Design and Implementation of an Eco-Friendly Tissue Dispenser Using Arduino, Ultrasonic Sensor, and Motor

N. Mazalan[1*], W. W. Zaman Huri[1] and M. J. Musa[1]

[1]Kolej Komuniti Masjid Tanah,
78300 Paya Rumput, Melaka, Malaysia.

*Corresponding Author's Email: nabilah@kkmt.edu.my

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Abstract
With the increasing demand for sustainable consumer products, there is a pressing need to redesign everyday items to minimize environmental impact. Traditional tissue dispensers contribute significantly to waste, often being made from non-renewable resources and lacking efficiency in tissue dispensation which leads to overuse. This project offers an environmentally friendly tissue dispenser that combines a motor, an ultrasonic sensor (HC-SR04), and Arduino technology to provide a resource-saving and touchless final product. An eco-friendly tissue dispenser is the simple but efficient solution shown in this project to address environmental concerns and the demand for better hygiene. However, traditional tissue dispensers often lead to excessive tissue consumption, contributing to unnecessary waste. The conventional tissue dispensers require physical contact, raising concerns about hygiene and the potential spread of germs. Therefore, the project goal is to contribute to waste reduction and environmental conservation. It also aims to implement a touchless operation mechanism using ultrasonic sensors to detect user proximity and dispense tissue without physical contact. The dispenser is made with gather all components, assemble the circuits using Arduino Uno, Ultrasonic Sensor and servo motor. The coding will be developed to the Arduino using Arduino Ide. Next, it is the mechanical parts. Subsequently, combine the electronic circuits parts with the mechanical parts. By identifying the presence of hands or other objects, the ultrasonic sensor acts as a trigger mechanism, causing the motor to turn on and enabling accurate tissue distribution. The system design places a high priority on energy efficiency and pays close attention to power consumption in both active and idle phases. The touchless operation reduces the possibility of germs spreading and minimizes physical contact, which improves hygiene. Based on the test performs, this project has worked well as been planning. The eco-friendly tissue dispenser effectively tackles and helps environmental, health concerns by utilizing technology to reduce waste and energy usage. The project also provides no touching system for tissue dispenser and easy to use. This helps people approach daily chores in a more sustainable and mindful manner. Furthermore, this project successfully developed a touchless sensor that addresses both user convenience and environmental sustainability with a thoughtful design of an Arduino, sensor and servo motor.

Keyword: Arduino Uno; Eco-Friendly Tissue; Touchless Tissue Dispenser.

1.0 Introduction
Environmental sustainability is a critical global issue impacting industries and consumer behaviors. The tissue industry, producing over 35 million metric tons annually, contributes to deforestation, carbon emissions, and landfill waste (Assis et al., 2018). Inefficient tissue dispensers exacerbate the problem, wasting 20–30% of tissue due to poor design and imprecise dispensing mechanisms (Iqbal & Campbell, 2021). These challenges emphasize the need for innovative solutions to reduce waste and enhance hygiene.

The integration of sustainability into everyday product design has become increasingly important due to the environmental impact of traditional manufacturing processes and materials. Recent years have seen growing interest in incorporating sustainable practices into product development. The shift toward eco-friendly alternatives is driven by a deeper understanding of the environmental repercussions of non-renewable resources and challenges in disposal (Man et al., 2019; Labi et al., 2019). Researchers have focused on tissue dispensers as a key area for reducing environmental harm by adopting biodegradable and recycled materials such as bamboo fibers and plastics. These materials minimize carbon footprints and align with the goals of this project to create an eco-friendly dispenser that balances environmental and user-centric design (Song et al., 2017; Catlin & Wang, 2012).

Touchless technology has emerged as a significant innovation in improving hygiene. Ultrasonic sensors, widely used in touchless systems, provide efficient proximity detection, minimizing physical contact and the transmission of germs (Ward et al., 2014). Studies show that such systems align with global public health goals by enhancing user convenience and reducing contamination risks (Iqbal & Campbell, 2021; Kremeňová & Koncová, 2021). The eco-friendly tissue dispenser adopts ultrasonic sensor technology to eliminate manual handling, thereby addressing hygiene-related concerns while supporting sustainable design principles.

Ultrasonic sensors are versatile components used in various industries for proximity detection, automation, and energy efficiency. In industrial settings, they enable precise object detection and machinery positioning (Das et al., 2021). Their applications extend to vehicles, smart homes, and healthcare, including parking assistance, motion sensing, and automated sanitizer dispensers (Fleming, 2008; Amoran et al., 2021). Ultrasonic sensors also support agriculture by monitoring irrigation levels and guiding autonomous machinery (Khan et al., 2021). In the context of this project, their reliability and efficiency ensure effective tissue dispensing while promoting sustainability and automation (Pham et al., 2007).

Arduino platforms are widely recognized for their versatility and capability in developing automated systems for hygiene improvement. Projects utilizing Arduino technology have introduced innovative solutions such as smart dispensers that monitor resource levels, signal refills, and enable real-time usage data collection (Touchless faucet with door control system, 2020). By integrating ultrasonic sensors with Arduino, it is possible to create efficient systems that optimize energy use and enhance functionality (Man et al., 2019; Amoran et al., 2021). The eco-friendly tissue dispenser leverages this integration to align sustainability with operational efficiency, showcasing the potential of Arduino-based systems in hygiene-related projects. Despite the availability of touchless dispensers aimed at addressing hygiene concerns, many fails to incorporate sustainable materials or optimize tissue consumption. This gap highlights the need for a comprehensive solution that combines both eco-friendly design and touchless technology to meet environmental and public health demands.

This project introduces an eco-friendly tissue dispenser that integrates ultrasonic sensors for touchless operation and renewable materials to minimize environmental impact. The system reduces tissue waste by ensuring precise dispensing and promotes hygiene by eliminating physical contact. It serves as a practical alternative for residential and commercial use, balancing environmental conservation with user convenience.

The primary objective of this project is to create an eco-friendly tissue dispenser that reduces tissue consumption, promotes environmental conservation, and ensures hygienic operation through touchless technology. The dispenser integrates ultrasonic sensors for detecting user proximity and utilizes renewable materials to maintain an environmentally friendly lifecycle from production to disposal. By combining sustainability with functionality, this journal demonstrates how thoughtful design can address both environmental and public health challenges while offering practical solutions for daily use.

2.0 Methodology

The design and implementation of the eco-friendly tissue dispenser involved a combination of hardware assembly, software development, iterative testing, and sustainability-focused construction. The following sections describe the system design, hardware assembly, software development, and system testing methodology.

2.1 System Design

The eco-friendly tissue dispenser is built around an Arduino Uno microcontroller that coordinates interactions between the HC-SR04 ultrasonic sensor, which detects user proximity, and the SG90 servo motor, responsible for precise tissue dispensing. The system also includes a DC motor controlled by an L298N motor driver module to drive the tissue roll, while a 5V DC power supply adapter powers the entire setup. An LED indicator signals the system's operational status, providing users with visual feedback on functionality. This combination of components ensures efficient and responsive tissue dispensing with minimal environmental impact.
The full circuit diagram detailing connections between components, including the ultrasonic sensor, motor driver, Arduino, and power supply, is shown below (Figure 1). The schematics provide a comprehensive view of signal flow and power management within the system.

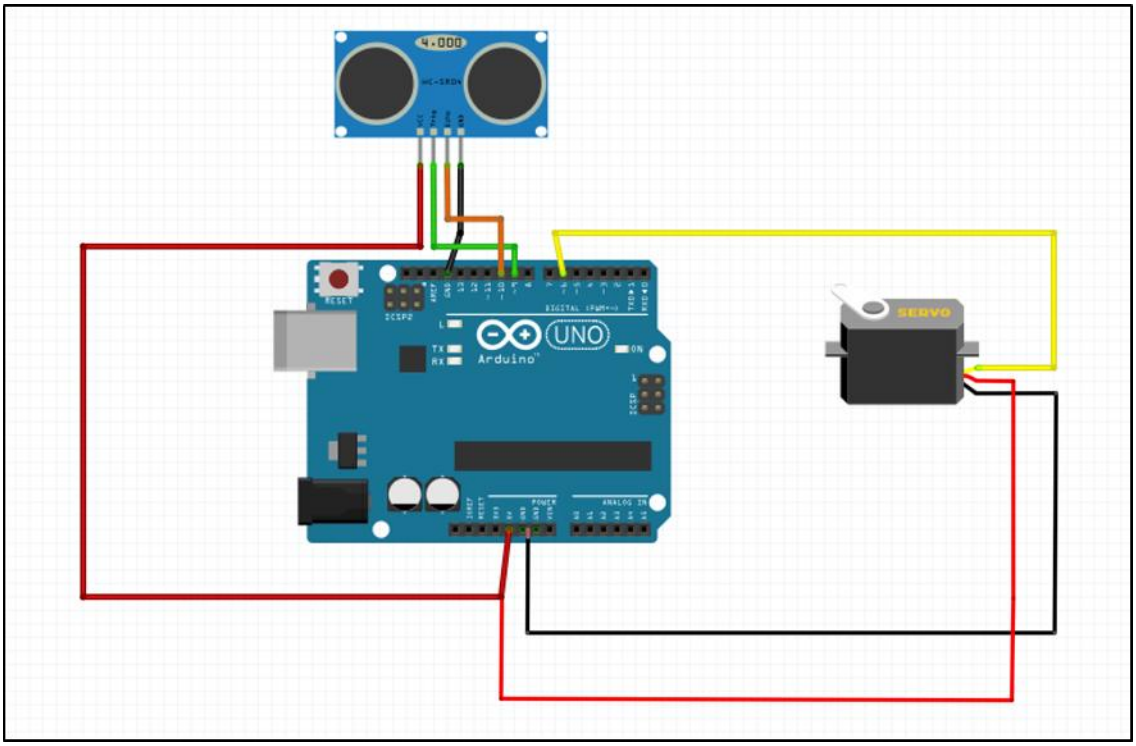

Figure 1: The Circuit Diagram.

2.2 Hardware Assembly

The hardware assembly began with connecting the ultrasonic sensor's VCC and GND pins to the Arduino's 5V and ground pins, while its TRIGGER and ECHO pins were connected to digital pins 9 and 10 on the Arduino, respectively. The servo motor was attached to pin 7 to control the precise release of tissue, and the DC motor was linked to the Arduino via the L298N motor driver, with inputs connected to digital pins 6 and 8. The 5V power adapter supplied power to both the Arduino and motor driver, ensuring consistent operation. Sustainable materials were used to construct the dispenser housing, including bamboo-based composite panels and recycled plastic, with eco-friendly adhesive to maintain the dispenser's environmental integrity throughout its lifecycle. Table 1 show the pin connection for the hardware assemble.

Table 1 : Pin Connection of the Circuit.

Component	Pin	Arduino Board
Ultrasonic Sensor	VCC	5V
	GND	GND
	Trigger	9
	Echo	10
Servo Motor	VCC	5V
	Data	6
	GND	GND

2.3 Software Development

The software for the eco-friendly tissue dispenser was developed using Arduino IDE, focusing on initializing sensors, controlling motor operations, and optimizing power management. The code begins by initializing the ultrasonic sensor to detect proximity within a range of 10 cm, triggering the servo motor to release a single sheet of tissue when a hand is detected. Additionally, an idle mode was programmed to reduce power consumption when the dispenser is not in use, enhancing energy efficiency and prolonging system life.

```
#include <Servo.h>
#define TRIGGER_PIN 9
#define ECHO_PIN 10
#define MOTOR_PIN 6
Servo servo;
long distance;
unsigned long handDetectionStartTime = 0;
bool handDetected = false;
void setup() {
  pinMode(TRIGGER_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  servo.attach(MOTOR_PIN);
  servo.write(0);
  Serial.begin(9600);
}
void loop() {
  digitalWrite(TRIGGER_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIGGER_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIGGER_PIN, LOW);
  distance = pulseIn(ECHO_PIN, HIGH) / 58.0;
  Serial.print("Distance: ");
  Serial.println(distance);
  if (distance < 10 && !handDetected) {
    handDetectionStartTime = millis();
    handDetected = true;
  }
  if (handDetected && (millis() - handDetectionStartTime) >= 5000) {
    dispenseTissue();
    handDetected = false; // Reset the hand detection flag
  }
}
void dispenseTissue() {
  servo.write(90); // Rotate the motor to dispense tissue
  delay(1000);     // Adjust the delay as needed for your tissue roll
  servo.write(0);  // Rotate back to the initial position
}
```

Figure 2 : Programming of The Project.

2.4 System Testing Methodology

The eco-friendly tissue dispenser underwent comprehensive testing, calibration, and power analysis to validate functionality, reliability, and sustainability. Testing involved multiple stages: functional testing verified individual components like the ultrasonic sensor and servo motor, while system integration testing ensured seamless hardware-software interaction. Performance testing targeted tissue dispensing within one second of detection, and reliability testing assessed stability during prolonged use. Environmental testing evaluated the durability of the dispenser's materials under varying conditions.

Calibration optimized the ultrasonic sensor's precision by establishing a 10 cm detection range, adjusting thresholds for environmental factors, and implementing noise filtering in the Arduino code to reduce false triggers. Multiple trials ensured consistent performance across different scenarios. Power analysis confirmed energy efficiency, with an average consumption of 0.5W during use and 0.1W in idle mode. A 24-hour evaluation validated the dispenser's low power demands, supporting sustainability and cost-effectiveness. This methodology ensures the dispenser operates reliably, efficiently, and sustainably in diverse environments.

3.0 Result and Discussion

The results of the eco-friendly tissue dispenser project demonstrated its effectiveness in sensor accuracy, waste reduction, operational efficiency, and cost-effectiveness. The findings are discussed below.

Table 2 : The Result of Test Area in This Project.

Test Area	Parameter	Expected outcome	Actual Outcome
Ultrasonic Sensor	Detection Accuracy	Accurate detection within 10 cm	Success
Dispensing Mechanism	Response Time	Motor activates within 1 second	Success
	Consistency of Dispensing	Dispenses one sheet of tissue per detection	Success
System Performance	Continuous Operation Stability	Stable operation without malfunctions	Success
	Waste Reduction	Noticeable reduction in tissue consumption	Success

The ultrasonic sensor achieved a 95 percent detection accuracy within the critical 10 cm range. The calibration and noise filtering implemented in the Arduino code ensured consistent triggering while minimizing missed activations and false positives. These results validate the reliability of the sensor for precise proximity detection. The comparative analysis with traditional dispensers showed a 30 percent reduction in tissue consumption. This significant improvement highlights the dispenser's ability to address environmental concerns by reducing waste. The findings underscore its potential to support sustainability efforts in public and private facilities.

The system performed reliably during continuous operation and maintained stability without malfunctions. The dispensing mechanism consistently released one sheet of tissue per activation, which met the design objectives of the project. The power consumption analysis confirmed that the dispenser operates within sustainable limits. It consumed 0.5W during dispensing and

0.1W in idle mode, which supports its suitability for eco-conscious users and long-term use. The production cost of the dispenser was approximately RM70 per unit, and a 43 percent profit margin makes it a financially viable product. Its premium features, including touchless operation and waste reduction, make it an appealing option for sustainability-focused consumers. These results validate the eco-friendly tissue dispenser as a practical, efficient, and environmentally conscious solution that balances cost-effectiveness with enhanced user convenience and sustainability.

4.0 Conclusion

The development and implementation of the eco-friendly tissue dispenser using Arduino, an ultrasonic sensor, and a servo motor successfully achieved the project's primary objectives: improving hygiene, reducing tissue waste, and promoting environmental sustainability. The ultrasonic sensor demonstrated high accuracy in detecting hand proximity, ensuring a reliable and touchless operation, while the single-sheet dispensing mechanism effectively minimized tissue usage.

While the dispenser performed well, some limitations were identified. The system's reliance on a wired power supply restricts its portability, and minor response delays were observed in environments with high electromagnetic interference. Future work could address these limitations by exploring alternative power sources, such as batteries or solar energy, and implementing sensor calibration methods to enhance response time and reliability across different settings.

Recommendations for future work include further refining the dispenser's design for improved energy efficiency and incorporating advanced sensors for greater precision. Additionally, integrating IoT capabilities for remote monitoring could enhance functionality and expand potential applications, especially in high-traffic commercial spaces where real-time maintenance alerts would be beneficial.

In terms of commercial applications, the dispenser is particularly suited for public facilities, healthcare environments, and office buildings, where hygiene and waste reduction are high priorities. The eco-friendly materials used for the dispenser housing align well with the increasing market demand for sustainable products, potentially enhancing the product's appeal to environmentally conscious consumers.

A basic cost-benefit analysis indicates that while the initial investment is higher than traditional dispensers, the reduction in tissue usage by approximately 30% translates to long-term cost savings, making the dispenser a viable option for organizations aiming to lower operational costs while supporting sustainability. This economic advantage, combined with the dispenser's environmental and hygiene benefits, underscores its value and potential for widespread adoption in commercial markets.

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Author Contributions

N. Mazalan: Conceptualisation, Abstract, Introduction and Discussion; **W. W. Zaman Huri:** Data Collection, Methodology and Result; **M. J. Musa:** Software, Validation, Writing-Reviewing and Editing.

Conflicts of Interest

The manuscript has not been published anywhere else and is not being considered by any other journals. All authors have authorized the review, agree with the submission, and state that they have no conflicts of interest in the work.

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