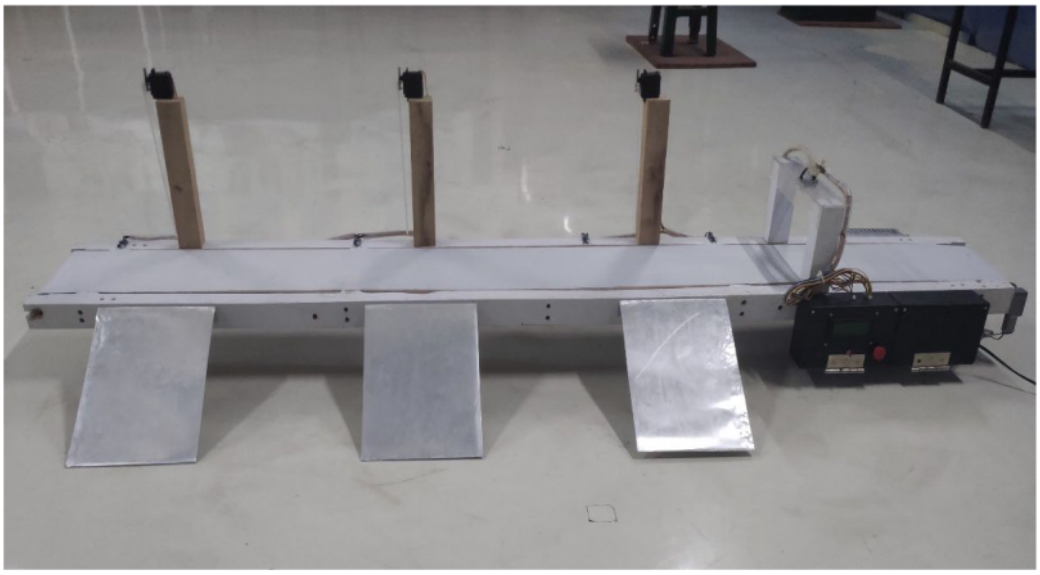

FIGURE 3. The Design Results of Automatic Shoebox Sorter Based On Color

The result of testing the infrared sensor module is shown in **TABLE 1**. It can be said that the infrared sensor only measure a maximum distance of up to 12 cm and if the object passes over a distance of 12 cm it will not be detected.

TABLE 1. Test Result Of Infrared Sensor

The Distance Measured By The Sensors	Result Measured By Infrared Sensors
1 cm	Detected
4 cm	Detected
8 cm	Detected
12 cm	Detected
16 cm	Not Detected
20 cm	Not Detected

The result of testing the color sensor is shown in **TABLE 2**. It can be seen in **TABLE 2**. that the color sensor can detect three different colors, namely red, green, and blue. Each color is measured with a maximum distance of 5 cm. The maximum distance from the detection of the color sensor to red and green is 4 cm, while the maximum detection of blue is 5 cm.

TABLE 2. Test Result Of Color Sensor

The Distance Measured By The Sensors	Color On Object		
	Red	Green	Blue
1 cm	Detected	Detected	Detected
2 cm	Detected	Detected	Detected
3 cm	Detected	Detected	Detected
4 cm	Detected	Detected	Detected
5 cm	Not Detected	Not Detected	Detected

DC motor testing is done by testing the rotation of the DC motor to be able to move clockwise and counter clockwise. This test can be seen on a conveyor that has been made in this design to see the movement of the conveyor. The test results of the DC motor can be seen in **TABLE 3**.

TABLE 3. Test Result Of DC Motor

Voltage Source	Input	Motor Direction	Conveyor
Power Supply	+24V	Clockwise	Move forward
Power Supply	-24V	Counter Clockwise	Move backward

Testing the step-down module is done by providing a voltage input using a 24V switching power supply as the input voltage from the step-down module. This test is conducted to determine the output voltage of the step-down module resulting from the measurement result of the step-down module. Measurement of the output voltage on the step-down module is done using a multimeter. The results of the step-down module test can be seen in **TABLE 4.**

TABLE 4. Test Result Of Step-down Converter

Voltage Indicator	Input Voltage Of Power Supply	Output Voltage Of Step Down Module
Maximum	+24,35V	24,35V
Minimum	+24,35V	1,23V

Testing the whole system is done by testing the entire module used in this design. The test is done by looking at the results of the number of shoe production on the smartphone application, namely Blynk. The Blynk application shows results from the detection of each color from each shoe production. Test results is shown in **TABLE 5**.

The second test was carried out on the power supply system, which is the power source for the entire module. It also to make sure that when the power supply is on, the entire system can run properly, which includes: the processing module is the core module used to run all modules starting from the sensor module to be able to detect objects. The LCD displays the detection results from the sensor module, the sorting module to be able to sort shoebox to its designated place. Besides that making sure that the relay module is able to stop the system when the emergency button is pressed. Then the driver module should be able to move the conveyor belt either clockwise or counterclockwise and finally, ensuring that the Wi-Fi module is able to connect to an internet connection. Test results is shown in **TABLE 6.**

TABLE 5. The Results of Testing the Whole System with Smartphone Application

Testing	Color on shoebox	Color Read on LCD	Shoebox Placement By Sorting Module	Number of Items on LCD Screen	Number of Items on the Blynk App
1	Red	Red	Red	1	1
	Red	Red	Red	2	2
	Blue	Blue	Blue	1	1
2	Green	Green	Green	1	1
	Red	Red	Red	3	3
	Green	Green	Green	2	2
3	Blue	Blue	Blue	2	2
	Blue	Blue	Blue	3	3
	Green	Green	Green	3	3
4	Yellow	Green	Green	4	4
	Brown	Green	Green	5	5
	Purple	Blue	Blue	4	4

TABLE 6. Results Of Testing for Entire System On Each System

No.	Testing	Test Result
1.	Power Supply System can Power Entire Module	successful
2.	The relay module can stop the system when the emergency button is pressed	successful
3.	DC Motor can run the direction of movement of the conveyor (Clock Wise) and (Counter Clock Wise) when the toggle switch is moved	successful
4.	Wifi Module can Connect Device with Smartphone Application	connected
5.	Processing Module can Run Entire system	successful

CONCLUSION

Based on the test results of each module that is in the design automatic shoebox sorter based on color, it is concluded that:

From the results of the design of automatic shoebox sorter based on color, it has been successfully implemented using the TCS3200 color sensor as a color detector for each shoebox, 3 sorting modules as a place to sort each color on the shoebox, and a dc motor as a conveyor driver. The colors that were successfully sorted on the shoebox were red, green, and blue.

ACKNOWLEDGEMENT

The authors would like to thank the Dean of Engineering Faculty and Program Head for Electrical Engineering for supporting our Subject Program. We would extend our gratitude and thank to Directorate of Research and Community Engagement Universitas Tarumanagara for supporting part of our research funding.

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