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Design and Development of an Automatic Clothes Folding Machine with Garment Fragrance and Heating Features Based on Arduino Uno

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Abstract

Manual clothes folding requires considerable time and effort, making it necessary to develop a more efficient and practical solution for everyday life. This study aims to design and build automatic clothes folding device based on Arduino Uno, equipped with heating and fragrance features to improve the quality of folding results. The device design encompasses the integration of mechanical and electronic components controlled via three control buttons, making operation simple and efficient. Testing was conducted on three types of clothing, namely t-shirts, shirts, and jerseys, considering material variations such as cotton, polyester, and canvas. The test results show that the device can fold clothes in an average time of 6.67 seconds, faster than the manual method which requires an average of 7.05 seconds. The heating and fragrance feature also proved to function well, producing neatly folded clothes with a fresh scent. The system operates stably, although folding performance is influenced by the type of fabric used. This device provides added value in the clothing packaging process and has the potential to become a practical solution that enhances efficiency and comfort in everyday clothes folding activities.

Keywords: *Arduino Uno; Clothes Folder; Heater; Fragrance; Servo Motor*

1. Introduction

Automation Automation technology is advancing rapidly, including in the garment industry, which demands neatness and consistency in the production process. One emerging innovation is the automatic clothes folding machine, serving as a strategic solution to support the garment industry in maintaining product quality standards prior to distribution [1].

This innovation leads to a device capable of making the garment folding process faster and more consistent by utilizing servo motors to drive mechanical components according to a programmed folding sequence, thereby guaranteeing uniformity in the folding results [2].

The garment folding process in the garment industry highly requires speed, precision, and high concentration to produce neat folds. To date, however, the folding process in most garment industries is still performed manually, causing workers to frequently experience fatigue and difficulties in maintaining folding consistency in large quantities. Consequently, the folding process becomes irregular, slow, and inefficient, particularly during high market demands or urgent delivery schedules.

Based on these issues, this study aims to design and build an automatic clothes folding device based on the Arduino Uno microcontroller as the central control unit to process the folding sequence and operate the servo motors. In addition to the primary folding mechanism, this device is equipped with heating and fragrance features, as well as three control buttons colored green, yellow, and red to activate and deactivate the device. Thus, folding can be executed rapidly and uniformly, while simultaneously improving packaging quality and alleviating the workload in the garment industry.

2. Literature Review

2.1. Garment

Garments are clothing items used to cover and protect the body, while also serving as an identity, social value, and self-expression for the user. Common types of garment materials include cotton, polyester, and canvas, each possessing different characteristics in terms of flexibility and thickness, thereby influencing the automatic folding process and its results [3].

2.2. Automatic clothes folder

An automatic clothes folder is a mechanical or electronic device designed to assist in the garment folding process either automatically or semi-automatically using servo motors, sensors, and microcontrollers programmed to execute a specific folding sequence. This device has proven effective in saving time and effort, while producing neat and uniform folds with a relatively simple design and more affordable costs compared to industrial machinery [4].

2.3. Fragrance

Garment fragrance is a care product functioning to provide a fresh scent and eliminate unpleasant odors on fabric. One of the primary active ingredients in fragrances is cationic surfactants, which coat fabric fibers to make them feel softer while retaining the scent to last longer [10]. In this device, the fragrance is sprayed automatically onto the center of the garment before the folding process begins.

2.4. Garment Heater

A garment heater functions to dry remaining moisture on fabric and reduce wrinkles after the folding process is completed. Heating lamps emit controlled heat to prevent excessive temperatures, as stable heat can maintain the softness of fabric fibers while serving as an efficient drying solution for household or laundry industry needs [5].

2.5. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328p chip designed as an open-source platform with a simple, flexible, and easy-to-program design. This board is equipped with digital and analog input/output pins that enable the simultaneous control of various electronic components, making it suitable for use as a central control unit that integrates servo motors, a heater, and a fragrance feature into a single system [6].

2.6. MG996R Servo Motor

The MG996R servo motor operates based on the principle of precise position control using Pulse Width Modulation (PWM) with closed-loop feedback control through a potentiometer on the motor shaft, ensuring the output position always aligns with the provided control signal. This type of Arduino-based servo motor control principle is also implemented in research on automatic dispenser tap actuators with fast response and high precision [7].

2.7. Lcd

An LCD (Liquid Crystal Display) is utilized in microcontroller-based systems to provide crucial status information to the user, such as whether the device is turned on or off [8]. In this device, a 16x2 I2C LCD displays the folding progress as well as the system status during operation and upon completion.

2.8. Power Supply

A power supply functions to convert AC voltage from the main grid into a lower and stable DC voltage through the stages of step-down voltage conversion, rectification using bridge diodes, filtering using capacitors, and voltage regulation by regulators, enabling all electronic components in the device to operate with the required power [9].

3. Research Methods

To build the prototype of the Arduino Uno-based automatic clothes folding machine, the author utilized the Agile development method. This method allows system design and testing to be conducted iteratively and flexibly, focusing on the design of the folding mechanism, heating, and fragrance features. The stages conducted in this method are: (1) Requirements, which is the stage of analyzing the system component needs with Arduino Uno as the primary central control unit. (2) Design, aiming to provide a schematic overview of the electronics and mechanical design of the device. (3) Development, encompassing the process of separately programming each feature using the Arduino IDE through short sprint cycles. (4) Testing, which involves unit and integration testing to measure the precision and effectiveness of the device on cotton, polyester, and canvas fabrics. (5) Deployment, constituting the full integration of hardware and software components into the final prototype form. (6) Review, acting as a comprehensive evaluation and system error correction stage to ensure the device functions optimally.

3.1. Tools and Materials

The hardware utilized includes an Arduino Uno, five MG996R servo motors, a 10-watt heating bulb, a relay module, a fragrance container, three push buttons (green, yellow, and red), a 16x2 I2C LCD, a 12V 15A power supply, and a step-down module. The software employed consists of the Arduino IDE for microcontroller programming, Cirkit for schematic design, TinkerCAD for three-dimensional design, and Visio for constructing the system workflow diagram.

4. Results and Discussion

4.1. Requirements

The requirements stage identifies the system needs of the automatic clothes folding machine, which include five MG996R servo motors as the folding actuators, a 10-watt heating bulb as the heating element controlled via a relay, an automatic fragrance spraying mechanism, three push buttons (green, yellow, and red) along with one toggle switch as the control interface, and an I2C LCD as the status indicator. The Arduino Uno is designated as the central control unit, powered by a 12V power supply that is stepped down through two step-down modules (5V and 6V) to match the voltage requirements of each component.

4.2. Design

4.2.1. Block Diagram

The block diagram illustrates the structure and workflow of the Arduino Uno-based automatic clothes folding system. The system consists of several input components, namely two push buttons for selecting the folding mode, one push button to stop the process, and a toggle switch to activate the heating lamp. The power source originates from a 12V power supply, which is subsequently stepped down using a 5V step-down module to meet the voltage requirements of the Arduino Uno and the servo motors. The Arduino Uno functions as the central control unit that receives input from the control buttons and subsequently regulates the output, which includes the LCD for information display, four servo motors for the garment folding mechanism, one servo motor for the fragrance system, and the heating lamp. With this configuration, the system is capable of automatically executing the garment folding, fragrance spraying, and heating processes according to the user's commands, as illustrated in Figure 1.

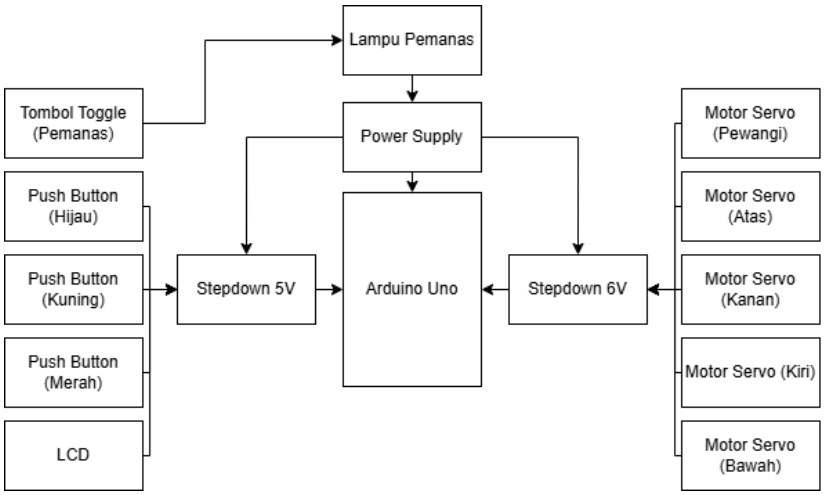

Fig. 1: Block Diagram

4.2.2. Schematic

The schematic illustrates the wiring between components, ranging from the push buttons and toggle switch on the input side, the Arduino Uno as the controller, to the five servo motors, heating lamp relay, and LCD on the output side, as illustrated in Figure 2.

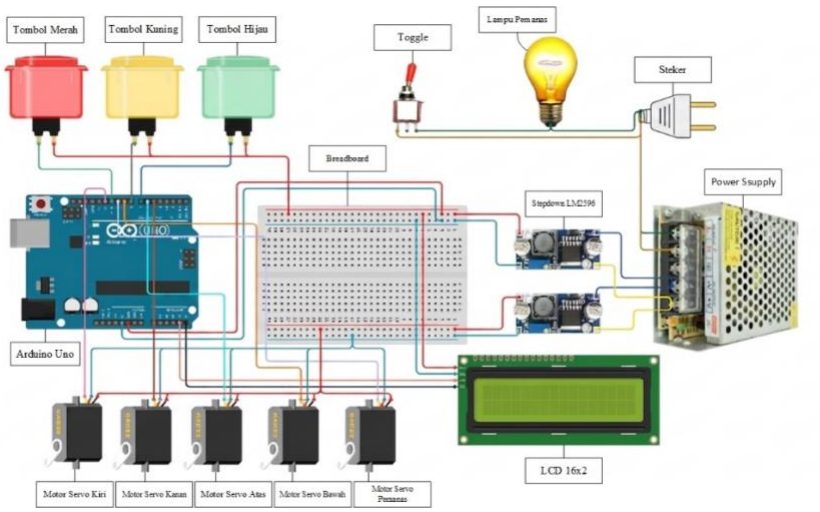

Fig. 2: Schematic

4.2.3. System Workflow

The system workflow is illustrated through a flowchart. The system provides two folding modes activated via the green button, which follows a folding sequence of (top-left-right-bottom-top), and the yellow button, which follows a folding sequence of (left-right-bottom), while the red button immediately stops the entire process and displays the final status on the LCD, as illustrated in Figure 3.

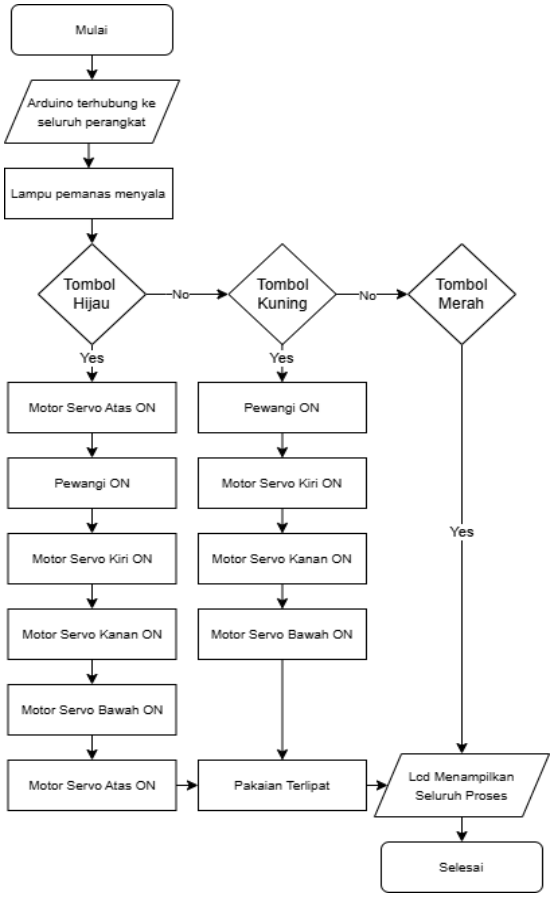

Fig. 3: System Workflow

4.2.4. Clothes Folding Machine

The physical design of the device consists of three main folding boards as the automatic folding mechanism, three push buttons and an LCD screen on the front side as the user interface, and an enclosed heating chamber at the bottom of the device that functions as temporary storage for the clothes after being folded. The heating chamber can also be used to keep the clothes warm. The entire design is constructed to support the folding and fragrance spraying processes, and the device design is illustrated in Figure 4.

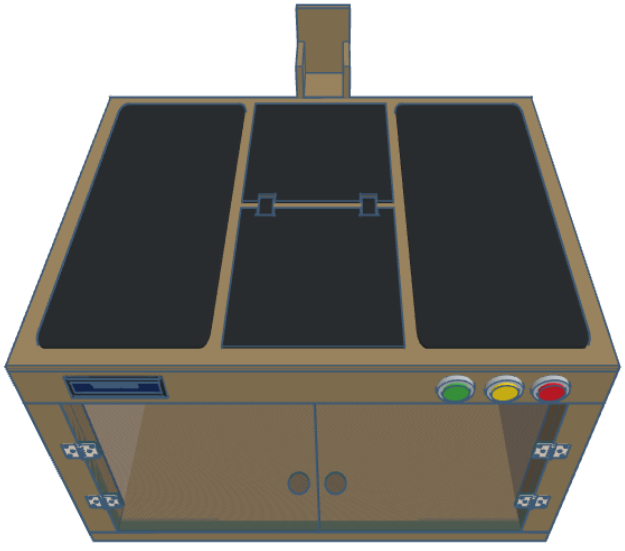

Fig. 4: The clothes folder design

4.3. Development

The development stage transforms the design into a physical device. The device frame is constructed from wood and plywood, utilizing five MG996R servo motors: two servos on the left and right sides to drive the horizontal folding boards, one servo at the bottom for vertical folding, one servo at the top, and one additional servo for the fragrance spraying mechanism. The heating element, consisting of a 10-watt light bulb, is installed at the bottom of the device and controlled by a toggle switch via a relay module. The fragrance system utilizes one additional servo motor that actuates the fragrance liquid container to spray scent onto the clothes at the beginning of the folding cycle, before the board arm mechanism moves to fold the clothes according to the selected mode. Each feature was programmed and tested separately using the Arduino IDE prior to being integrated into the overall system. The hardware implementation results are shown in Figure 5.

Fig. 5: The prototype of The Automatic Clothes Folding Machine

4.4. Testing

4.4.1. Servo Motor Testing

The actuator system testing was conducted on five high-torque MG996R servo motors connected to the Arduino Uno via digital pins 12 (Servo 1), pin 5 (Servo 2), pin 6 (Servo 3), pin 9 (Servo 4), and pin 10 (Servo 5). This functional testing evaluated two mechanical movement modes for the folding board: the first mode follows a top-right-left-bottom sequence, while the second mode executes a right-left-bottom sequence. Based on the evaluation of various angular degrees and directional rotations, all servo motors demonstrated optimal and precise performance without mechanical constraints, successfully lifting the folding panels and driving the automated fragrance sprayer actuator, as presented in Table 1.

Table 1: Servo Motor Testing

Servo Motor	Servo Degree	Result
Fragrance	0°–180°	Rotated 3x, Success
Top	0°–50°	Success
Right	180°–70°	Success
Left	0°–120°	Success
Bottom	180°–60°	Success

4.4.1. Fragrance System Testing

This test aimed to evaluate the performance of the automatic clothes fragrance spraying system driven by a servo motor as an additional feature to provide a fresh scent to the clothes. Device integration was conducted by connecting the VCC, GND, and PWM pins of the fragrance servo to the digital control pins of the Arduino Uno. The testing demonstrated that the actuator mechanism is capable of responding to signal commands rapidly without any symptoms of delay or stuttering mechanical movement. The fragrance system can operate automatically and timely in accordance with the program logic, as presented in Table 2.

Table 2: Fragrance System Testing

Testing	Description	Result
Servo rotation	3 Times	As expected
Active response	<1 Second	Fast
Spray consistency	Stable	As expected

4.4.1. Heating System Testing

This test was conducted to ensure that the heating system can maintain temperature stability after the folding process. The heating element demonstrated excellent performance with the ability to reach a temperature of 25°C within 2 minutes. Subsequently, from the 5th to the 10th minute, the temperature was observed to remain stable at 35°C. These results prove that the heating system has a good response to help keep clothes warm after being folded.

Table 3: Heating System Testing

Time	Temperature (°C)	Description
2	25	Preheating
5	35	Starting to stabilize
10	35	Stable
30	35	Remaining stable

4.4.1. Push Button Testing

This test was conducted to observe the response of three push buttons (green, yellow, and red buttons) as control inputs for the automatic clothes folding system. The green and yellow buttons are configured to activate the sequence of the folding process and fragrance spraying automatically by the Arduino Uno. Meanwhile, the red button is integrated as an emergency stop button function to instantly shut down the entire system operation in the event of a mechanical malfunction, as presented in Table 4.

Table 4: Push Button Testing

Button	Function	Status
Green	Full mode (Top-left-right-bottom-top)	Succes
Yellow	Simple mode (Left-right-bottom)	Succes
Red	Stopping the entire system	Succes

4.4.1. Comparison of Manual and Automatic Folding Time

Based on the test results, the automatic system requires an average time of 6.67 seconds, which is 0.38 seconds faster (a time efficiency of 5.39%) compared to the manual method that requires 7.05 seconds. In terms of quality, manual folding exhibits weaknesses in the consistency of garment edge neatness, as it heavily relies on the individual skill of the operator. Conversely, folding using the Arduino Uno-based automatic device produces folds that are far more precise, symmetrical, and uniform across every trial.

Table 5: Comparison of Manual and Automatic Folding Time

Fabric Type	Automatic (Seconds)	Automatic (Seconds)
24s cotton t-shirt	6.59	7.64
20s cotton t-shirt	6.95	7.34
20s cotton t-shirt	7.06	7.19
20s cotton t-shirt	7.11	7.23
Dot jersey	6.48	6.01
Topo jersey	6.38	7.53
Air Walk jersey	6.06	5.42
Airism t-shirt	6.46	5.12
Polyester t-shirt	7.17	8.85
24s cotton t-shirt	6.44	8.16
Average	6.67	7.05
Time difference	0.38	

4.5. Deployment

The deployment phase represents the final implementation process by integrating all hardware and software components into the definitive form of the device, which is then fully operated under real operational conditions to fold clothes, heat, and spray fragrance according to its functions. During advanced operational condition testing, it was discovered that power supply instability could cause imprecise servo movements, preventing the folding arms from reaching their programmed positions; this indicates that power supply capacity and stability are critical factors in maintaining the consistency of the mechanical system's performance, aligning with the notes in study [11] regarding the importance of voltage regulation in multi-servo-based systems.

4.6. Review

The review phase aims to evaluate the overall system performance after the implementation process is completed. The evaluation results indicate that all components, including the servo motors, fragrance system, heating system, and control buttons, are able to function according to their designed purposes without experiencing any interference or operational errors.

5. Conclusion

This study successfully develops an automatic clothes folding device featuring a garment fragrance dispenser and heater based on the Arduino Uno, which consists of four servo motors for folding, one fragrance servo, and a 10-watt light bulb as the heater.

Based on the test results, the device is capable of folding t-shirts, shirts, and jerseys with an average time of 6.67 seconds, which is faster compared to manual folding that requires 7.05 seconds. The fragrance and heating systems are also able to function well without compromising the quality of the folds.

The advantage of the developed device is its capability to integrate the folding, fragrance dispensing, and heating processes into a single automatic system. However, the testing is still limited to a few garment types, so further development can be conducted to enhance the device's capability in handling a wider variety of clothing sizes and types.

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