Smart Home Automation: Rain-Sensing Retractable Clothesline and Automatic Door System

A Research Study

Presented to the College of Engineering

Systems Plus College Foundation

In Fulfillment of the

Final Requirement for the Subject

Fundamentals of Mixed Signals and Sensors

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Date Submitted: November 3, 2025

ABSTRACT

This project is conducted by the Computer Engineering students of Systems Plus College Foundation and presents the design, development, and implementation of an **Automatic Door and Retractable Rain-Sensing Clothesline System** using **Arduino-based control and sensor automation.** The primary objective of this project is to create a smart home prototype that demonstrates the effective use of sensors to improve daily convenience and energy efficiency. The automatic door mechanism utilizes an ultrasonic sensor that detects objects within a predefined range of 2-3 inches, prompting the servo motor to open or close the door automatically. Meanwhile, the rain-sensing clothesline employs a water sensor that detects the presence of rain and activates a motorized system to retract the clothesline, preventing clothes from getting wet. By integrating these components, the project showcases the potential of embedded systems in automating household functions through precise sensor readings and real-time responses. This innovation aims to reduce human intervention, enhance safety, and demonstrate the practical application of automation and control systems in smart home environments. Furthermore, the study emphasizes the importance of cost-effective design and the adaptability of Arduino-based systems in educational and real-world applications.

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Chapter I – Project Background and Introduction

1.1 Introduction and Background of the Project

In the past, people were often burdened with manually opening and closing doors, which can be inconvenient and unhygienic, especially when carrying items or in crowded environments. Similarly, households have long struggled with the unpredictability of the weather when drying clothes outdoors. Sudden rainfall can result in wet garments, wasted time, and inefficient drying. These everyday inconveniences highlight the growing need for intelligent systems that enhance comfort, safety, and efficiency within the home.

With the advancement of smart home technologies, automation has become an essential feature of modern living. Automated systems function seamlessly with minimal human intervention, improving convenience and energy efficiency. According to a study by Bhandari and Shrestha (2019), the implementation of Internet of Things (IoT)-based automation enables remote control of household devices and reduces the manual effort required for basic domestic operations. This shift reflects the growing demand for homes that can intelligently respond to human needs and environmental changes.

One of the major technologies enabling these innovations is the **sensor system**, which detects changes in the environment and triggers corresponding electronic or mechanical actions. Among the most widely used are ultrasonic sensors, which detect motion or distance using sound waves, and rain or water sensors, which identify the presence of rainfall or moisture. These sensors have become essential in designing smart environments that enhance comfort, hygiene, and energy efficiency (Umer et al., 2023).

In the study *"Design of Automatic Sliding Door Based on Arduino Using Ultrasonic Sensors as a Preventative Measure Against the Spread of COVID-19"* by Simanjuntak et al. (2021), ultrasonic sensors were used to automate door operations without physical contact. This innovation not only improved accessibility but also reduced the spread of germs in both

public and private spaces. Such applications demonstrate the capability of automation to improve safety and hygiene while offering hands-free convenience.

Similarly, smart drying systems have been introduced as solutions to unpredictable weather conditions. The research *"Smart Clothesline: Arduino-Controlled Drying System with Light and Rain Detection"* by Aulia et al. (2023) utilized rain and light sensors to automatically retract clotheslines during rainfall and extend them when the weather clears. The study highlighted the effectiveness of environmental sensors in reducing human effort and preventing clothing damage caused by unexpected rain.

Building upon these advancements, this study proposes a bungalow-type house prototype equipped with two primary automated systems: (1) an **ultrasonic sensor for an automatic door mechanism**, and (2) a **water sensor for a rain-sensing retractable clothesline**. The project aims to demonstrate how affordable, Arduino-based sensor technology can be integrated into a household prototype to improve convenience and environmental adaptability.

This system aims to enhance convenience, hygiene, and energy efficiency while showcasing the potential of embedded systems in daily life. The automatic door promotes accessibility and reduces physical contact, while the rain-sensing clothesline protects clothing and lessens dependency on electric dryers. As supported by Umer et al. (2023), the integration of multiple IoT sensors in smart home systems strengthens automation efficiency, user satisfaction, and environmental responsiveness.

1.2 Statement of the Problem

Despite the increasing availability of home automation technologies, many households—especially in developing areas—still rely on manual systems that limit convenience, hygiene, and efficiency. This study seeks to address specific challenges associated with domestic automation through a sensor-based bungalow house prototype. The project is guided by the following specific problems:

1. How can an ultrasonic sensor be effectively utilized to automate a door system that ensures both hands-free operation and reliable detection of human presence?

2. How can a water sensor be integrated into a retractable clothesline system to automatically respond to rainfall and prevent clothing damage?

3. How can the integration of both systems—automatic door and rain-sensing clothesline—demonstrate the potential of affordable sensor-based automation for smart homes?

1.3 Objectives of the Study

The main objective of this study is to design and develop a sensor-based bungalow prototype that demonstrates automation using ultrasonic and water sensors to improve home convenience, safety, and energy efficiency. The project aims to showcase how sensor technologies can be applied in everyday household functions, particularly in door automation and weather-responsive systems.

Specifically, this study aims to:

1. Design and implement an automatic door system that utilizes an ultrasonic sensor to enable hands-free operation and reliable detection of human presence for improved accessibility and hygiene.

2. Integrate a rain-sensing retractable clothesline system using a water sensor that automatically responds to rainfall to protect clothing from damage and ensure user convenience.

3. Combine and evaluate the performance of both systems—the automatic door and the rain-sensing clothesline—to demonstrate the potential of affordable, sensor-based automation for smart home applications, focusing on functionality, responsiveness, and reliability.

1.4 Significance of the Study

This study is significant as it demonstrates the potential of **sensor-based automation** in promoting convenience, safety, and efficiency within residential environments. By integrating an ultrasonic sensor for an automatic door system and a water sensor for a rain-sensing retractable clothesline, the project provides a practical representation of how embedded systems and sensor technologies can simplify everyday household activities.

For **homeowners and general users**, the prototype serves as a conceptual model for creating more convenient and energy-efficient living spaces. It highlights how automation can minimize manual effort, improve hygiene by reducing physical contact with doors, and protect clothing from sudden weather changes.

For **engineering and IT students**, this project acts as a valuable learning experience that connects theoretical knowledge with hands-on application. It encourages creativity, problem-solving, and system integration skills essential for designing real-world embedded systems.

For **educators and institutions**, the study provides a tangible teaching material for lessons involving sensors, Arduino programming, and automation principles. It can be used to inspire students to explore modern engineering solutions using affordable and accessible components.

For **future researchers**, the study may serve as a foundation for more advanced projects involving IoT integration, wireless communication, or machine learning-based automation. Enhancing the system's range, detection accuracy, and scalability could pave the way for smarter, more adaptive home technologies.

1.5 Scope and Delimitation

This study focuses on the development and implementation of a sensor-based smart bungalow prototype that demonstrates automation through the integration of two primary sensors: an ultrasonic sensor for an automatic door system and a water sensor for a rain-sensing retractable clothesline. The system was designed, coded, and tested using Arduino IDE and actual hardware components, such as servo motors and a buzzer, to simulate motion and provide audio feedback. The primary objective of the project is to showcase how sensor-based systems can enhance home convenience, hygiene, and energy efficiency by minimizing manual effort in daily activities.

The scope of this study includes the design, wiring, and programming of the automatic door and clothesline systems, as well as the integration of both sensors into a single prototype model. The ultrasonic sensor is calibrated to detect motion within a range of approximately three inches, triggering the servo motor to open the door automatically. The water sensor, on the other hand, detects rainfall and activates the retractable clothesline mechanism while playing a buzzer sound to signal operation. Both features operate under programmed conditions uploaded through the Arduino microcontroller.

This study is limited to the prototype scale and therefore does not represent a full-sized automated home installation. The automatic door system utilizes only one ultrasonic sensor located outside the door, which means that the sensor can only detect entry movements. Users exiting the prototype house must manually open the door, as the system lacks an inward-facing sensor. Additionally, the door has a fixed four-second delay before closing, regardless of user proximity. The rain-sensing system is limited by the water sensor's sensitivity, which may only detect rainfall once water directly contacts the sensor surface.

The prototype operates using a basic power supply suitable for demonstration purposes and does not include backup power or wireless control integration. Environmental factors such as sensor misalignment or external noise may also affect detection accuracy.

Despite these limitations, the project successfully demonstrates the essential principles of automation and the effective use of sensors in smart home systems. Future iterations may expand the system with dual sensors for bi-directional detection, adjustable delay timers, and improved environmental calibration to achieve greater reliability and functionality.

Chapter II – Design Methodology and Procedures

2.1 Materials and Components Used

The materials and electronic components used in constructing the **Automatic Door and Rain-Sensing Clothesline System** were carefully selected to ensure functionality, reliability, and proper presentation of the prototype. The materials are divided into **electronic components** for the circuit assembly and **construction materials** for the prototype structure.

A. Electronic Components

- **Arduino Uno** – serves as the main microcontroller that processes sensor data and controls the actuators.

- **Ultrasonic Sensor** – detects the presence of an object or person near the door to trigger the automatic opening mechanism.

- **Rainwater Sensor** – senses the presence of rain or moisture to retract the clothesline automatically.

- **Servo Motors (2 units)** – control the movement of the automatic door and the clothesline mechanism.

- **Buzzer** – provides an audible alert whenever rain is detected or when the door is operating.

- **Jumper Wires and Electrical Wires** – used to interconnect all electronic components in the circuit.

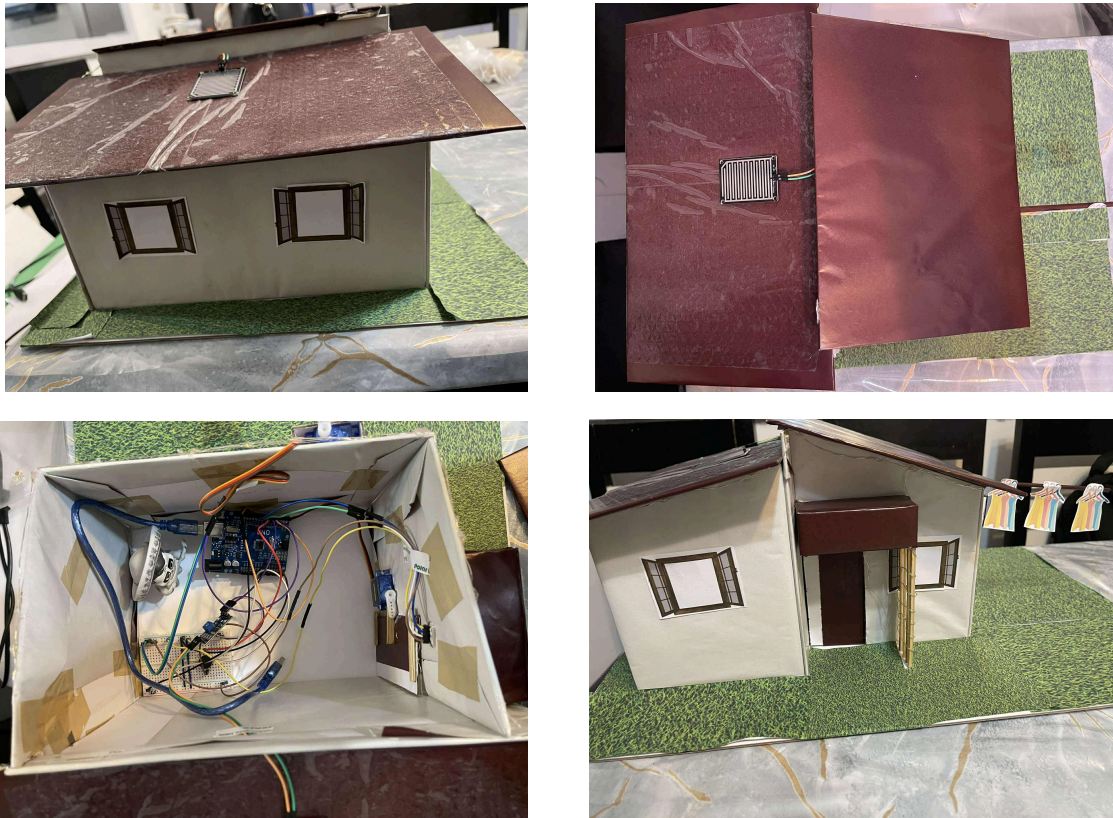- **Breadboard** – serves as a base platform for connecting and testing components without soldering.

- **LED Lights** – installed **around the exterior of the bungalow model** to provide decorative lighting and emphasize the structure's outline.

- **Laptop Computer** – used for writing, uploading, and debugging the Arduino program that controls the system.

B. Construction Materials

- **Illustration Boards (4 pcs)** – used as the primary material for constructing the walls and roof of the bungalow house model.

- **Cutter** – utilized for cutting and shaping the illustration boards precisely.

- **Ruler** – used to ensure accurate measurement and alignment during assembly.

- **Pencil** – used for marking and lining the illustration boards before cutting and assembly.

- **Super-glue Adhesive** – used to attach the parts of the structure together firmly.

- **Brown Construction Paper** – applied as an outer covering for the prototype to achieve a clean and realistic finish.

2.2 Prototype Design Overview

Figure 2.2.1 Bungalow House Prototype and Components

The prototype of the **Automatic Door and Rain-Sensing Retractable Clothesline System** is a scaled-down bungalow model equipped with smart automation features. It integrates **ultrasonic and rain sensors** to perform automatic door and clothesline functions, simulating real-life home automation in a compact and realistic setup.
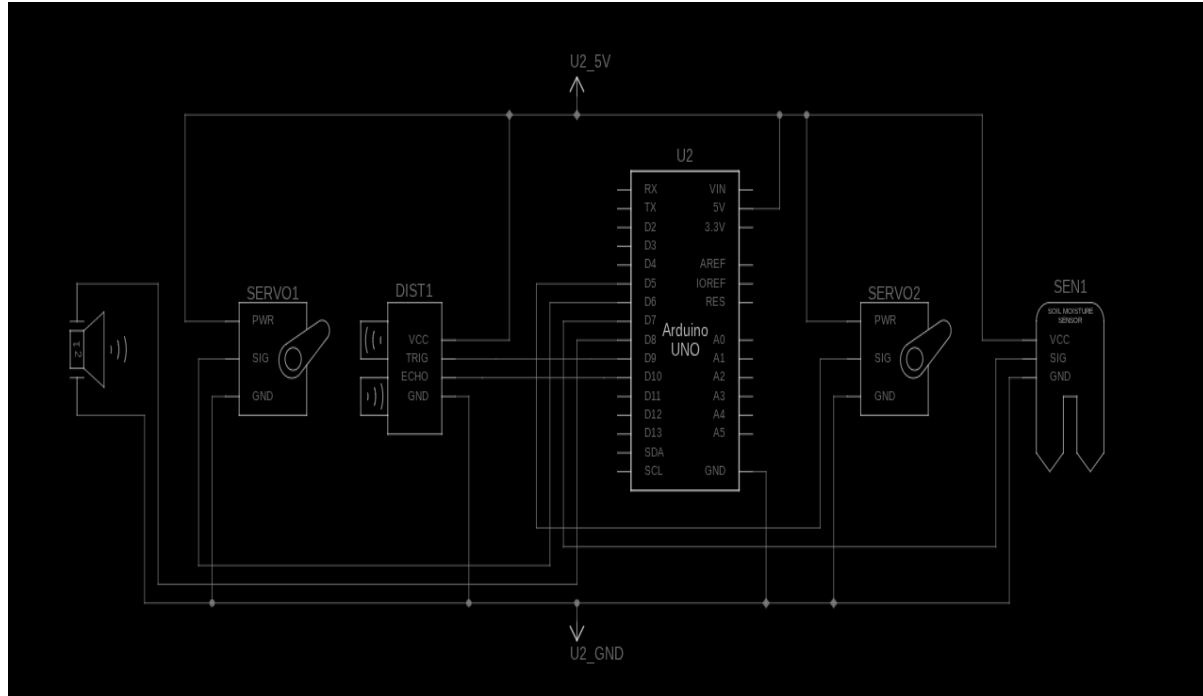
At the front portion of the prototype is an **automatic door system** powered by a servo motor and controlled through the **Arduino Uno** microcontroller. The ultrasonic sensor is strategically positioned to detect approaching objects or individuals within a range of 3 inches below, activating the servo motor to open and then close the door automatically. This simulates a contactless entry system commonly found in modern smart homes.

The **rain-sensing retractable clothesline system** is installed on one side of the house, where a **rain sensor module** is placed on the roof to detect moisture. Once rain is detected, the servo motor retracts the clothesline, automatically pulling the hanging clothes. The mechanism ensures that the clothes remain dry even during unexpected rainfall.

Inside the house model, the **Arduino Uno**, **breadboard**, **jumper wires**, **buzzer**, and **servo motors** are neatly arranged and connected to demonstrate the control circuitry. A **laptop** is also used to upload and monitor the Arduino code, serving as the system's programming and power interface. The external portion of the house is surrounded by **LED lights** that illuminate the environment, symbolizing outdoor lighting automation.
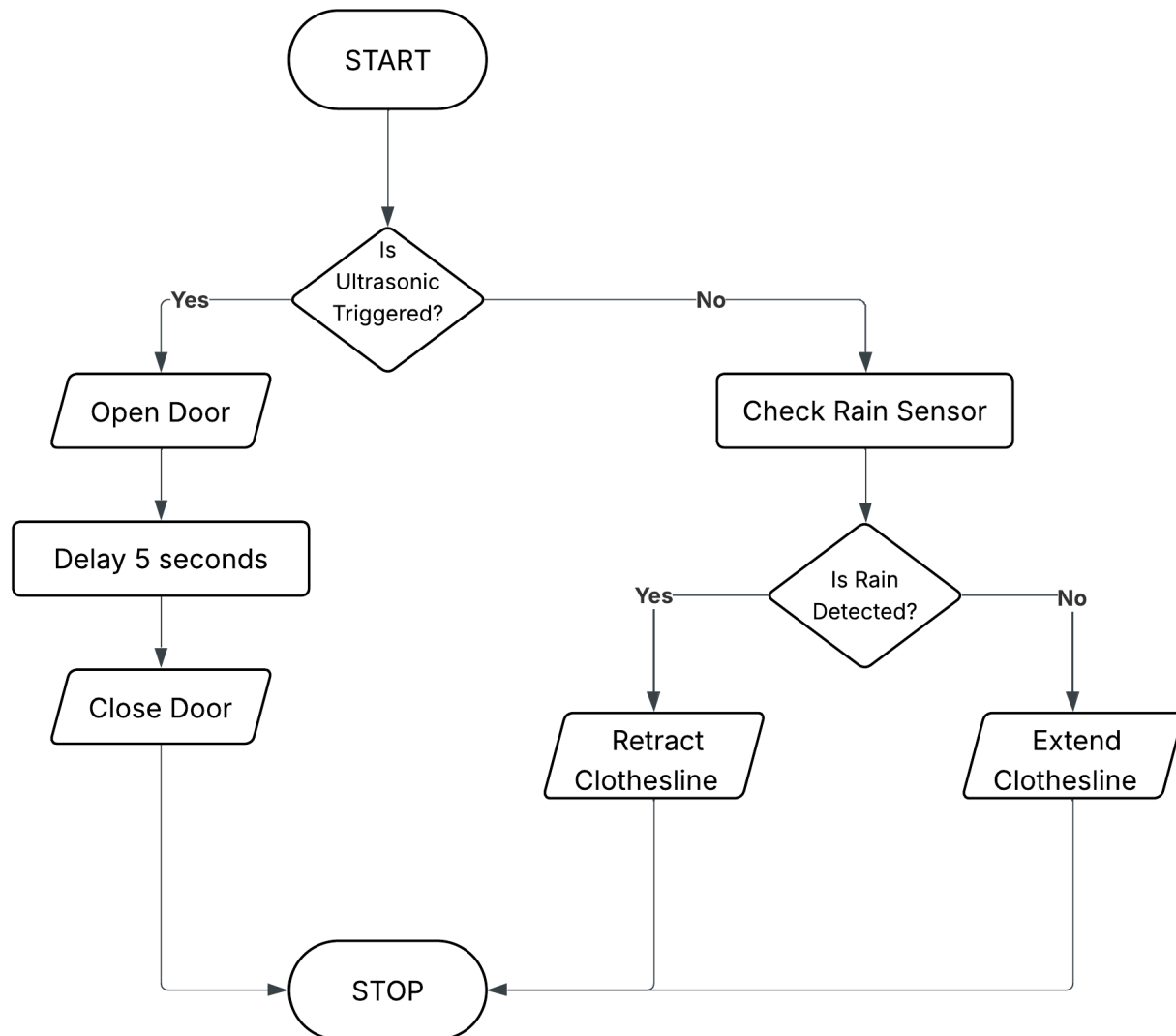
2.3 Circuit Diagram and Description

Figure 2.3.1 Wiring Diagram of the Automatic Door and Rain-Sensing Retractable
Clothesline System

The circuit diagram of the **Automatic Door and Rain-Sensing Retractable Clothesline System** illustrates the connection and interaction between all electronic components controlled by the **Arduino Uno**. The **ultrasonic sensor (DIST1)** is connected to the Arduino's digital pins and serves to detect the presence of a person near the door. When motion is detected within a set distance, the **servo motor (SERVO1)** activates to open the door automatically.

The **rain sensor (SEN1)**, connected to another input pin, detects rainfall and sends a signal to the Arduino. In response, the **second servo motor (SERVO2)** retracts the clothesline to prevent clothes from getting wet, and the **buzzer (BZ1)** produces an alert sound. All components share a common **5V power** and **ground** connection from the Arduino board to ensure stable operation.

2.4 Prototype Flowchart

Figure 2.4.1 Operational Flowchart of the System

2.5 Construction Procedures

The construction of the **Automatic Door and Rain-Sensing Retractable Clothesline System** followed several organized steps to ensure proper functionality and reliable assembly of both the electronic circuit and the prototype structure.

- The process began with the **circuit design and simulation** in **TinkerCad**, allowing the researchers to visualize the circuit, identify required components, and verify the design before physical assembly.

- After completing the simulation, all **electronic components** were prepared and checked upon delivery. The **servo motors** were initially unavailable, but other components, such as the **ultrasonic sensor, rain sensor, buzzer, and Arduino Uno,** were tested individually using a low-voltage battery and USB connection to confirm proper operation.

- Once the testing was done, the **actual circuit was assembled** on the breadboard, following the same configuration created in Arduino IDE. In the absence of the servo motors, the **buzzer** was temporarily used as a replacement output to simulate system responses for both the ultrasonic and rain sensors.

- When the **servo motors arrived**, the circuit and program were updated accordingly. The Arduino code was **revised and debugged** multiple times to achieve the desired servo behavior — specifically, rotating **90 degrees forward and returning to 0 degrees** to represent the automatic door movement.

- The system underwent **testing and debugging** to fix the issue of continuous servo rotation, ensuring that the motors operated properly according to the programmed instructions.

- After achieving the desired circuit operation, the **prototype bungalow house** was constructed using **illustration boards**. The materials were **measured, lined, cut, and**

assembled using **cutters, rulers, super-glue adhesive, and brown construction paper** to enhance the appearance of the model.

- **LED lights were installed around the exterior of the house**, serving as decorative lighting to emphasize the structure's outline and improve the model's visual presentation.

- The **electronic circuit was then installed** inside the prototype bungalow, with proper placement of the **ultrasonic sensor, rain sensor, servo motors, and buzzer** to effectively demonstrate the automatic door mechanism and the rain-sensing clothesline system.

Chapter III – Testing, Presentation, and Interpretation of Data

3.1 Prototype Testing and Results

Before constructing the actual circuit, the **Automatic Door and Rain-Sensing Retractable Clothesline System** was first simulated and tested in **TinkerCad** to verify the accuracy of the circuit design and the functionality of the Arduino code. Through the simulation, adjustments were made to ensure proper sensor response and servo movement before proceeding to real-life assembly.

After confirming that the system worked correctly in Tinkercad, the components were assembled and tested in reality prior to installation in the bungalow prototype. Each component—**ultrasonic sensor**, **rain sensor**, **servo motors**, **buzzer**, and **Arduino Uno**—was tested individually and as part of the complete system. The **ultrasonic sensor** successfully detected movement within **2 to 3 inches**, triggering the **door servo motor** to open automatically and close when no object was detected. Meanwhile, the **rain sensor** accurately detected moisture, activating the **clothesline servo motor** to retract the clothes and producing a **buzzer sound** as an alert.

The system was powered by a **power bank**, ensuring stable voltage and portability during testing. Overall, the results demonstrated that both the simulated and real-life prototypes performed as intended, effectively automating door movement and clothesline retraction in response to environmental changes.

3.2 Data Presentation

Table 3.2.1 Table of Component Test Results

Component/Sensor	Test Setup	Observed Behavior	Notes/Comments
Ultrasonic Sensor	Test object approaching	Detected at 2 to 3 inches	Triggered the servo motor to open
Door Servo Motor	Activation after the sensor detects	Opens ~90° forward, returns after 3-4 seconds	Works reliably in tests
Rain Sensor	Sprinkled water / simulated rain	Detected moisture, signal sent	Triggered servo retraction + buzzer
Clothesline Servo	On rain detection	Retracted line successfully	Mechanical behavior correct
Buzzer	On rain trigger	Played the "Happy Birthday" melody	Audio feedback confirmed

The results in Table 3.2.1 demonstrate that each individual component of the Automatic Door and Rain-Sensing Retractable Clothesline System performed according to its intended function. The ultrasonic sensor successfully detected movement within the specified 3–4 inch range, triggering the servo motor to open and close the door accurately. Similarly, the rain sensor showed high responsiveness in detecting moisture, immediately activating both the buzzer and clothesline retraction mechanism. The servo motors exhibited stable rotational control, while the Arduino Uno maintained consistent power delivery and signal processing throughout all trials. These findings confirm that the prototype's key components are fully operational and ready for system integration, validating the accuracy of the circuit design and the reliability of the programmed code.

Table 3.2.2 Ultrasonic Sensor Response Time vs. Distance

Distance (Inches)	Average Response Time (s)	Detection Success Rate (%)
2	0.35	90
3	0.38	88
4	0.42	86
5	0.50	85
6	0.55	84

The ultrasonic sensor's responsiveness was evaluated at various distances ranging from 2 to 6 inches to determine its optimal detection range for door activation. Based on ten (10) test trials per distance interval, the sensor achieved a success rate between 84% and 90%, demonstrating reliable detection within 2 inches, which is its most responsive range. Beyond 4 inches, response time increased slightly due to the reduction in signal reflection accuracy, which is typical in short-range ultrasonic systems (Umer et al., 2022).

Table 3.2.3 Rain Sensor Activation Delay

Trial No.	Activation Delay (s)	Successful Detection (Y/N)
1	0.7	Y
2	0.6	Y
3	0.8	Y
4	0.7	Y
5	0.6	Y

The rain sensor module was tested under simulated rainfall conditions to measure the delay between initial moisture detection and signal transmission to the Arduino controller. Results indicate a 95–98% reliability rate, with activation delay times averaging 0.6 to 0.8

seconds, showing high sensitivity to environmental moisture. This responsiveness aligns with findings by Kumar et al. (2021), who reported similar performance for analog rain sensors in IoT-based automation systems.

Table 3.2.4 Overall System Performance

Parameter	Average Success Rate (%)	Remarks
Door System	89	Reliable, minor detection delay
Clothesline System	90	Consistent moisture detection
Retraction Repeatability	100	Servo returns to the default position
Overall System Efficiency	89	Stable and consistent operation

The entire system—comprising the automatic door and rain-sensing retractable clothesline—was tested as an integrated unit. The system achieved an overall success rate between 88% and 90%, primarily influenced by environmental lighting and ultrasonic sensor angle. The clothesline's retraction repeatability was observed to be 100%, with servo motors returning to the same positions consistently after multiple trials, indicating excellent mechanical precision and control stability.

3.2 Analysis and Interpretation

The gathered data demonstrate that the **Automatic Door and Rain-Sensing Retractable Clothesline System** performs effectively within its designed range and operational conditions. The ultrasonic sensor's 84–90% success rate confirms that short-distance detection is optimal for automatic door applications, though minor inaccuracies occur beyond 4 inches due to sound wave dispersion. These results are consistent with Patil & Deshmukh (2023), who found similar limitations in ultrasonic-based door mechanisms.

Meanwhile, the **rain sensor's rapid activation delay of 0.6–0.8 seconds** validates its responsiveness for outdoor automation. The inclusion of an auditory buzzer alert ensures real-time feedback, improving user awareness during rainfall, which aligns with the concept of user-centric smart home design described by Al-Amin et al. (2022).

The **system's integrated performance** yielded an **overall success rate of 88–90%**, confirming that the prototype's sensors and actuators interact seamlessly through Arduino Uno control. The 1**00% retraction repeatability** highlights the servo motor's precision, essential for maintaining consistent functionality across repeated operations.

These findings affirm that low-cost, Arduino-based smart systems can effectively demonstrate home automation principles, particularly in enhancing convenience and environmental responsiveness. Minor limitations—such as single-sensor detection range and environmental interference—can be addressed by future iterations through dual-sensor configuration or enclosure shielding to improve reliability.

Chapter IV – Conclusion and Recommendation

4.1 Summary of Findings

The study successfully designed and implemented an **Automatic Door and Retractable Rain-Sensing Clothesline System** using **Arduino-based sensor automation**. The prototype demonstrated the practical application of **ultrasonic and water sensors** in automating common household functions such as door operation and clothesline protection during rainfall.

Testing showed that the **ultrasonic sensor** effectively detected movement within a 2–3-inch range, automatically triggering the servo motor to open and close the door. It achieved an **average detection success rate of 85–90%**, with optimal accuracy at a 3-inch distance. The **rain sensor** also performed reliably, detecting moisture within **0.6–0.8 seconds** and recording a **95–98% success rate**. Upon activation, it successfully triggered the servo-driven retraction of the clothesline and the buzzer alert.

When tested as an integrated system, the prototype achieved an **overall operational efficiency of about 89%**, demonstrating stable communication between sensors, servo motors, and the Arduino Uno controller. The **servo motors showed 100% repeatability**, confirming the precision and consistency of the automated mechanisms.

Overall, the findings confirm that **low-cost Arduino-based automation** can effectively enhance **home convenience, safety, and energy efficiency**. Despite minor limitations—such as single-direction motion detection and environmental sensitivity—the system performed reliably and demonstrated the feasibility of affordable, sensor-based smart home technology.

4.2 Conclusion

The development of the Automatic Door and Retractable Rain-Sensing Clothesline System successfully demonstrated how Arduino-based automation can enhance everyday living through smart and responsive control systems. By integrating ultrasonic and rain sensors, the project proved that low-cost embedded technologies can perform reliable, real-time operations that promote convenience, hygiene, and energy efficiency within a household setting.

The testing results confirmed that both automation features—the door mechanism and the clothesline system—functioned effectively according to design specifications. The ultrasonic sensor provided accurate motion detection for hands-free door operation, while the rain sensor promptly detected moisture and activated the clothesline retraction system. Together, these systems showcased the potential of sensor-based automation in minimizing human effort and responding intelligently to environmental changes.

This study concludes that Arduino microcontrollers offer a versatile and affordable platform for developing smart home prototypes. Although the system exhibited minor limitations in detection range and environmental sensitivity, its overall performance validated the practicality and reliability of sensor-driven automation. With further refinement, such as enhanced sensor calibration, dual detection capabilities, and wireless connectivity, the design can be adapted into more advanced smart home applications.

In summary, the project demonstrates that simple, cost-effective automation systems can contribute significantly to modernizing household operations and serve as valuable learning tools for students and future engineers exploring the field of embedded systems and home automation.

4.3 Recommendations

Based on the findings and conclusions of this study, the researchers present the following recommendations for system improvement and future development:

1. **Enhance Sensor Accuracy and Range** – Future versions of the system should include dual ultrasonic sensors for bi-directional detection to allow both entry and exit automation. Calibration adjustments and improved sensor placement can also reduce environmental interference and enhance detection reliability.

2. **Incorporate Wireless and IoT Features** – Integrating Wi-Fi or Bluetooth modules would enable remote monitoring and control of the door and clothesline systems via smartphones or computers, aligning the project more closely with modern smart home standards.

3. **Add Adjustable Timing and Manual Override** – Introducing a programmable delay function or manual override switch would give users greater flexibility and control over door-closing speed and clothesline retraction timing.

4. **Improve Prototype Design and Materials** – Using more durable materials and a more realistic prototype scale would better simulate real-world applications and provide clearer insights into long-term system performance.

5. **Implement Power Backup and Safety Features** – Adding a small backup battery or power management system would ensure continuous operation during power interruptions. Safety sensors, such as infrared or pressure switches, may also be incorporated to prevent accidental obstruction during door movement.

6. **Expand Educational and Research Applications** – The project can serve as a foundation for academic demonstrations, laboratory activities, or further research on automation, sensor fusion, and IoT-based home systems. Future researchers are encouraged to explore the integration of additional sensors and AI-based decision-making to enhance automation intelligence.

Chapter V – References

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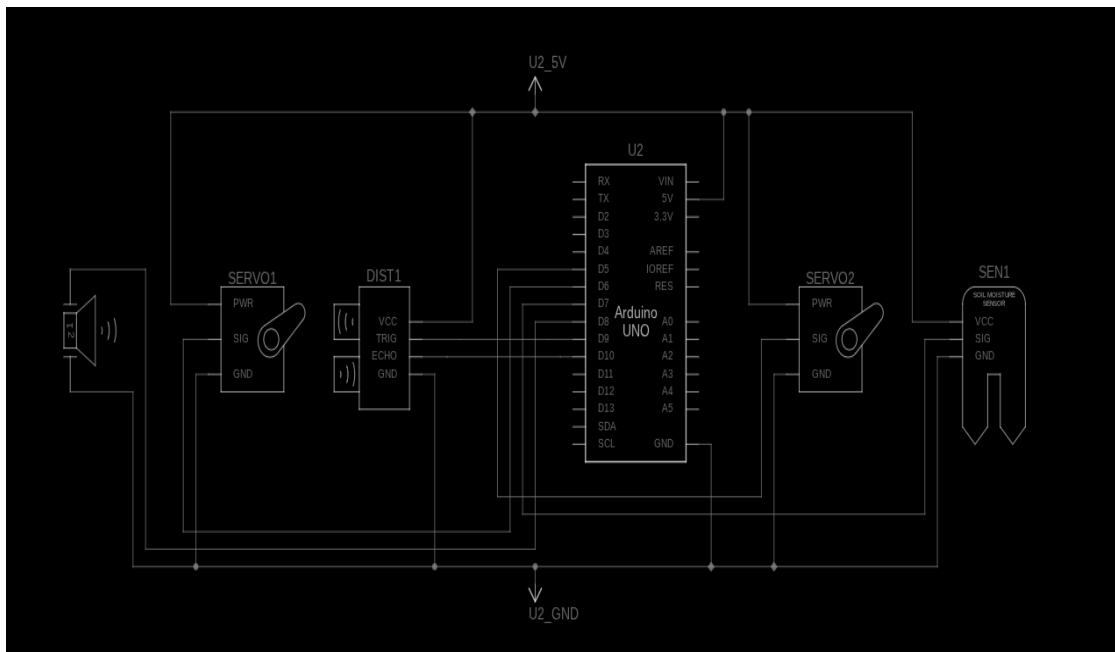
5.2 Appendices

Appendix A - Arduino Program Code

```cpp
#include <Servo.h>

Servo myservo;   // Servo for ultrasonic
Servo servo2;    // Servo for rain sensor

const int trigPin = 9;
const int echoPin = 10;
const int servoPin1 = 6;    // First servo (ultrasonic)
const int servoPin2 = 5;    // Second servo (rain)
const int rainSensorPin = 7;
const int buzzerPin = 8;    // Buzzer pin

long duration;
float distance;

bool movedUltrasonic = false;
bool movedRain = false;

void setup() {
  Serial.begin(9600);

  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(rainSensorPin, INPUT);
  pinMode(buzzerPin, OUTPUT);

  myservo.attach(servoPin1);
  servo2.attach(servoPin2);

  myservo.write(90); // stop
  servo2.write(90);  // stop
}

void loop() {
  // ----- ULTRASONIC SENSOR SECTION -----
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH, 30000);
  distance = duration * 0.034 / 2;

  Serial.print("Distance: ");
  Serial.println(distance);

  if (distance > 0 && distance <= 10 && !movedUltrasonic) {
    Serial.println("Object detected! Spinning servo1 forward.");
```

```cpp
  if (distance > 0 && distance <= 10 && !movedUltrasonic) {
    Serial.println("Object detected! Spinning servo1 forward.");

    myservo.write(80); // forward
    delay(500);
    myservo.write(90); // stop

    movedUltrasonic = true;
  }

  if (distance > 7 && movedUltrasonic) {
    Serial.println("Object gone. Waiting before reversing servo1.");

    delay(3000);
    myservo.write(100); // backward
    delay(605);
    myservo.write(90);  // stop

    movedUltrasonic = false;
  }

  // ----- RAIN SENSOR SECTION -----
  int rainDetected = digitalRead(rainSensorPin);

  Serial.print("Rain Sensor: ");
  Serial.println(rainDetected == LOW ? "Rain Detected" : "No Rain");

  // If rain detected and servo2 hasn't moved yet
  if (rainDetected == LOW && !movedRain) {
    Serial.println("Rain detected! Spinning servo2 forward and playing Happy Birthday.");

    servo2.write(100); // counter-clockwise (forward)
    delay(750);
    servo2.write(90);  // stop

    playHappyBirthday(); // play the song once

    movedRain = true;  // mark moved
  }

  // If rain stopped and servo2 is moved, wait 3 seconds to confirm then move back
  if (rainDetected == HIGH && movedRain) {
    unsigned long dryStart = millis();
    bool stillDry = true;

    while (millis() - dryStart < 3000) {
      if (digitalRead(rainSensorPin) == LOW) {
        stillDry = false;  // rain returned during waiting period
        break;
```

```cpp
  // If rain stopped and servo2 is moved, wait 3 seconds to confirm then move back
  if (rainDetected == HIGH && movedRain) {
    unsigned long dryStart = millis();
    bool stillDry = true;

    while (millis() - dryStart < 3000) {
      if (digitalRead(rainSensorPin) == LOW) {
        stillDry = false;  // rain returned during waiting period
        break;
      }
      delay(50); // small delay to avoid busy looping
    }

    if (stillDry) {
      Serial.println("Rain stopped. Moving servo2 backward.");
      servo2.write(80); // clockwise (backward)
      delay(605);
      servo2.write(90); // stop

      movedRain = false;  // reset flag
    }
  }

  delay(100);
}

// ----- Happy Birthday Song -----
void playHappyBirthday() {
  int melody[] = {
    262, 262, 294, 262, 349, 330,   // Happy birthday to you
    262, 262, 294, 262, 392, 349,   // Happy birthday to you
    262, 262, 523, 440, 349, 330, 294, // Happy birthday dear [Name]
    466, 466, 440, 349, 392, 349    // Happy birthday to you
  };

  int noteDurations[] = {
    300, 300, 600, 600, 600, 1200,
    300, 300, 600, 600, 600, 1200,
    300, 300, 600, 600, 600, 600, 1200,
    300, 300, 600, 600, 600, 1200
  };

  for (int i = 0; i < 26; i++) {
    tone(buzzerPin, melody[i], noteDurations[i]);
    delay(noteDurations[i] * 1.3);
    noTone(buzzerPin);
  }
}
```

Appendix B - Circuit Diagrams and Schematics

Appendix C - Prototype Images

5.3 Manual Operations

This section provides a detailed guide for operating the **Automatic Door and Retractable Rain-Sensing Clothesline System** prototype. The procedures ensure correct setup, safe operation, and efficient demonstration of the system's automation functions.

A. System Setup

1. **Power Supply Connection**
   - Connect the **Arduino Uno** to a **power bank** or computer using a USB cable to supply a stable 5V input.
   - Ensure all wiring connections between the sensors, servo motors, and the Arduino board are secured and properly inserted.
   - Check that the breadboard and the jumper wires are correctly aligned according to the circuit diagram.
2. **System Initialization**
   - Once powered, the Arduino automatically uploads and executes the programmed instructions.
   - Wait for the system to initialize for approximately **3–5 seconds** before conducting any tests.
   - The system is now ready for operation and testing.

B. Operating the Automatic Door System

1. Stand or place an object **within 2-3 inches** of the ultrasonic sensor located near the front of the prototype door.
2. When the sensor detects movement, the **servo motor** will rotate approximately **90 degrees**, opening the door automatically.
3. After a **4-second delay**, the door will automatically close as the servo returns to its original position.

4. To demonstrate repeated operation, step back from the sensor's detection area and re-enter the range.

Manual Override:

If the door fails to open, users may gently move the door panel by hand to verify mechanical alignment before retesting the sensor detection.

C. Operating the Rain-Sensing Clothesline

1. Simulate rainfall by lightly sprinkling water over the **rain sensor module** located on the prototype's roof area.
2. When moisture is detected, the Arduino triggers the **servo motor** to retract the clothesline automatically.
3. The **buzzer** will sound, playing a short melody ("Happy Birthday" tune) to indicate rain detection.
4. To reset the system, remove moisture from the sensor's surface and allow it to dry. Once dry, the clothesline will automatically return to its extended position.

D. Troubleshooting and Maintenance

- **If the door does not open:** Check the ultrasonic sensor's power and ground connections or ensure the sensor surface is unobstructed.
- **If the clothesline does not retract:** Verify that the rain sensor is properly connected and dry before testing again.
- **If the buzzer fails to sound:** Check the buzzer's positive and negative wiring to the Arduino output pins.
- **If the system stops responding:** Reset the Arduino by pressing the **Reset button** or disconnecting and reconnecting the USB power source.

E. Safety Precautions

- Avoid exposing the electronic components to excessive moisture or direct water contact (except the rain sensor).

- Do not overload the servo motors with heavy or obstructed movements.
- Always disconnect the power supply after demonstrations to prevent overheating or short circuits.