Peer Review Article

Automatic Foldron T-Shirt With Proportional Integral Derivative method and M5Stack for IoT-Server

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Abstract: The process of folding clothes is one of the activities carried out in the household, and the laundry business is one of the micro-enterprises that are mushrooming at this time. Business actors use many strategies to increase productivity and customer satisfaction. Based on research, the process of ironing and folding clothes is a process that takes a long time compared to the washing and drying process, so a method or tool is needed to make folding clothes more practical. An automatic Foldron T-Shirt is the perfect solution to make folding and ironing clothes more manageable and time-efficient. This tool is equipped with a servo motor that moves the folding board and a steam iron designed so that the user only needs to control the clothes once and simply press one button; the clothes will fold, and the iron themselves will be neatly arranged. The PID method uses an ultrasonic sensor to measure the speed distance of the wiper motor, which is used to run the steam iron so that it can stop appropriately at the end of the table. The output of this ultrasonic sensor is used as the input (set point) of the PID controller applied to the tip so that the movement of the motor can adjust its speed. Moreover, the M5Stack, equipped with 12 Channel Servo, is used to drive the servo motor on the Application Server, making it more dynamic and flexible.

Keywords: folding clothes; steam iron; ultrasonic sensor; microcontroller; PID; M5Stack

I. INTRODUCTION

The development of science and technology today is very rapid and plays a role in realizing a better life. Electronic technology is a part of helping to ease human work, various practical and efficient electronic tools have been created to assist humans in meeting their needs. Different kinds of equipment that operate manually are increasingly abandoned and switched to fully automatic equipment, so automated equipment dominates human life. Housework is one of the most time-consuming activities. Not only that, this activity is carried out every day, and of course, when there is a homework left behind, it will not feel comfortable to be left behind. One of the household chores that are a concern for this problem is that in this case, it will certainly take time to fold and iron the clothes quickly and neatly [7], so that time to do other activities is wasted. So from the problems above, a solution emerged to ease the activity and the flying time; for that, a model tool was made that can assist in folding [1, 2] and ironing clothes quickly with automatic labor.

Automatic clothes folding [3, 4, 8] and ironing are tools made of cardboard or mica consisting of 3 parts that have their respective functions automatically programmed and driven using a servo motor. Mechanics will be installed in such a way with a comparator gear so that the rotation does not

rotate quickly and can be adjusted, and on the installation of the folding board, a load cell is also installed as a sensor to determine the mass or weight on the shirt. The DC motor used is a DC micro servo motor with a voltage of 5 volts [25,29, 30]. The PID (Proportional Integral Derivative) [10,11] control method regulates the speed control automation system on the wiper motor, which is made with the concept of back and forth rotation on the steam iron and runs the wiper motor rotation at the correct stop.

Therefore, the clothes to be ironed are placed on a folding board. Then inputting the weight/mass of the dresses above through the load cell sensor will measure the mass/weight of the clothes that fit between clothes with different hot iron temperatures. Thick and thin so that the steam iron can adjust the temperature's heat on the clothes, and the system will work according to the specified time. The control system used in the steam iron is able to produce an output that matches the input entered. This clothes folding and ironing tool is useful for housewives; this tool can fold one shirt in 6 seconds much faster than folding clothes manually and can iron with a predetermined time on the time iron steam works in folding and ironing one clothes so that it can provide services for housewives to be able to save time to be able to do other household chores. In the scientific development of sensors and Micro Sensors, IoT is based on the quality of Uplink and Downlink using M5Stack and uses LoRa module in sensor data transmission mode [13,18].

II. RESEARCH-RELATED

Apriliyanto, Muhammad, Miftachul Ulum, and Koko Joni. "Semi-Automatic T-Shirt Folding Machine Based on PID (Proportional Integral Derivative)." Journal Electronics, Electricity, Telecommunications, Computers, Informatics, Control Systems 2020. The PID method is applied to a DC motor that moves under the folds of clothes; therefore, the accumulation of clothes underneath will not be pushed up when the clothes accumulate when finished folding. The ultrasonic sensor [12] will measure the right height between the clothes and the opening door for the stack of clothes with kp = 1, ki = 0.1, kd = 0.5 for thin clothes and kp = 5, ki = 1, kd = 2.5. The control used in the single-phase AC generator AVR uses PID, so 0.6 times Kcr can determine the value of Kp, Ki equals 0.5 times Pcr, and Kd equals 0.125 times Pcr. for thick clothes so that the movement of the motor can adjust its speed. This tool can fold one shirt in 16.83 seconds, which is 11 seconds faster than folding clothes manually. This tool utilizes the Arduino microcontroller as the processing brain and the servo as an automatic driver on the therapy clothes folding device. However, the weakness of this tool is that there is still no process of stacking clothes that have been folded automatically so that when this tool finishes folding, the folded clothes must first be picked up from the tool so that they can be reused.

Nanang Budi Hartono et al., "Setting the Position of DC Servo Motor With P, PI, and PID Methods," The mechanics will be installed in such a way with comparison gear so that the rotation does not rotate quickly and can be adjusted. And on the installation of a DC motor, a potentiometer is also installed as a sensor. The DC motor used is a DC motor with a voltage of 12 volts. By using the P, PI, and PID control methods, each response will be compared and analyzed why this happens. From this design, the PC will be installed with PCI 1712, which is then connected to PCLD 8712 as an I/O card. The input from the I/O will enter an analog PWM circuit which consists of 2 kinds of circuits, namely a sawtooth signal generator circuit and a comparator circuit. This circuit will produce a PWM signal according to the desired result. Then it will go to the motor driver, who will enter the motor mechanic fitted with a position sensor, namely a potentiometer. This potentiometer will send feedback back, which will then become information to the PC. And there is also a limit switch as a limiting motor rotation. Proportional control amplifies the drive error signal (error signal), which will

accelerate the system output to reach the reference point. The relationship between the controller input u(t) and the error signal e(t) is shown in the equation.

Research conducted by "Arduino-Based Semi-Automatic Clothes Folding Machine Design" Ahmad Sofi Al Hafis Mechanical Engineering Faculty of Engineering, University of Muhammadiyah Malang 2019. The clothes folding machine is a tool used to fold clothes automatically (one click). The automatic clothes folding machine is driven using four servos, in which the servos move alternately according to a system called hardware programming and move the board left, right, down, and up. This experiment was carried out and was able to fold 20 clothes in 144 seconds. Of course, this can be developed further to streamline the time needed in 1 fold of clothes. This research was conducted by "Automatic Clothes Folding Device Based on Microcontroller" Abim Nurcahyo S, an Electrical Engineering student at ITN Malang, in 2019. With this research, it can be concluded that it takes quite a lot of time to fold a shirt manually. By looking at these limitations, then one solution to overcome these limitations, we need a tool that can save time for folding clothes. In this research, a device is designed that is capable of automatically folding clothes. This design uses Arduino Mega2560, an ultrasonic sensor, and a servo motor. The average value of success and failure from 10 attempts to fold clothes using a tool is 8.75 successful, and 0.81 failed [5,6,9].

III. MATERIALS AND METHODS

Servo motors are small-scale servo motors [14,16,17]. A servo motor is an electric motor with a closed feedback system where the position of the motor will be informed back to the servo motor through a control circuit. Basically, the working principle of servo motors is based on pulse width modulation (PWM) signals using control cables. The control cable controls by giving a signal pulse which will determine the rotational position of the servo motor shaft [23,24,26,28]. For example, at a pulse width of 1.5 ms (milliseconds), it will rotate the servo shaft at an angle of 900. If the pulse width time is shorter (less than 1.5 ms), it will rotate towards position 00 or rotate to the left (rotating counterclockwise). Meanwhile, if the pulse width time is greater so that it can be calculated (more than 1.5 ms), then the servo shaft will rotate towards the 1800 position or rotate to the right (rotate clockwise). The servo motor [19,20,21] can be shown in Figure 1.

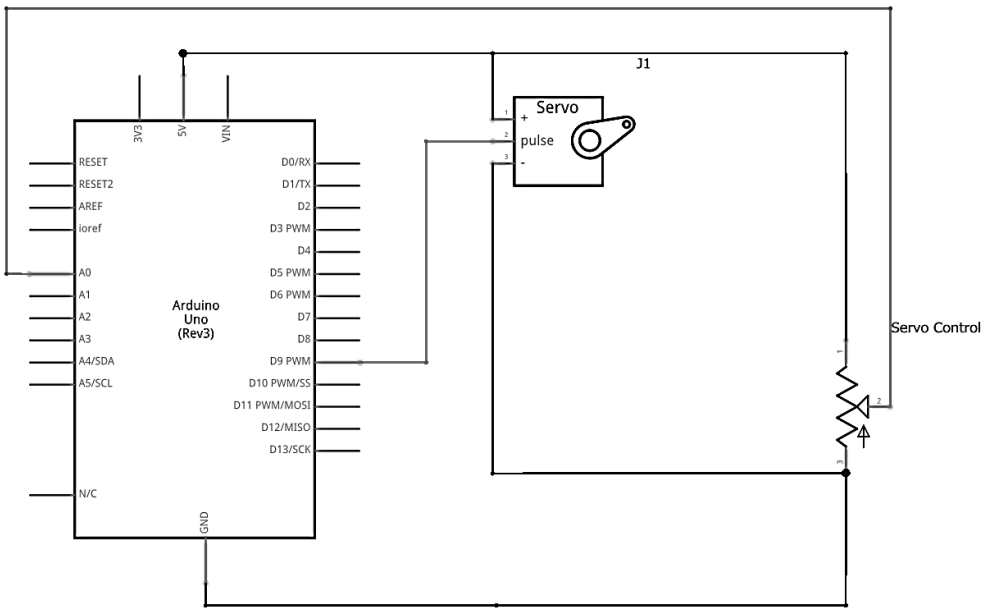

Figure 1. Motor Servo – Arduino Schematic

There are 2 types of servo motors: continuous servo motors with a rotating angle of 360° and standard servo motors that usually have a rotating angle of 180°. Another radio control receiver system or controller generates a pulse whose width changes about every 20ms. This pulse width is generally between 1 and 2 ms; the pulse width used by the servo determines the desired rotational position. Furthermore, Arduino MEGA 2560 [Figure 2] is a microcontroller board based on the ATmega2560. Arduino has 54 input/output pins, of which 15 can be used as PWM outputs, 16 analog input pins, 4 UART pins, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino can support microcontrollers and connect to a computer using a USB cable or AC power to an AC-DC adapter or battery to run it. Arduino is also called a single-board microcontroller (microcontroller in one circuit board) which is open source and popular today. The Arduino system is in the form of hardware using an Atmel AVR chip, software in the form of standard C programming language, and a bootloader installed on the main chip.

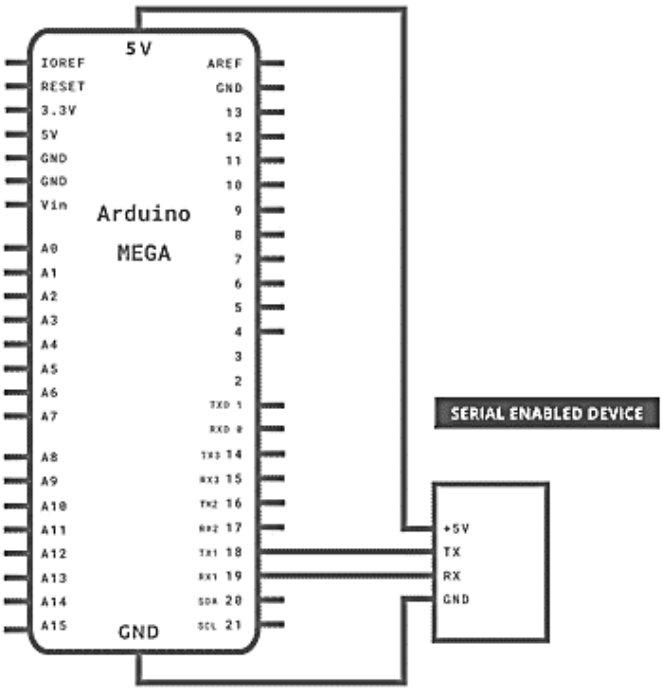

Figure 2. Arduino Mega 2560 Pins

In caring for clothes, ironing is essential. Just like stains, wrinkled clothes will significantly reduce the aesthetics of clothes and interfere with the eye. In the manufacture of this final project, the iron used is a steam iron. Steam iron is an iron whose heat source comes from water vapor. Unlike ordinary irons, this iron plate doesn't just generate heat. The vessel also produces water vapor so that the heat generated is even. Therefore this iron can also be a dryer and a lubricant for clothes, be aware that not all types of clothes can be ironed by spending a long time to get maximum results. most people repeatedly flip through the clothes to be rubbed for a long time until the condition of the clothes is neat and slippery even though there are several materials, e.g., chiffon, silk, or other types of clothing such as kebaya, suits, and other soft fabrics that are difficult be ironed arbitrarily.

For this reason, steam irons do a better and faster job of removing wrinkles or creases in clothes when compared to ordinary irons. Having this type of iron will undoubtedly save you time. Steam irons are very popularly used in laundry or in boutiques to maintain the quality of clothes. Apart from being superior in time and labor efficiency, this iron also has three times faster ironing speed

and three times more yield than ordinary electric irons. In addition, using a steam iron can reduce the possibility of sticky or torn clothes because it is safe for all types of screen printing. Steam irons should be treated differently from regular irons. It can come from fragrances or detergents that are not rinsed clean. In addition, immediately folding and packing clothes after ironing can also make your clothes smell musty. Clothes that are polished with a steam iron will get a little wet.

Therefore, clothes should not be stored immediately, but let them dry naturally without drying. Load cell sensor is a sensor designed to detect the pressure or weight of a load; load cell sensors are generally used as the main component in digital weighing systems and can be applied to bridge scales that function to weigh the weight of trucks carrying raw materials, measurements made by load2cell using pressure principle. Load cells are widely used in electronic scales by using the principle of pressure that utilizes a strain gauge sensor. Load cells are typically sensors consisting of one or more strain gauges attached to a ring-shaped metal rod. The number of strain gauges in a load cell can be adjusted as needed. The strain gauge in the load cells is made of a foil grid, which is a long thin wire arranged in a zigzag manner. Load cells electrical circuit can be shown in Figure 3.

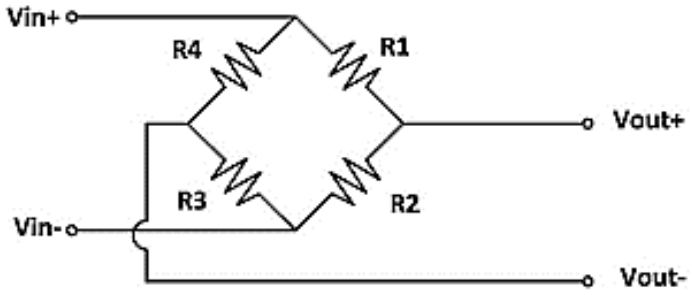

Figure 3. Load cell electrical circuit

A clothes folding board is a surface on a tool that functions to move or fold clothes in a predetermined order driven by a servo motor. The clothes folding board is divided into three parts, as shown in Figure 4. The clothes folding board has a lightweight and sturdy material and weighs 1000 grams for the material used. Each part of the board is connected with a connecting slider as a mechanism for transmitting the driving force from the motor to the folding board to operate according to the design. Each of these sliders is connected to a servo motor that drives the folds.

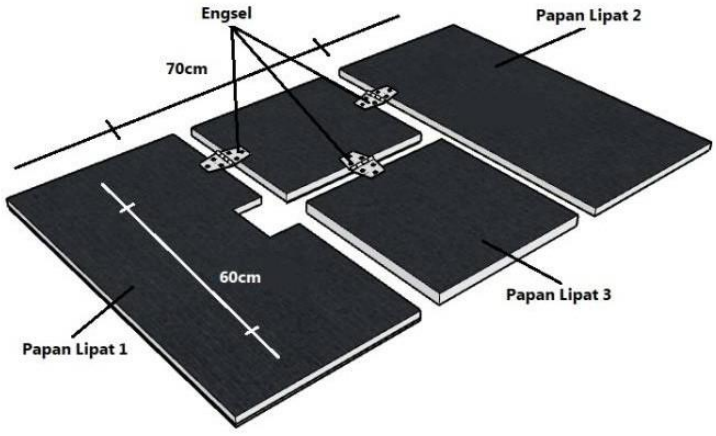

Figure 4. Folding Board

The work of the wiper consists of two speeds in general, namely slow speed (low speed) and high speed (high speed). However, nowadays, the wiper is equipped with intermittent work. The wiper works. The wiper motor can move when the wiper motor is energized. This current comes from the battery and then goes to the fuse, then to the ignition, then to the wiper switch, and then to the wiper motor. When the wiper is operated and then turned off (off), the wiper arm must return to its original position (down position) so that it does not stop in the middle, interfering with the driver's view. So we need a system that can make the wiper position return to its original position when the wiper switch is off.

Moreover, An ultrasonic sensor is a sensor that works based on the principle of sound wave reflection. It is used to detect the presence of an object or certain object in front of the working frequency in the area above the sound wave from 20 kHz to 2 MHz. The ultrasonic sensor consists of two units, namely the transmitting unit and the receiving unit, the structure of the transmitter and receiver unit. It is simply that a piezoelectric crystal is connected to a mechanical armature and only connected to an alternating voltage vibrating diaphragm having a working frequency of 20 kHz to 2 MHz. The ultrasonic wave reflection occurs when there is a certain object, and the receiving sensor unit will receive the ultrasonic wave reflection back. Furthermore, the receiving sensor unit will cause the vibrating diaphragm to vibrate, and the piezoelectric effect produces an alternating voltage with the same frequency.

Figure 5. M5Stack 12 Channel Servo extension board

An integrated IoT device is needed to send data to the internet server, for example, the M5Stack servo board, which has 12 mini servo channels; this M5Stack uses the ESP32 WiFi module be used to control the servo on the Folding board. This is an approach. Figure 5 is a view of the M5Stack 12 Channel Servo extension board [15, 22, 27].

Research methods

In completing the design of the folding and ironing tool using Arduino, it is necessary to conduct research based on the method carried out in accordance with the design that has been made. Tests are carried out in stages for each component used following the series of tools to be tested.

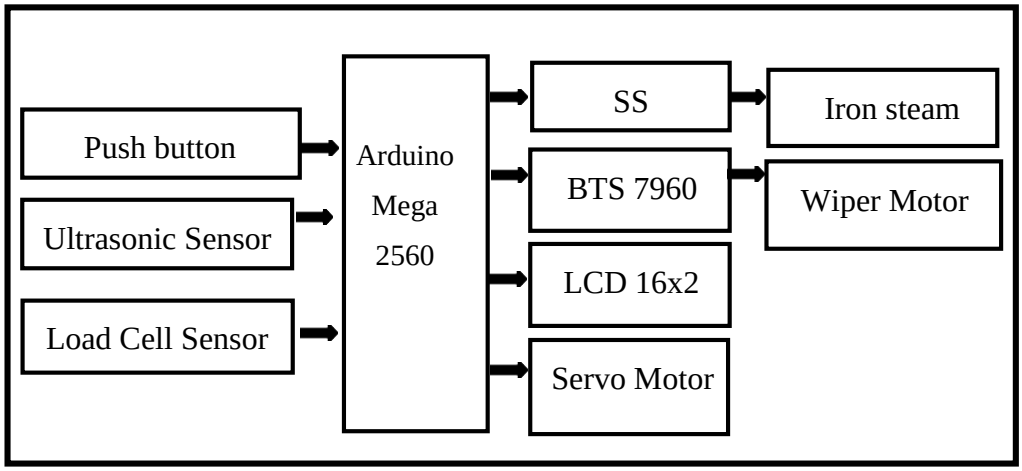

Figure 6. Block Diagram

To explain the system design carried out in realizing the design of this tool can work and run according to its function. The first is generally described by the block diagram and workflow shown in Figure 6, and Figure 7 is a flowchart system in this research.

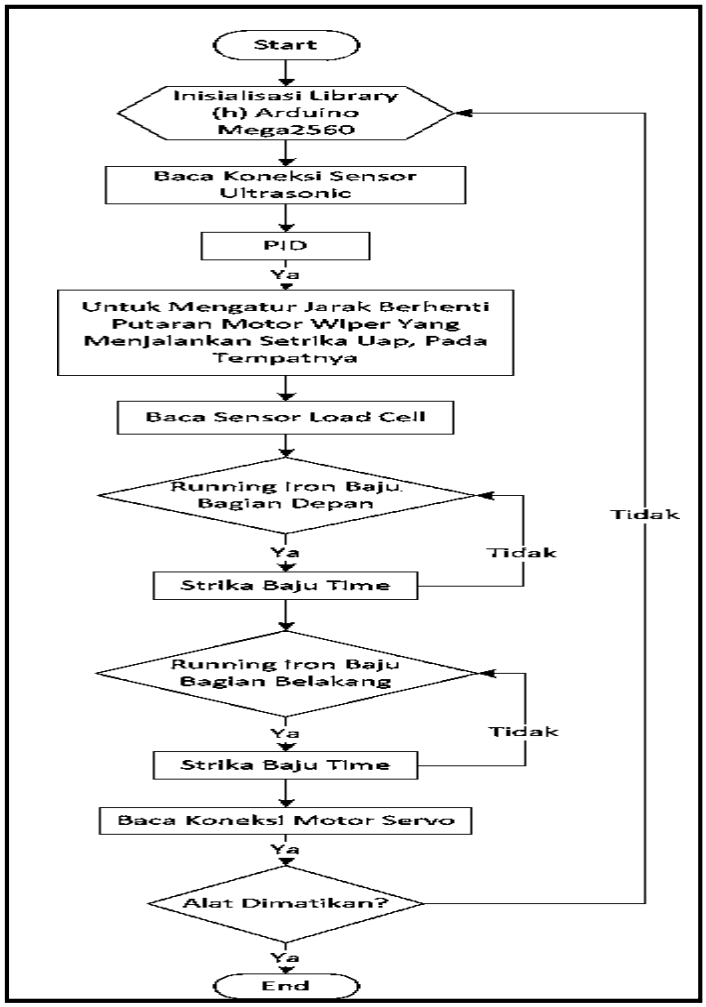

Figure 7. Flowchart system

On the first system, it is turned on or started, which will be initialized or arduino programming and supported with the help of a library (h) to optimize programming. Followed by checking the ultrasonic sensor in this design functions as a sensor for measuring the distance the motor speed is lowered to stop properly at the end of the table. The output of this ultrasonic sensor is used as the input (set point) of the PID controller. Load cell readings for measuring the weight/mass of clothes that adjust the thickness of the clothes to be ironed as input in the form of weight in units (kilograms) which will adjust the temperature of the steam iron to run the iron. Furthermore, run a steam iron with a predetermined duration of 5s for the front of the shirt and to turn the back of the shirt, it's still in a manual state after the shirt is turned over; the ironing process will continue for another 5s. If the ironing process is complete, continue to check the servo motor connection to fold the clothes; Servo motor 1 for folding the right side of the clothes, servo motor 2 for folding the left side, servo motor 3 for folding the back to the front. The program will continue to be active when the machine is ON; when the tool has been used or is not needed, the tool will be turned off (End). Moreover, Figure 8, Figure 9, and Figure 10 are depictions of a prototype automatic shirt folding machine from 3 angles, top, side, and bottom.

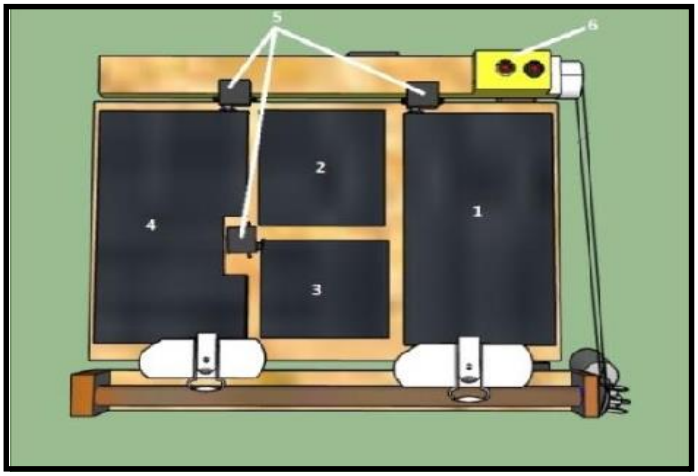

Figure 8. Folding Table Top Design

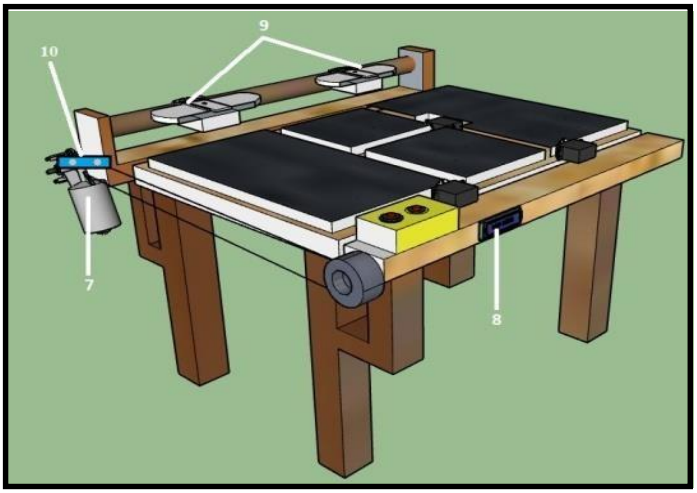

Figure 9. Side Folding Table Design

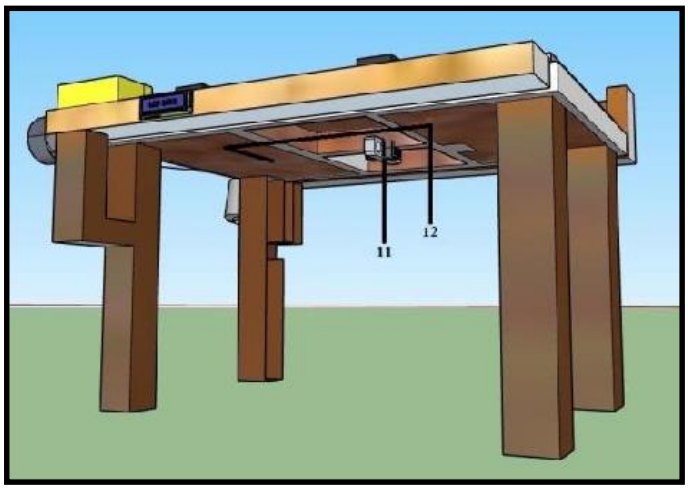

Figure 10. Bottom Folding Table Design

Research development is an approach to IoT; this can be done using the M5Stack IoT Board, which is equipped with the ESP32 Module it. The complete way of working can be seen in the flowchart Figure 11 and the Block Diagram in Figure 12.

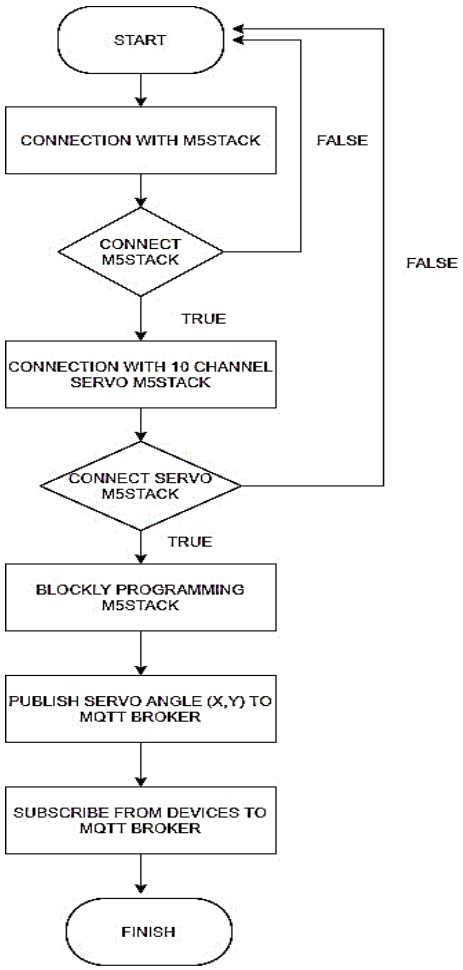

Figure 11. Flowchart M5Stack Servo for Application Server

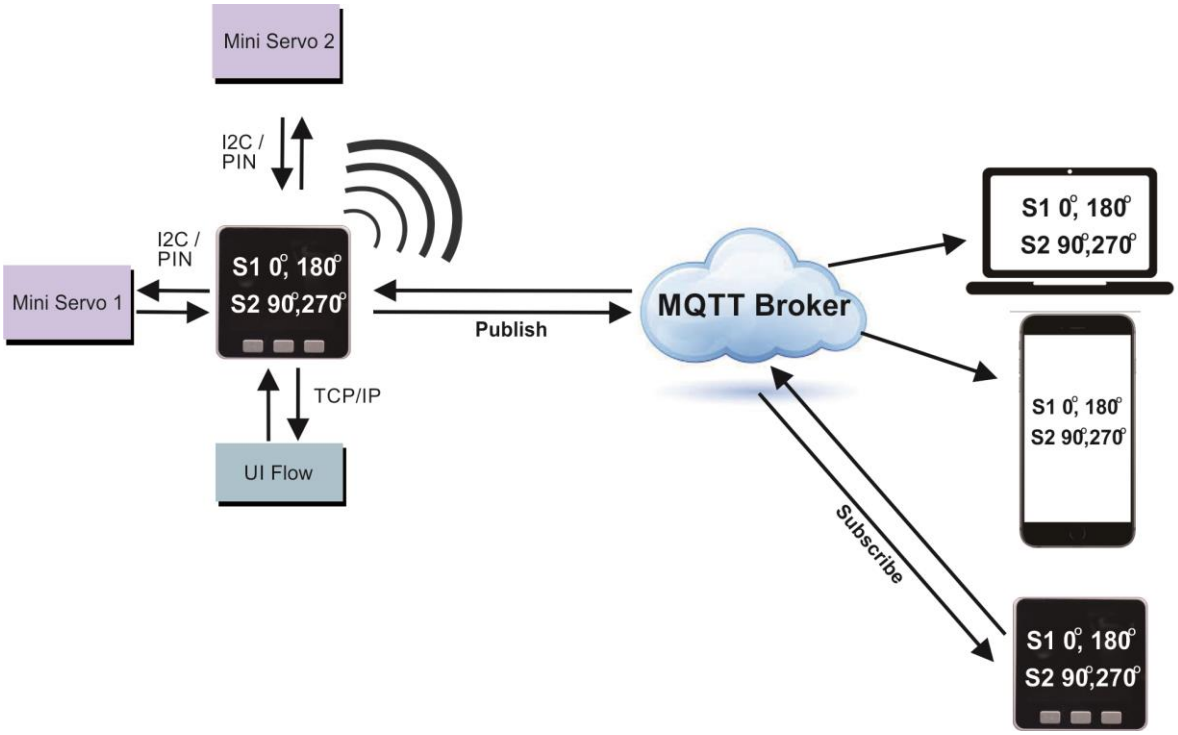

Figure 12. IoT based servo motor diagram blog using M5Stack

IV. RESULTS AND ANALYZE

Testing of the clothes weight detection system using a load cell sensor is done by placing the clothes on a folding board under which a load cell sensor has been given. The author here uses three different sample clothes for the thickness of the gramation 40S, 30S, and 20S. Testing the clothes weight detection system using a load cell sensor is done by placing the clothes that are to be folded and ironed on a folding board or table underneath, which has been given a load cell sensor. There is a sample of clothes with a thickness of 40S. Clothes detection results can be shown in Figure 13. Testing of the clothes weight detection system using a load cell sensor is done by placing the clothes that are to be folded and ironed on a folding board or table underneath, which has been given a load cell sensor. There is a sample of clothes with a thickness of 30S. Clothes detection results can be shown in Figure 14. Testing of the clothes weight detection system using a load cell sensor is done by placing the clothes that are to be folded and ironed on a folding board or table underneath, which has been given a load cell sensor. There is a sample of clothes with a thickness of 40S. Clothes detection results can be shown in Figure 15.

Figure 13. 40S Clothes Load Cell Detection Results

Figure 14. 30S Clothes Load Cell Detection Results

Figure 15. 20S Clothes Load Cell Detection Results

Weight on clothes is measured to adjust the temperature at the temperature of the steam iron, the thickness of the clothes adjusts the weight on the clothes, the following is the data for the variable thickness of clothes (grams) to the weight of clothes (grams), i.e., Thickness 40S (110-120)gsm: 140-170 gram, Thickness 30S (140-150)gsm: 180-225 gram, and Thickness 20S (190-200)gsm: 240-290 gram. Finally, for testing with three different samples of clothing, the results are almost the same as the digital scale measuring instrument.

Table 1. Testing Results of Load Cell Sensor Scales

No	clothes thickness	Digital weighing results (kg)	Load cell sensor results (kg)	Error difference (kg)
1	40S shirt	0,152	0,150	0,002
		0,152	0,152	0
		0,152	0,151	0,001
		0,152	0,151	0,001
		0,152	0,150	0,002
		0,152	0,151	0,001
		0,152	0,151	0,001
		0,152	0,151	0,001
		0,152	0,151	0,001
		0,152	0,152	0
2	30S shirt	0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
		0,190	0,190	0
3	20S shirt	0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003
		0,253	0,250	0,003

Source: experiment result

In this design, the author tries to design a folding board used for this final project by looking for existing libraries to be applied so that the folding board is formed. The design of the folding board will be used to support the device. The design of the folding board can be shown in Figure 16. The

results of the design using a folding board combined using three servo motors and the folding board will be able to rotate on its axis.

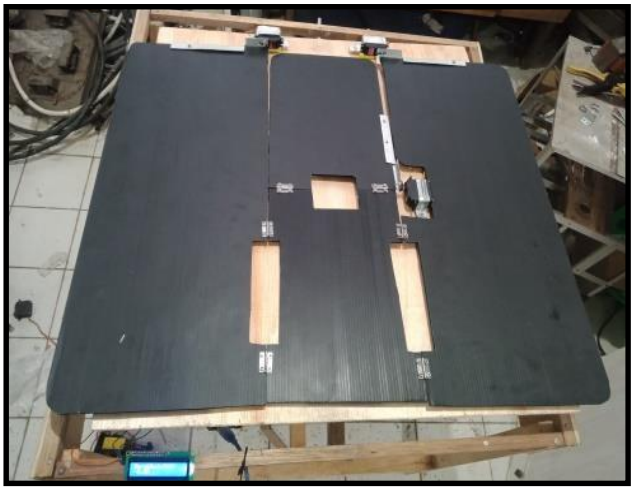

Figure 16. Folding Board Design Results

The first step in folding clothes on a folding board is to do training on the folding board to fold according to the desired degree so that the clothes are folded, Next is the clothes are prepared on the board to be ready to be folded. Next is the clothes have been prepared and placed on the table to be folded. Can be shown in Figure 17.

Figure 17. Clothes on a Folding Board

Next is the clothes that have been prepared and placed on the table, the left side of the clothes to be folded on the first folding board, which is set at an angle of 0˚ to 180˚. It can be shown in Figure 18 and Figure 19.

Figure 18. Automatic folding on the left and right sides

Figure 19. Automatic folding on the top and bottom

Next is the clothes have been prepared and placed on the table, the middle side of the shirt to be folded on the second folding board which is set at an angle of 0˚ to 180˚. Can be shown in Figure 18.

Figure 20. Folds on all four sides back to the starting position

Figure 20 is clothes being placed so that the folding boards fold in order. The testing stage is the process of testing the tool as a whole, where the testing of this tool is carried out after tool testing. Finished the last stage, namely data analysis to be processed and drawn conclusions. The following is the result of testing the folding board 20 times. The results of testing the accuracy of the iron steam temperature can be shown in Table 2., moreover, Table 3 is an Iron Steam Temperature Accuracy Testing. Finally, testing the uplink and downlink data on the M5Stack board is shown in Table 4.

Table 2. Folding Result Test Table

No	Clothes sample	Right side fold (cm)	Left side fold (cm)	Centerfold (cm)	Right side error (cm)	Left side error (cm)	Center error (cm)	Presentation of folded results
1	L shirt (68x51)	25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
		25	25	20	0	0	0	100%
2	M shirt (66x48)	22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%
		22	22	18	0	0	0	100%

Source: experiment result

Table 3. Iron Steam Temperature Accuracy Testing Table

No	Micro servo rotation (˚)	Accuracy results		Temperature accuracy (LOW, MEDIUM, and HIGH)
		Success	Unsuccessful	
1	15	-	√	NOT RIGHT LOW

No	Micro servo rotation (˚)	Accuracy results		Temperature accuracy (LOW, MEDIUM, and HIGH)
		Success	Unsuccessful	
2	20	-	√	NOT RIGHT LOW
3	30	√	-	LOW TEMPERATURE
4	50	-	√	NOT RIGHT MEDIUM
5	70	-	√	NOT RIGHT MEDIUM
6	90	√	-	MEDIUM TEMPERATURE
7	120	-	√	NOT RIGHT HIGH
8	150	-	√	NOT RIGHT HIGH
9	180	√	-	HIGH TEMPERATURE

Source: experiment result

Table 4. M5Stack Data 4 Mini Servo communication on Cloud MQTT Broker

Times (m)	connections /+	bytes/received/+	bytes /sent/ +	messages/ received/+	messages/sent/+	dropped/+	publish/received/+	publish/sent/ +	sockets /+
1	0.08	1925	11.226	261	479	0	233	448	0.04
5	0.4	1913	11.088	258	478	0	230	450	0.4
15	1.16	1495	8.308	197	372	0	177	350	0.52

Source: experiment result

V. DISCUSSION, CONCLUSION, AND SUGGESTION

Based on testing and analysis, several conclusions can be drawn between other: Using the PID (Proportional Integral Derivative) method, it can detect and adjust the rise time of the wiper motor speed, which is used to adjust the back and forth rotation of the steam iron/steam iron to make the right stop on the gear rotation shaft. From testing several times, it was concluded that the laying of clothes on the folding board followed all the suggestions and how to work in the tool instructions. Steam irons/steam irons can work with the input of weight/mass readings on clothes that have been detected to regulate the temperature of the iron steam. Based on testing and analysis, several shortcomings in this system are drawn, which are used as suggestions for further research, including Use and manufacture of folding boards in order to increase the size of the boards to fit clothes, The material on the folding board is designed and uses light and hard materials so that the folding of the clothes can be maximized, and the rotation of the servo motor can be stable. The data on the M5Stack

Board Broker load shows the uplink and downlink data communication between the M5Stack Board and the Servo Motor movement data, and this data is realtime, it can be seen on the M5Stack Broker MQTT, the longer it takes, the larger the byte data generated. The problem is that if the WiFi signal is unstable, it may affect the ESP32 M5Stack, and this causes packet loss or dropped data.

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REFERENCES

1. S Apriliyanto, Muhammad, Miftachul Ulum, and Koko Joni. "Semi Automatic T-Shirt Folding Machine Berbasis PID (Proportional Integral Derivative)." Jurnal Elektronika, Listrik, Telekomunikasi, Komputer, Informatika, Sistem Kontrol (J-Eltrik) 2.1 (2020).
2. Bukardi, Erwin Sukma, and Wahyu Setyo Pambudi. "Perancangan Dan Pembuatan Semi Automatic T-Shirt Folding Machine Menggunakan Metode Fuzzy Proportional Derivative (Fpd)." Jurnal Sains dan Informatika 1.1 (2015): 34-44. Erlangga, Muhammad. Otomasi Mesin Pelipat Baju Berbasis Arduino Berdasarkan Paten No. 2,758,761. Diss. University of Muhammadiyah Malang, 2019.
3. Hafis, Ahmad Sofi Al. RANCANG BANGUN MESIN PELIPAT BAJU SEMI-OTOMATIS BERBASIS ARDUINO UNO. Diss. University of Muhammadiyah Malang, 2019.
4. Purwanto, Romdhon. Semi Automatic Foldron (folding and Ironing) Machine.Diss. Universitas Internasional Batam, 2020.
5. Ramady, Givy Devira, and Rendi Juliana. "Sistem Kunci Otomatis Menggunakan Rfid Card Berbasis Mikrokontroler Arduino Uno R3." Jurnal Online Sekolah Tinggi Teknologi Mandala 14.1 (2019): 49-53.
6. Syahwil, Muhammad2013. Panduan Mudah Simulasi & Praktek Mikrokontroler Arduino. Yogyakarta : Penerbit Andi.
7. Maulana, Ahmad. "Kajian eksperimental boiler setrika uap yang terintegrasi dengan mesin pengering laundry." Prosiding5Seminar Hasil Penelitian dan Pengabdian5kepada Masyarakat Unjani Expo (Unex). Vol. 1. No. 1. 2020.
8. Apriliyanto,5Muhammad, Miftachul Ulum, and Koko Joni. "Semi Automatic T-Shirt Folding Machine Berbasis PID (Proportional Integral Derivative)." Jurnal5Elektronika, Listrik, Telekomunikasi, Komputer,Informatika, Sistem Kontrol (J-Eltrik) 2.1 (2020).5
9. Boro, Aloysius Gonzaga Lai, and Aries Boedi Setiawan. "Pemberian pakan babi otomatis berbasis Arduino Mega 2560." SinarFe7 2.1 (2019): 195-199.Program5Studi Teknik Elektro (S1) Universitas Batam 6.3 (2016): 30-38.
10. Suprapmoko, Agus, Rahman Arifuddin, and Aries Boedi Setiawan. "Mesin Nasi Goreng Otomatis Menggunakan Metode PID Berbasis Arduino Mega 2560." JEECAE (Journal of Electrical, Electronics, Control, and Automotive Engineering) 5.1 (2020): 9-14.
11. Sipul, Y. U., Prasetya, D. A., Nachrowie, W. D., & Dirgantara, W. (2019). CONTROL SYSTEM KENDALI KECEPATAN SEPEDA MOTOR LISTRIK DENGAN METODE PID. JASIEK (Jurnal Aplikasi Sains, Informasi, Elektronika dan Komputer), 1(1), 45-49.

12. Arsada, Bakhtiyar. "Aplikasi sensor ultrasonik untuk deteksi posisi jarak pada ruang menggunakan arduino uno." Jurnal Teknik Elektro 6.2 (2017).
13. Puput Dani Prasetyo Adi, Akio Kitagawa, "A performance of radio frequency and signal strength of LoRa with BME280 sensor", April 2020, TELKOMNIKA Indonesian Journal of Electrical Engineering Vol.18 No.2:649-660, DOI: 10.12928/telkomnika.v18i2
14. Abdul Hadi, Zainal Abidin, "Kontroler Proporsional Integral Motor Servo untuk Kesalahan Kontur", August 2021, CYCLOTRON 4(2), DOI: 10.30651/cl.v4i2.8467
15. Adi, Puput Dani Prasetyo, and Akio Kitagawa. "A Review of the Blockly Programming on M5Stack Board and MQTT Based for Programming Education." 2019 IEEE 11th International Conference on Engineering Education (ICEED). IEEE, 2019.
16. Y.-M. Zhang, P. Yan, "Adaptive robust control for linear motor servo systems", March 2015, DOI: 10.7641/CTA.2015.40744
17. Shengju Li, Xiaoming Ren, "Design of Controller for Linear Motor Servo System", November 2019, Conference: 2019 6th International Conference on Systems and Informatics (ICSAI), DOI: 10.1109/ICSAI48974.2019.9010451
18. Puput Dani Prasetyo Adi, Akio Kitagawa, "Performance Evaluation of LoRa ES920LR 920 MHz on the Development Board", January 2020, International Journal of Advanced Computer Science and Applications 11(6), DOI: 10.14569/IJACSA.2020.0110602
19. Yun Cheng, Ren Xuemei, "Extended-State-Observer-Based Funnel Control for Motor Servo System with Quantized Input", In book: Proceedings of 2020 Chinese Intelligent Systems Conference, Volume II, DOI: 10.1007/978-981-15-8458-9_75, September 2020
20. Yu. V. Ilyukhin, R. V. Kolesnichenko, "Accuracy of Milling by Robots with Two-Motor Servo Drives", December 2019, Russian Engineering Research 39(12):1069-1072, DOI: 10.3103/S1068798X19120086
21. Baomin Li et.al., "Adaptive Event-triggered Fuzzy Control for DC Motor Servo Systems", May 2021, Conference: 2021 IEEE 10th Data Driven Control and Learning Systems Conference (DDCLS), DOI: 10.1109/DDCLS52934.2021.9455634
22. Puput Dani Prasetyo Adi, Akio Kitagawa, "A Review of the Blockly Programming on M5Stack Board and MQTT Based for Programming Education", Conference: 2019 IEEE 11th International Conference on Engineering Education (ICEED), DOI: 10.1109/ICEED47294.2019.8994922, November 2019
23. Tu Ya, Jialu Du, Peng Cui, "Design of Direct Current Motor Servo Control System Based on SOPC", January 2020, DOI: 10.1007/978-981-13-6508-9_61, In book: Communications, Signal Processing, and Systems
24. Abdul Hadi, "Desain Kontroler Proporsional Modifikasi pada Motor Servo", September 2019, DOI: 10.33387/protk.v6i2.1212
25. Wang Bolun, "A method for Rapid Deployment of Brushless DC Motor Servo System Model Based on FPGA", Conference: 2021 6th International Conference on Automation, Control and Robotics Engineering (CACRE), DOI: 10.1109/CACRE52464.2021.9501387, July 2021
26. Jiashun Shi, Jin Chen, Wen Qi,"Research on Stepper Motor Servo Controller Based on Pan-Boolean PID Control", DOI: 10.23919/CCC50068.2020.9189307, Conference: 2020 39th Chinese Control Conference (CCC), July 2020
27. Adi, Puput Dani Prasetyo, Akio Kitagawa, and Junichi Akita. "Finger Robotic control use M5Stack board

and MQTT Protocol-based." 2020 7th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE). IEEE, 2020.

28. Baofang Wang, et.al., "Command filtered adaptive backstepping control for dual-motor servo systems with torque disturbance and uncertainties", March 2021, IEEE Transactions on Industrial Electronics PP(99):1-1, DOI: 10.1109/TIE.2021.3059540
29. Andrzej ANDRZEJEWSKI, "Time-Optimal Position Control of DC Motor Servo Drive", December 2019, Przeglad Elektrotechniczny 1(12):87-90, DOI: 10.15199/48.2019.12.16
30. Xiangyu Wang, "Adaptive Control of DC Motor Servo System With Application to Vehicle Active Steering", March 2019IEEE/ASME Transactions on Mechatronics PP(99):1-1, DOI: 10.1109/TMECH.2019.2906250