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Prototype Of Automatic Clothes Folding Device Based on Arduino Uno (Liquid Crystal Display) for Clothes Convection

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Abstract
Folding clothes is an important job in a convection, where when folding clothes must be neat so that when packing, consumers become interested. But many think that folding clothes is boring. From this problem, the researcher produced anautomatic clothes folding device based on Arduino uno. It is hoped that it can make it easier and shorten the time in folding clothes in the middle to lower convection. The purpose of design and research is to be able to design and make a folding device with automatic drive, the size of the shirt that can be folded with an automatic mechanism folding device, namely Small (S), Medium (M), Large (L). This tool uses three servos for the drive, LCD and buzzer as a reporter of the display and sound. By testing the feasibility of the hardware and the entire prototype of the automatic folding tool used at the Ririn Tailor Convection in Blitar Regency, based on two sources, the first from the user test, the results of the user test that has been carried out 3 times per person obtained a value of 72,6% of the average percentage of each user test because it has not been exposed to water, then the second source of robotics system experts with 3 tests got a score of 75% because, the existence of construction less solid so less for the long term.

Keywords: Arduino Uno, Buzzer, Convection, LCD, Ultrasonic Sensor.

1. INTRODUCTION

In today's modern era, technology is developing very rapidly to help ease human work. Many technologies have been made practical and effective to help humans meet their needs. Churniawan, et al., (2023), with the development of technology, various manual operating systems are beginning to be abandoned and switched to automatic systems. This clothes folding tool is one of the tools from a manual system to an

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automatic system. Where there are still many people who use the manual system to fold clothes.

According to Karlyle Setiawan (2024), Clothes are a symbol of the soul. Clothing is inseparable from the historical development of human life and culture. In other words, fashion can be interpreted as a social aspect that contains messages and also the way of life of certain individuals and communities that are part of social culture.

In addition to being a household chore, folding clothes is also routinely carried out in the clothing manufacturing industry. In this garment manufacturing industry, tailors not only sewing, but also have to fold large-scale clothes in a very fast time, based on an interview with Mrs. Ririn, the owner of Ririn Tailor Belu convection stated that the work of folding clothes after the sewing process is completed is not easy and takes a long time, this makes the packing process not go fast. In addition, it has to expend a lot of energy because of the large number of clothes produced. Sometimes it also requires additional special labor to fold clothes.

With the problems mentioned above, the researcher intends to make anautomatic clothes folding device designed using an Arduino Uno-Based Ultrasonic Sensor. The purpose of this research is to design and made anArduino Uno-based automatic clothes folding tool by displaying an LCD and this tool can be tested to find out the average time required for the process of folding clothes. (Sibuea et al., 2022).

This research will make a prototype of an automatic shirt folding based on arduino uno as a microcontroller and that works if the ultrasonic sensor detects an object, when the ultrasonic sensor detects the object servo 1 moves, after servo 1 moves then servo 2 moves, after servo 2 moves then servo 3 moves until the shirt is folded. When the tool is processed, there is a display on the LCD (Liquid Cyrstal Display) folding clothes and the buzzer will sound once. After the shirt is folded, the LCD display will show that the shirt has been folded and the buzzer will sound several times. With the prototype of an automatic folding device, it is able to save time in terms of folding clothes in convection and in daily life.

Based on several studies of automatic clothes folding tools Arduino-based and the problems faced today, so this research designed anArduino-based automatic clothes folding device with LCD" that saves time and effort. This tool is very helpful for humans in performing the task of folding clothes in an efficient time.

2. LITERATURE REVIEW

2.1. Tailor

Convection business, is a business in the fashion field that is carried out by several people or in bulk, another name for this convection is home industry and if the capacity is larger, it is called a garment business. Some convectiones usually produce clothes in large quantities and the process takes a long time (Suprihatiningsih, 2020). Convection here is a place for tools to be used, because there is still a lot of production in terms of manual and takes a long time.

2.2. Arduino Uno R3

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The function of the arduino is to make it easy to use in controlling electronic components with programs such as LEDs, DC motors, relays, servo motors, modules, and all kinds of sensors. Razor, (2020).

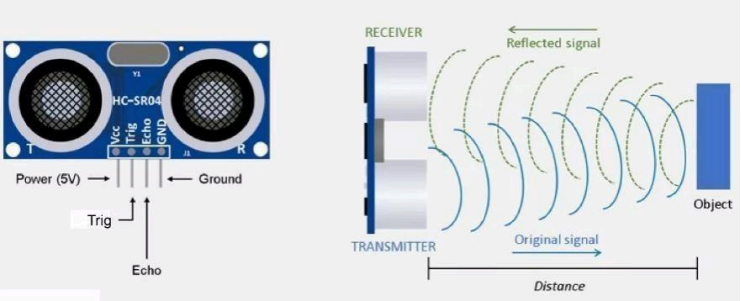
(Source: *https://www.arduinoindonesia.id/2018/08/arduino-uno-r3.htm*)

Figure 1. Arduino Uno

This Arduino uno will be used as a microcontroller that will process commands from the user which will be followed by running an actuator in the form of a servo motor to fold clothes automatically and for the command system using an Ultrasonic Sensor.

2.3. Ultrasonic Sensor

Ultrasonic sensor is a device that operates by utilizing the reflection of sound waves to identify the presence of a particular object in front of it. (Jowangkay, 2016) This sensor uses ultrasonic waves with a frequency of more than 20,000 Hz to measure specific distances and times. In addition to measuring distances, ultrasonic sensors also have the ability to detect cracks and types of objects capable of reflecting signals.



(Source: *https://www.empatpilar.com/pengertian-sensor-ultrasonik/*)

Figure 2 Ultrasonic sensor parts

Ultrasonic sensors sometimes have different values when detecting distance. Sensor calibration is the process of adjusting the sensor to minimize measurement errors and ensure the accuracy of the data obtained, where the sensor is placed at the same distance as the adjacent position. The magnitude of the sensor error is calculated using the equation

$$Error : \frac{JP-JS}{JS} \times 100\% \quad (2.3)$$

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Where, JP is the sensor reading distance, and JS is the actual distance. In this case, the actual distance is the distance obtained through manual measurements using a ruler and/or meter. (Martalia. Andayani, 2016)

In this study, the Ultrasonic sensor functions for commands when the tool is working, when the sensor detects an object, the tool will automatically work and fold and if it does not detect then the tool does not work.

2.4. Liquid Crystal Display (LCD I2C)

LCD or Liquid Crystal Display is a type of display media that uses liquid crystals to produce visible images. (Issue, 2022).
This sensor is used to notify if the automatic folding device is working and when it is finished working.

2.5. Servo Motor MG996r

MG996R is a metal gear digital servo motor. The servo has a high-stall torque of 11kg/cm contained only in a small package. You usually find this bike in a lot of equipment because it is a form of improvement of the MG995 (Khairi, 2023)

(Source : *http://id.mfgrobots.com/mfg/it/10629746.ml*)
Figure 4 Servo motor Mg996r

The Servo motor Mg996r will be used as an actuator and at the same time as a driver from the board for folding clothes. The tool will move 180 degrees and if it opens it moves to 0 degrees.

2.6. USB Adaptor

Adapters are typically used to convert electrical current from one form to another to suit the needs of electronic devices. For example, an adapter can convert AC current to DC to fit devices such as laptops or mobile phones. (Admin, 2024). The USB adapter is useful for powering the Arduino uno from an outlet and to avoid shorting the Arduino uno.

2.7. Buzzer Sensor

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Buzzers convert kinetic energy into sound energy as a result, there is a change in energy from electrical energy to sound energy that can be heard by humans Generally, the type of buzzer on the market is a piezoelectric buzzer that works at a voltage of 3 to 12 volts DC. (Razor, 2020). The buzzer here is used to notify in the form of a sound that if the ultrasonic sensor detects it, the device will run and the device will finish folding.

3. METHODS

In this study, the author conducted research with the type of RnD (Research and Development), namely by taking several studies and developing the research to become a new tool. (Sugiyono, 2011:297). There are several stages in the research that are carried out starting from interviews, observations, designs, analysis, design and implementation.

4. RESULTS

Prototype Research on Automatic Clothes Folding Tools Based on Arduino Uno Using LCD and Utrasonic has been carried out using the Research and Development (RnD) method. This research was conducted to make convection work easier and housewives. And developed a prototype of an automatic folding tool that has been carried out in previous studies, by finding out how much influence automatic folding tools in convection and household in making it easier and faster to convection clothes at Ririn tailor, by testing comparing the time between folding clothes manually using an automatic folding tool. As well as the small number of convection jobs and also the many consumer requests in a very short time.

4.1 Product Design

Researchers will create product designs such as block diagrams and flowcharts. When the device is run, the microcontroller will take data from the ultrasonic sensor when an object is approaching and when it is not approaching. Then the microcontroller data is forwarded to the servo that has been installed in 4 parts, each part has its own function so that folding clothes can be precise.
When the tool is run, the first process is to initialize the Arduino port so that during programming, the program can enter optimally, after that the Ultrasonic sensor reads an object approximately 5 cm, if the Ultrasonic sensor reads an object less than 5 cm the tool will work and if it is more than 5 cm the tool will not work, with that the researcher uses a push button to replace the ultrasonic if the situation does not work. The ultrasonic sensor reads then the lcd will detect if the tool is working and then the 4 servos that have been placed in place will move sequentially according to the program. After the servo motor has stopped, the LCD will detect if the tool has finished working and will repeat again according to the program made.

4.2 Product Trial

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Prototype tests were carried out to test the performance of functionality and system performance. Testing the function of each tool whether it is in accordance with the plan. Testing is carried out thoroughly on both software and hardware This prototype test is carried out with the following steps;

4.1.1 Tool range

The set of tools corresponds to the circuit scheme in figure 6.

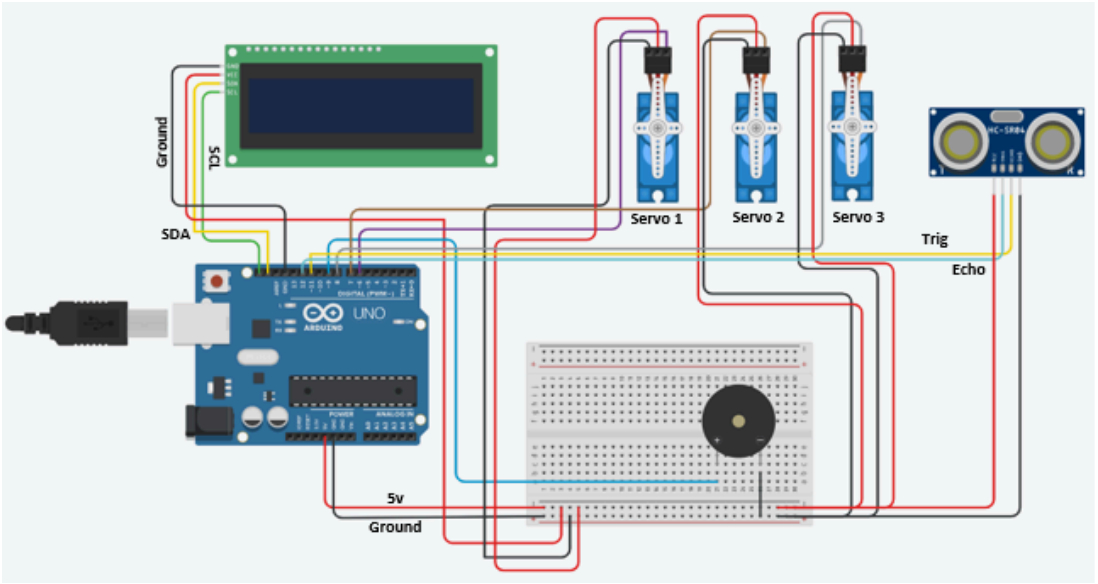

Figure 7. Tool Range

Table 1. Cable Connection

From	To
Pin Trigger Ultrasonic	Digital Pin 12 on Arduino Uno
Pin Echo Ultrasonic	Digital Pin 11 on Arduino Uno
Pin SCL LCD 12 X 2 (12C)	SCL Pin on Arduino Uno
Pin SDA LCD 12 X 2 (12C)	SDA Pin on Arduino Uno
Pin + Buzzer	Digital Pin 9 on Arduino Uno
Pin Signal on Servo Motor 1	Digital Pin 6 on Arduino Uno
Pin Signal on Servo Motor 2	Digital Pin 7 on Arduino Uno
Pin Signal on Servo Motor 3	Digital Pin 8 on Arduino Uno
VCC Pin on Servo 1,2,3, LCD and Ultrasonic	5V Pin on Arduino Uno

4.1.2 Arduino Uno Trial With USB Adapter

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Figure 8. Trial Arduino with USB Adapter

Testing the Arduino is also done by connecting a USB adapter with a type C cable to ensure that the Arduino can turn on or not. In the test, the Arduino Uno turned on optimally and did not heat up (short) when it turned on.

4.1.3 Ultrasonic Sensor Trial With Ruler

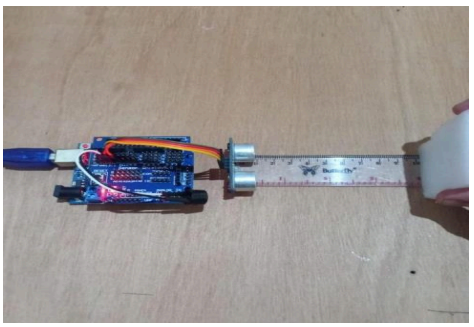

Figure 9. Measurements with a ruler

In the test above, the results can be seen from the table below, where the results of ultrasonic sensor distance measurement using the Ultrasonic Sensor Calibration Program. Where the sensor is placed at the same distance as the adjacent position. The magnitude of the sensor error is calculated using an equation. Where, JP is the sensor reading distance, and JS is the actual distance. In this case, the distance is actually the distance obtained through manual measurements using a ruler or meter.

Table 2. Results of Ultrasonic Sensor Distance Measurement

No	Ruler Measurement Results (cm)	Ultrasonic Measurement Results (cm)	Eror (%)
1	0	0	0%
2	1,3	2	53,86%
3	2,3	2,5	8,7%
4	4,3	4,5	4,65%
5	6,3	6,5	3,17%
6	8,3	8,5	2,41%
7	10,3	10,5	1,94%
8	12,3	12,5	1,62%
9	14,3	14,5	1,4%

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10	16,3	16,5	1,22%
11	18,3	18,5	1,1%
12	20,3	20,5	0,99%
13	22,3	22,5	0,90%
14	24,3	24,5	0,82%
15	26,3	26,5	0,76%
16	28,3	28,5	0,70%
17	30	30	0%

The results of the tests and measurements carried out can be seen in table 2, namely the value measured by the ruler is not always the same as the value measured by the ultrasonic sensor and it is known that the average error of the reading between the ultrasonic sensor and the ruler can be calculated based on the formula:

$$Error: \frac{JP-JS}{JS} \times 100\% \quad (4.1.3)$$

Information:
JP = Measurement by ultrasonic sensor (cm)
JS = measurement by ruler (cm)
From the test results, it was found that the distance of the test results on the tool was not the same as the calculation distance with an error percentage of 0% to 53.86%. Based on the characteristics of ultrasonic sensors, it can calculate in the range of 2 – 400 cm, while from the measurement data obtained that for a distance of 1.3 cm produces a fairly large percentage of errors and the rest only a small percentage of errors occur, this indicates that the ultrasonic sensor works well.

4.1.4 Ultrasonic Sensor and Buzzer Trial

Testing with a buzzer allows the tool to operate properly. And if it is between 1cm sometimes unreadable for the ultrasonic sensor.

4.1.5 LCD 16X2 (I2C) Trial

Testing the 16X2 I2C LCD to see if the LCD can display pre-programmed characters. This 16X2 I2C LCD module has two lines and each line can display a maximum of 16 characters.

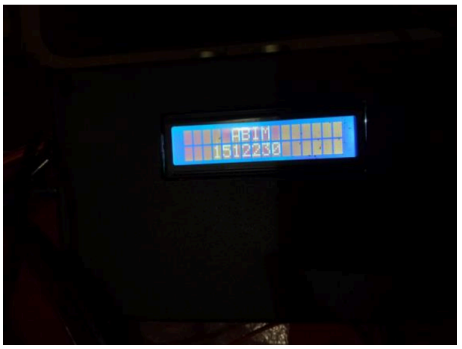

Figure 10. Test Result LCD 16x2 I2C

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The results of the 12x6 LCD test show that in 16 lines can appear different characters and the second line is the same according to the program made in the Arduino IDE, with the first line programmed texs "ABIM" starting in column 6 and row 0 (top), the second row is programmed with tekx "1512230" starting in column 3 and row 1 (bottom).

4.1.6 Servo Motor Trial

Servo Motor Testing to find out if the servo is moving optimally and as desired. The servo motor is run from an angle of 10 degrees to an angle of 180 degrees and measurements are made with sizes S, M and L.

Table 4. Testing of Servo Motors with S size garments

Types of clothing	Input on the program (degree)	Servo Motor Results (degree)	Object weight	Ket
Short sleeve shirt	180	180	100 gr	appropriate
	180	180	250 gr	appropriate
	180	180	300 gr	appropriate
	180	165	350 gr	not suitable
	180	160	400 gr	not suitable
Long sleeve shirt	180	180	120 gr	appropriate
	180	180	270 gr	appropriate
	180	175	310 gr	not suitable
	180	170	380 gr	not suitable
	180	165	410 gr	not suitable
Shorts pants	180	180	94 gr	appropriate
	180	180	150gr	appropriate
	180	170	306 gr	not suitable
	180	165	360gr	Not suitable
	180	155	440gr	not suitable
long pants	180	180	159gr	appropriate
	180	180	260gr	appropriate
	180	180	305gr	appropriate
	180	170	398gr	not suitable
	180	160	400gr	not suitable

From table 4 of the test of the servo motor with S size clothes, it is known that the suitable ones can fold the clothes perfectly and for those that are not suitable can fold but are still a bit messy, for those that do not fit, cannot fold the clothes to the maximum. The calculation of the formula is as follows:

$$Average = \frac{total\ Approprite}{Total\ All\ Tests} \times 100\% \quad (4.1.6)$$

$$Average = \frac{10}{20} \times 100\% \ = 50\% \quad (4.1.6)$$

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And after calculation, the average tool can fold clothes automatically with size S clothes is 50%.

Table 5 Testing of Servo Motors with M size garments

Types of clothing	Input on the program (degree)	Servo Motor Results (degree)	Object weight	Ket
Short sleeve shirt	180	180	120 gr	appropriate
	180	180	250 gr	appropriate
	180	180	297 gr	appropriate
	180	170	333 gr	not suitable
	180	160	401 gr	not suitable
Long sleeve shirt	180	180	150 gr	appropriate
	180	180	270 gr	appropriate
	180	180	305 gr	appropriate
	180	170	330 gr	not suitable
	180	165	398 gr	not suitable
Short pants	180	180	100 gr	appropriate
	180	180	165 gr	appropriate
	180	177	300 gr	appropriate
	180	165	335 gr	not suitable
	180	155	400 gr	not suitable
Long pants	180	180	150gr	appropriate
	180	180	220gr	appropriate
	180	180	302gr	appropriate
	180	170	398gr	not suitable
	180	160	440gr	not suitable

From table 5 of the test of the servo motor with M size clothes, it is known that the suitable ones can fold the clothes perfectly and for those that are not suitable can fold but are still a bit messy, for those that do not fit cannot fold the maximum clothes. The calculation of the formula is as follows:

$$Average = \frac{total\ Appropriate}{Total\ All\ Tests} \times 100\% \quad (4.1.6)$$

$$Average = \frac{12}{20} \times 100\% \ = 60\% \quad (4.1.6)$$

And after calculation, the average tool can fold clothes automatically with M size clothes is 60%.

Table 6 Testing of Servo Motors with L size garments

Types of clothing	Input on the program (degree)	Servo Motor Results (degree)	Object weight	Ket
Short sleeve shirt	180	180	170 gr	appropriate
	180	180	295 gr	appropriate
	180	170	311,5 gr	not suitable
	180	150	350 gr	not suitable
	180	120	490 gr	not suitable
Long sleeve shirt	180	180	200 gr	appropriate
	180	180	280 gr	appropriate
	180	155	350 gr	not suitable
	180	150	377 gr	not suitable
	180	120	410 gr	not suitable
	180	180	150 gr	appropriate

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Short Pants	180	180	240 gr	appropriate
	180	180	300 gr	appropriate
	180	140	360 gr	not suitable
	180	120	450 gr	not suitable
Long Pants	180	180	270 gr	appropriate
	180	170	311 gr	not suitable
	180	165	390 gr	not suitable
	180	150	450 gr	not suitable
	180	100	500 gr	not suitable

From table 6 of the test of servo motors with L size clothes, it is known that the suitable ones can fold the clothes perfectly and for those that are not suitable can fold but are still a bit messy, for those that do not fit cannot fold the clothes to the maximum. The calculation of the formula is as follows:

$$Average = \frac{total\ Appropriate}{Total\ All\ Tests} \times 100\% \quad (4.1.6)$$

$$\text{Average} = \frac{8}{20} \times 100\% \ = \ 40\% \quad (4.6)$$

And after calculation, the average tool can automatically fold clothes with L size clothes is 40%.
From the clothes in sizes S, M, and L, which can fold well between S and M. because the clothes are not too big and lighter for the tool can fold perfectly.

4.3 Functional Testing

The prototype of the automatic clothes folding device was tested to ensure its functionalization, the test was carried out to ensure that the automatic clothes folding tool could fold neatly and quickly. The test also includes how the tool can fold and how the ultrasonic sensor can detect accurately

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Figure 11 The process of folding clothes

Figure 12. The result of folding clothes

Measurement data of automatic folding tools with tested time can be seen in the table below.

Table 7 Folding Time Comparison Results

Types of Clothing	Clothing Size	Manual Folding Time (seconds)	Tool Folding Time (seconds)	Experiment in 10 times	
				Successful manual folding time comparison	Failed manual folding time comparison
Short Sleeve Shirt	S	16.08	10.43	10	0
	M	10.49	10.49	8	2
	L	16.21	10.51	10	0
Long Sleeve Shirt	S	18.05	16.22	9	1
	M	18.16	16.24	10	0
	L	18.22	16.35	9	1
Shorts Pants	S	15.03	10.45	10	0
	M	15.13	10.52	9	1
	L	15.17	10.55	7	3
Shorts Pants	S	16.11	16.32	8	2
	M	16.19	16.40	10	0
	L	16.24	16.69	10	0
Average				91.6%	8,3%

From table 7 above, it can be seen from 10 experiments of folding tools with a comparison of manual folding tools on average faster folding tools calculation formula as follows:

$$\text{Average Success} = \frac{Total\ successful\ folding\ time}{Total\ All\ Tests} \times 100\% \quad (4.3)$$

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Average Success = $\frac{110}{120} \times 100\% = 91,6\%$ (4.3)

The test results showed that on average, automatic clothes folding tools succeeded in folding faster than manual folding by 91.6%.

Comparison of automatic folding tools that fail by folding the formula calculation manual as follows:

$$Average\ Failure = \frac{Total\ failed\ folding\ time}{total\ All\ Tests} \times 100\% \quad (4.3)$$

$$Average\ Failure = \frac{10}{120} \times 100\% = 8,3\% \quad (4.3)$$

The test results showed that on average, automatic clothes folding devices failed to fold faster than manual folding by 8.3%.

Thus, automatic clothes folding tools are still faster than manual folding. For S and M sizes, the time is faster than the L size, because of the large size and thick fabric, so for the L size it takes longer to fold it.

4.4 Users Testing

This test is carried out by dividing questionnaires to users who are in direct contact with the automatic folding tool at Ririn Tailor, respondents consist of owners and employees at Ririn Tailor Convection, the results of the user test can be seen in the attachment, the test will be carried out by calculating the questionnaire into a form of presentation to make it easier to assess the reliability of the automatic folding tool, From the results of the questionnaire carried out, a score of 90% out of 100% was obtained.
The test results from users obtained an average score of 72.6% from a total of 3 respondents, the highest score was classified as DECENT in assessing the usefulness of users of automatic folding tools.

5. DISCUSSION

This tool is designed using an Arduino Uno microcontroller. By using sensors i.e., ultrasonic, buzzer, LCD and Servo Motor, with an automatic clothes folding tool by attaching your hand to the ultrasonic sensor, the tool will work automatically and the clothes will automatically fold. In building an automatic folding device, there are three stages. The first stage is assembling the components. The required components include an Arduino Uno R3 microcontroller, 12 x 6 LCD, ultrasonic sensor, buzzer sensor, three servo motors, mini breadboard, power supply, plywood and wood. The toolkit has been described in the Results sub-chapter. The series will be placed under plywood to look neat and easy to apply.

After the construction stage is completed, the next stage is the testing of the equipment. The first test was conducted by the author. In the test, the author used several types of clothing. The test began by testing short-sleeved clothes to long pants, then from the test got the time needed and averaged from all types of clothes carried out, this tool was declared PASSED and functioned properly. Article from Sibuea et al,

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entitled Design and Build an Automatic Clothes Folding Tool Using an Arduino-based Shield Sensor, the article uses several sensors to control the tool, such as an ultrasonic sensor as a clothes detector and as input when the tool is working, article from Rahmat entitled Design and Build a Tool Clothes Folders Use Springs as a Manual Drive Mechanism which produces clothes folders with spring power without electricity at a low price. The article from Hariyanti et al entitled Automatic Clothes Folding Device With Three Microcontroller-Based Folding Methods produces a clothes folding device that uses ON and Off controls and a Loop system to turn on the clothes folding device. researchers study the article by upgrading the tool so that the research tool can be more efficient and useful. By adding an LCD sensor as output. And the LCD sensor is useful when the tool is working automatically. The LCD screen will display "clothes are being folded" and, when the clothes have been folded, the LCD will display "clothes have been folded".

6. CONCLUSION

Based on the formulation of the problems and objectives mentioned earlier, this study can be concluded as follows

1. How to design a prototype of an automatic clothes folding device consists of several hardware such as Arduino Uno, 12 x 6 LCD (i2c), by testing some of the hardware itself, namely testing the Arduino with a USB adapter can turn on or not, then testing the ultrasonic sensor whether it can detect objects or clothes optimally and adding a buzzer sensor and I2C LCD can bring up information in the form of sound and text according to the program, Then the drive of the folding device, the servo motor can move or lift the shirt to the maximum and the shirt can fold neatly according to the standard weight limit of the shirt, which is 300 grams. And lastly, the overall testing of the prototype of the automatic folding device with experts and users.,
2. The feasibility test of the prototype of the automatic folding tool used in the Ririn Tailor Convection of Blitar Regency is considered feasible, this is based on two sources, the first is from user tests, the results of user tests that have been carried out 3 times per person get a decent score in the test. The average percentage of user tests is 72.6%, then the second source of robotics system experts in testing 3 times, got a score of 75% out of 100%, because according to tool testing experts there are several things that must be considered, there is a construction that is still not solid so it is not possible for the long term.

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