Automatic Clothes Folder With Three Folding Modes Based on Microcontroller

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Abstract: In the digital era and increasingly rapid automation, technological innovation continues to penetrate various aspects of life, including household work. One household task that is often considered boring and time-consuming is folding clothes. Even though it looks simple, this activity can be a burden, especially in the context of modern society, where time is limited. The main feature of this system is its ability to fold clothes with three different folding modes. This provides the flexibility to handle different types of clothing or different fold preferences. The folding mechanism is implemented using a Tower Pro MG995 servo motor, which is programmed to move precisely using the Servo library. The design of an automatic system for folding clothes in three different modes is to build a tool that will use the Arduino Uno R3 microcontroller as a control center that coordinates all system operations. Next, the folding mechanism is implemented using a Tower Pro MG 995 servo motor, which is programmed to move precisely using a servo library.

Keywords: Automatic Clothes Folder, Arduino Uno, Microcontroller, Servo Library, Clothes.

INTRODUCTION

In today's modern technological era, innovations continue to develop to simplify various household tasks. One time-consuming and often tedious activity is folding clothes. Although seemingly simple, folding clothes manually can be tiring, especially for individuals with limited time in their daily lives. This condition is highly relevant in modern society, which prioritizes time efficiency. Automatic clothes-folding technology therefore emerges as a practical solution.

Several studies have developed automatic clothes-folding devices using various approaches. Previous research by Hariyanti et al. (2020) developed a microcontroller-based automatic clothes-folding device with three folding modes, capable of folding clothes in less than ten seconds. The device utilized a microcontroller to control servo motors responsible for executing the folding process. The study demonstrated that automation technology in household applications can significantly contribute to time efficiency.

Another study conducted by Mattalatta et al. (2023) designed a microcontroller-based automatic sarong-folding device by considering users' anthropometric aspects. The device was able to fold sarongs more efficiently using servo motors that adapted to the user's hand dimensions. Ergonomic considerations were emphasized to improve user comfort during operation.

Meanwhile, Churniawan et al. (2023) introduced an automatic clothes-folding device based on an Arduino Uno microcontroller equipped with an ultrasonic sensor. The system was capable of folding clothes weighing up to 400 grams within a short period. The findings highlighted the strong potential of automatic clothes-folding technology to improve household efficiency.

However, despite these developments, a research gap remains regarding flexibility in folding various types and sizes of clothing. Previous studies tended to focus on a single type of garment or limited folding modes. Therefore, this research aims to develop an automatic clothes-folding device capable of operating in three different folding modes using microcontroller technology. The system is expected to accommodate various clothing types such as formal wear, T-shirts, trousers, and shorts.

The objective of this study is to develop an automatic clothes-folding device that addresses the limitations of previous research. By utilizing an Arduino Uno–based system, this research seeks to provide a more efficient solution for saving time and energy in household activities. The Arduino Uno R3 microcontroller was selected due to its high precision in controlling electronic components, particularly servo motors that drive the folding mechanism.

The expected benefit of this research is improved efficiency in the clothes-folding process, producing consistent and neat folding results. With three folding modes, users can select the most suitable mode based on the type of clothing, offering greater flexibility than earlier systems. In addition, this research is expected to encourage further innovation in microcontroller-based household automation.

A system can be defined as an integrated framework designed to achieve one or more objectives by coordinating resources to transform inputs into outputs (Gunawan et al., 2020; Nugroho & Setiawan, 2024). An LCD is a display medium that uses liquid crystal technology to present information in the form of characters, numbers, or graphics (Nugraha & Sari, 2021). Arduino is an open-source electronics platform consisting of hardware and software that is easy to use (Ahmad & Faikul, 2021). A buzzer is an electronic component that converts electrical signals into sound (Rahmawati et al., 2020).

A microcontroller is a programmable integrated circuit that functions as a controller for electronic systems and is capable of storing and executing programs (Saptono & Sumbiaganan, 2020; Kusumah et al., 2021). An automatic system refers to a system capable of operating independently with minimal human intervention (Putra & Sari, 2021). Clothing is one of the basic human needs alongside food and shelter (Meliana & Hwihanus, 2022). A servo motor is an electromechanical actuator equipped with a closed-loop control system that enables precise control of position, speed, and movement (Pratama et al., 2020; Alifiah et al., 2023).

LITERATURE REVIEW

The term system originates from the Greek word sustema, which means unity or a whole composed of interconnected components that work together to achieve a specific goal. A system can be defined as an interconnected network within a particular domain, consisting of elements that interact and depend on one another. A system is an integrated framework with one or more objectives, coordinating resources to transform inputs into outputs. These resources may include materials, machines, or energy, depending on the type of system. In general, a system is a collection of subsystems or components that are organized and interact in an integrated and interdependent manner (Gunawan et al., 2020; Nugroho & Setiawan, 2024).

A Liquid Crystal Display (LCD) is a display technology that utilizes liquid crystals to present images and text. LCDs operate based on the optical properties of liquid crystals, which change orientation when an electrical signal is applied. Structurally, LCDs consist of a matrix of cells, each containing two polarizing layers and a layer of liquid crystal between them. By controlling the electrical signals applied to each cell, various images, characters, and colors can be displayed. LCDs are widely used in electronic devices such as televisions, calculators, and computer monitors (Nugraha & Sari, 2021).

Arduino is an open-source electronics platform that consists of easy-to-use hardware and software. It enables users to develop electronic projects more efficiently compared to conventional electronic systems. Arduino provides an integrated development environment that simplifies writing, compiling, and uploading program code to the microcontroller board. Arduino boards are capable of reading input signals and converting them into output actions, making them suitable for developing interactive electronic systems (Ahmad & Faikul, 2021).

A buzzer is an electronic component that functions to convert electrical signals into sound vibrations. The working principle of a buzzer is similar to that of a loudspeaker. It generally consists of a coil attached to a diaphragm. When an electric current flows through the coil, an electromagnetic field is generated, causing the coil to move inward or outward depending on the current direction and magnetic polarity. This movement causes the diaphragm to vibrate, producing sound waves (Rahmawati et al., 2020; Putra & Sari, 2021).

METHOD

1. Research Stage.

This research was conducted through several main stages, starting with initial data collection and ending with final testing of the automatic clothes folding system with three microcontroller-based folding modes. These stages involved the development, implementation, and testing of hardware and software that support the automated clothes folding function. These research stages are described sequentially as follows:

1. Problem Identification

In the initial stage, problems related to the need for an automatic clothes-folding device were identified. The problems identified were the time-consuming and labor-intensive manual clothes folding process, as well as the inflexibility of existing clothes folding devices. This stage aimed to understand the problems faced by users and how solutions could be provided.

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2. Literature Review

A literature review was conducted on automatic clothes folding technology based on microcontrollers, servo motors, and Arduino Uno microcontroller-based control systems. Previous research on automatic clothes-folding devices served as the basis for determining the direction of this device's development. References were obtained from relevant journals.

3. System Design

In this stage, the system design includes both hardware and software. The hardware design includes components such as an Arduino Uno R3 microcontroller, a Tower Pro MG995 servo motor, sensors, and a folding mechanism capable of operating in three folding modes. Figure 1 shows a block diagram of the device explaining how these components are integrated.
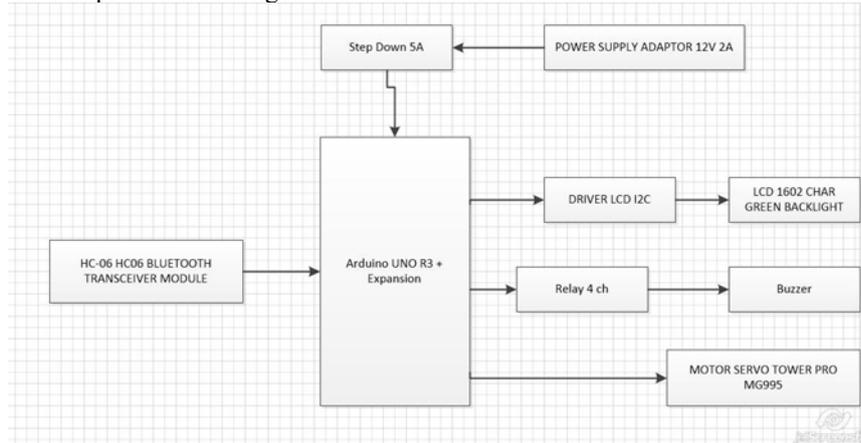

Figure 1. Block diagram of an automatic clothes-folding tool

Diagram Description:

   a. 12V 2A Power Supply Adapter: Provides 12V voltage and a maximum current of 2A for electronic devices.
   b. 5A Step-Down Module: Converts high voltage to lower voltage with a maximum current of 5A.
   c. HC-06 Bluetooth Module: Enables wireless communication between microcontrollers and devices such as smartphones.
   d. Arduino Uno R3: Flexible microcontroller board with additional I/O ports and sensor support via expansion boards.
   e. I2C LCD Driver: Simplifies LCD setup by reducing wiring and simplifying control.
   f. 4CH Relay: Controls up to four electrical circuits independently with a low-power control signal.
   g. 1602 LCD: Displays text and symbols with a green backlight for clarity in various lighting conditions.
   h. Buzzer: Generates warning or notification sounds on various devices[21].
   i. Tower Pro MG995 Servo Motor: Controls angular movements with precision, used in robotics and automation applications.

The software was designed to control the movement of the servo motor and folding mechanism in three different modes. The algorithm for setting the folding mode was programmed into the microcontroller to ensure the device operated according to the user's selected mode.

4. Development and Implementation

After the system design was complete, the development phase involved building a prototype of the automatic clothes-folding device. The microcontroller was programmed to control the movement of the servo motor based on user input. This prototype was also tested to ensure each component functioned properly, particularly in terms of coordination between hardware and software.

5. Testing and Evaluation

Testing was conducted to evaluate the device's performance in three different folding modes. The device was tested with various types and sizes of clothing to measure accuracy and folding speed. The test results were compared with other clothes-folding devices, and their effectiveness in saving time and energy was measured. Table 1 shows the average test time for each folding mode.

Table 1
Average Clothes Folding Time per Mode

Mode Pelipatan	Jenis Pakaian	Waktu Pelipatan (detik)

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Mode 1	Kaos	8
Mode 2	Celana Panjang	10
Mode 3	Pakaian Formal	12

2. Analysis of the Existing System

Manual clothes folding systems are still widely used in households and industries such as laundries. Despite their simplicity, this method has several major drawbacks, such as:

1. Time and Energy
   Manual folding is time-consuming and labor-intensive, especially for large quantities.
2. Consistency of Results
   Folding results vary in neatness and size, depending on the user's skill and physical condition.
3. Limitations
   Manual systems have difficulty handling different types of clothing with different folding methods.

3. Analysis of the System to be Built

The system to be built is an automatic clothes folding device with three microcontroller-based folding modes. This device is designed to address the shortcomings of manual systems by utilizing Arduino Uno-based automation technology. The following is an analysis of the system to be built:

1. Microcontroller-Based Automation
   An Arduino Uno microcontroller will be used to control the servo motor that drives the folding mechanism. The folding algorithm is programmed to select three folding modes according to the type of clothing, such as t-shirts, pants, or formal wear.
2. Consistent Results
   Using the Tower Pro MG995 servo motor, this tool is capable of producing consistent and neat folds every time it is used. Each folding mode is controlled by an algorithm implemented in the microcontroller.
3. Time Efficiency
   With an automated system, the tool can fold clothes faster than manual methods.
4. Versatility in Garment Types
   This tool is designed with three folding modes, allowing users to choose the mode that best suits the type and size of clothing. Using sensors and algorithms, the tool can detect the size of the garment and determine the most appropriate folding mode.

4. System Design

1. 12V 2A Power Supply Adapter
   Provides 12V voltage and a maximum current of 2A for electronic components.
2. 5A Step-Down Power Supply
   Converts high voltage to a lower voltage with a maximum current of 5A, to meet the needs of different components.
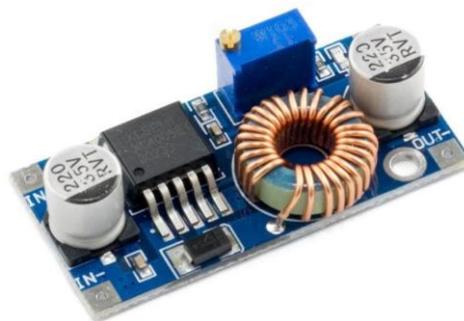
Gambar 2. 5A Step-Down Module

3. HC-06 Bluetooth Module
   Enables wireless communication between the Arduino Uno and external devices such as smartphones for remote control.
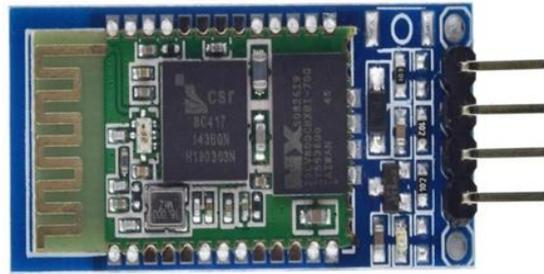
Gambar 3. HC-06 Bluetooth Transceiver Module

4.Arduino Uno R3

A microcontroller board is responsible for controlling the servo motors, relays, and other components connected to the system[22]. The program implemented in the microcontroller will determine the folding mode selected by the user.

Gambar 4. Arduino Uno R3

5. Driver LCD I2C

Digunakan untuk menampilkan informasi sistem pada layar LCD 1602 dengan komunikasi minimal, yaitu hanya menggunakan dua kabel. Hal ini menyederhanakan pengaturan dan penggunaan layar LCD.

Gambar 5. I2C LCD Driver

6. Relay 4CH (4 Channel)

Controls the electrical current to other components such as servo motors and power supplies[23]. This relay allows independent control of multiple devices through a single microcontroller.

Gambar 6. 4CH Relay (4 Channel)

7.1602
Displays information such as folding mode and device status visually with a green backlight, allowing users to read in various lighting conditions.
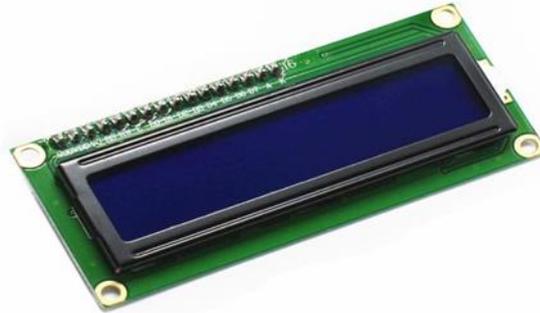

Figure 7. LCD 1602

8. Buzzer
Functions as an audible notification to inform the user that the folding process is complete or that there is an error in the system.

Figure 8. Buzzer

9. Tower Pro MG995 Servo Motor
A servo motor is a motor with a closed-loop feedback system[24]. It controls the mechanical movement of the folding device. This servo is responsible for rotating the folding arm according to the selected mode, ensuring precise folding of garments.

Figure 9. Tower Pro MG995 Servo Motor

5. System Design
After analyzing the system, the author continued the research by creating a system design. The image of the system to be designed is shown below:
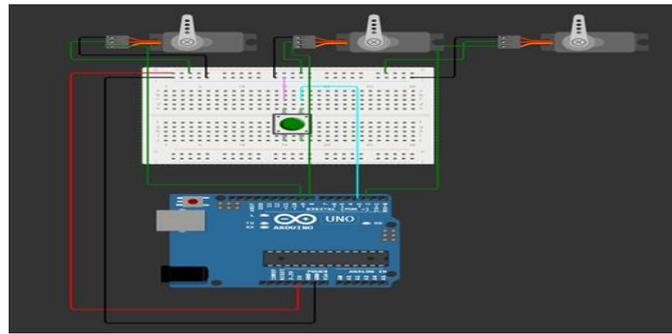
Figure 10. Simulation of an Automatic Clothes Folding System Design

The image above shows an electronic circuit using an Arduino Uno as its main controller. This circuit is designed to control three servo motors, which are a type of motor that can be positioned with high precision.

After the simulation, the next step is to design an automatic clothes-folding system using an Arduino Uno as the main controller. This circuit controls three servo motors, which are positioned with precision. The Arduino Uno is located at the bottom, connected to a breadboard that connects the various components. The servo motors are connected to the breadboard with power, ground, and control signal cables. These cables connect to the Arduino's digital pins (pins 9, 10, and 11), which send PWM signals to control the servo positions.

Additional components, such as push buttons or LEDs, are placed in the center of the breadboard as inputs or visual indicators. With the appropriate code, the Arduino is programmed to control the servo movements based on the inputs received, allowing the system to execute user-defined automatic folding modes.

With this system design, it is hoped that the automatic clothes folding device will provide an efficient solution for folding clothes, saving time and effort, and improving the consistency of folding results. Repeated testing was conducted to ensure the system's performance is consistent and meets expectations.

In this method, each folding mode is designed for a different type of clothing, such as t-shirts, trousers, and formal wear. These folding modes are controlled using sensors that detect the garment's size and adjust the servo motor movement accordingly. The use of sensors and actuators ensures that the garments are folded with high precision. Using this method, this research aims to produce an efficient and flexible automatic clothes-folding device.

RESULT

The resulting system is an innovative automatic clothes-folding device designed to replace manual folding. It uses an Arduino Uno R3 microcontroller as the control center, coordinating all system operations. A key feature of the system is its ability to fold clothes in three different folding modes, providing flexibility in handling various types of clothing. The folding mechanism is implemented using a Tower Pro MG995 servo motor, programmed to move precisely using the Arduino Servo library.

The system is equipped with a user interface in the form of a 1602 LCD with an I2C driver, which displays information and operating status. Users can select the desired folding mode through the control panel. For increased usability, the system also includes an HC-06 Bluetooth module, enabling wireless control from external devices such as smartphones.

Other key components include a 4-channel relay for controlling additional electrical components, and a power supply system consisting of a 12V 2A power supply adapter and a 5A step-down voltage to provide a stable voltage to all components. A buzzer is also integrated into the system to provide audio notification to the user when the folding process is complete.

The prototype system demonstrated satisfactory results in folding clothes with high accuracy, saving users time and effort. While it currently functions well, there is room for further development, such as adding sensors to automatically detect clothing types and improving the folding algorithm for greater flexibility.
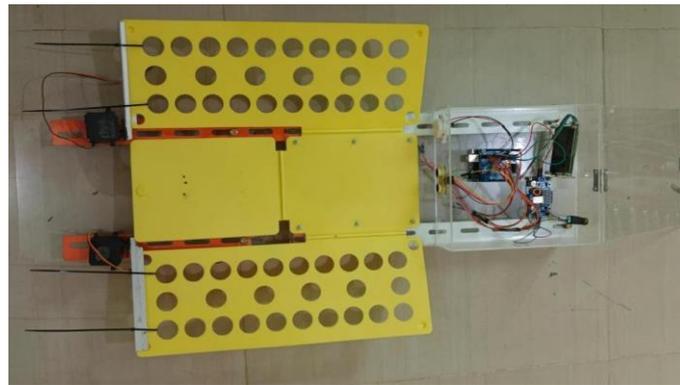
Figure (Fig. 11) Top View of the Device

This image shows a top view of an automatic clothes-folding device. The main platform is made of plastic or acrylic and is equipped with two mechanical arms driven by servo motors. These arms are responsible for folding the clothes according to the selected mode. A microcontroller also serves as the brain of the system, controlling the servo movements based on the input received. Sensors around the platform are used to detect the position of the clothes and ensure accurate folding.
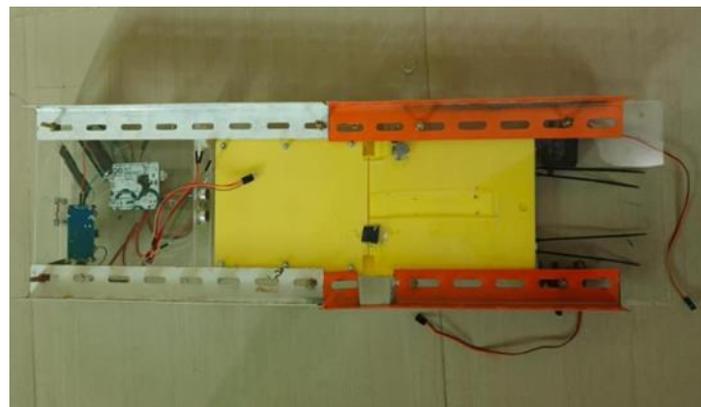

Figure 12. Rear View of the Device

In the final image, we see the rear view of the device, revealing the solid metal frame that supports all components. The main yellow platform serves as the platform where the clothes are placed before being folded. The power control module and sensors used to detect the position of the clothes are clearly visible, ensuring the system functions with high precision. A neat network of cables connects the microcontroller to the servo motors and sensors to maintain a stable power and signal flow.

DISCUSSIONS

In this section, we will discuss the operating principles of an automatic clothes folding system based on the Arduino Uno R3 microcontroller. This system consists of several components that work together to produce an efficient automatic folding process.

This automatic clothes-folding system relies on the precise movements of servo motors to fold clothes according to three pre-programmed modes. The servo motors move from 0° to 180° and back, creating the desired folding pattern. The 1602 displays the mode status and other important information. The Bluetooth HC-06 allows users to control the system remotely using a smartphone app. The designed system is an automatic clothes-folding device with three folding modes for various types of clothing. The Arduino Uno R3 serves as the control center, coordinating system operations, while Tower Pro MG995 servo motors are used to fold clothes precisely. Other components include the Bluetooth HC-06 module for wireless control, the 1602 LCD for the user interface, and a 4-channel relay to control additional electrical components. The system is also equipped with sensors to detect the position of the clothes and ensure accurate folding.

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The interface system is designed for ease of use, with a buzzer as an audio indicator and Bluetooth HC-06 to allow control from external devices such as smartphones. A 12V 2A power supply and a 5A step-down provide stable power for all components, while 4CH relays provide flexibility in controlling other components.

CONCLUSION

The conclusions that can be drawn from this research are that the design of an automated system for folding clothes with three different modes uses an Arduino Uno R3 microcontroller as the control center that coordinates all system operations. Furthermore, the folding mechanism is implemented using a Tower Pro MG 995 servo motor, which is programmed to move precisely using a servo library. To ensure accuracy and concentration in the microcontroller folding process, the microcontroller must be programmed with an algorithm that can precisely execute mechanical hand movements, so that clothes are folded consistently each time.

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