DESIGN AND FABRICATION OF AUTOMATIC RAIN SENSING & SHEDDING SYSTEM

A thesis
by

RASSIDUL HASSAN SHEFAT
MD JAHANGIR ALAM
BILLAL HOSSAIN
MD. SAYEED HASAN
MD. SALMAN FARSHI

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)

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RASSIDUL HASSAN SHEFAT	ID: BME2001020528
MD JAHANGIR ALAM	ID: BME2001020214
BILLAL HOSSAIN	ID: BME2001020070
MD. SAYEED HASAN	ID: BME2001020401
MD. SALMAN FARSHI	ID: BME2001020503

Supervisor: Nuruzzaman Rakib
Designation: Assistant Professor

Submitted to the
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of
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ABBREVIATIONS

RST	Rain Sensing Technology
SMPS	Switched Mode Power Supply
DC	Direct Current
AC	Alternating Current
RPM	Revolution per Minute
PWM	Pulse Width Modulation
GND	Ground
Amp	Ampere
I/O	Input /Output
IOT	Internet of Things

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Abstract

The study focuses on rain-sensing technology exploration, design, implementation, and testing, with a broader aim to contribute to the field of rain-sensing technology. The primary objectives include investigating various rain-sensing technologies, encompassing sensors and data processing methods, and exploring their applications. Furthermore, the study aims to design and realize a Rain Sensing Automatic Rain Shed System, capable of both manual and automatic operation. Rigorous testing in diverse environmental conditions will be conducted to evaluate its adaptability, performance, and usability across various scenarios, validating its versatility. The study will conclude by proposing future research avenues and opportunities for innovation within the realm of rain-sensing technology.

CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, advancements in technology have ushered in a new era of smart and responsive environments, transforming the way we interact with our surroundings. Among the various domains benefiting from these innovations, the field of architecture and design has witnessed a remarkable evolution. One such innovation that stands at the intersection of technology and architecture is the concept of the Rain Sensing Automatic Rain Shed System.

As climate change continues to impact weather patterns across the globe, finding sustainable and efficient ways to adapt our built environment becomes an imperative task. Rain, as both a life-sustaining force and a potentially disruptive element, presents challenges and opportunities for architectural design. The integration of rain-sensing mechanisms into shading systems introduces a dynamic layer of adaptability to structures, enabling them to respond in real time to environmental cues.

The Rain Sensing Automatic Rain Shed System, with its dual modes of operation, Manual and Automatic, represents a pioneering approach to addressing the impact of rain in various contexts. Whether used in agriculture, open restaurants, buildings, stadiums, or other applications, this system provides a versatile solution for managing rain-induced challenges. In Manual mode, users have direct control over the shading system, allowing for customization based on specific needs and preferences. In Automatic mode, the system leverages cutting-edge rain-sensing technology to autonomously adjust the shading configuration based on the presence and intensity of rain, enhancing occupant comfort and energy efficiency.

The primary objective of this thesis is to explore and analyze the feasibility, functionality, and benefits of the Rain Sensing Automatic Rain Shed System. By seamlessly integrating rain-sensing technology into architectural elements such as windows, facades, and outdoor spaces, a building can transform into a responsive and intelligent entity, capable of adapting to changing weather conditions. This adaptability not only enhances the user experience but also contributes to the overall sustainability of the built environment.

Throughout this thesis, we will delve into the technological underpinnings of rain-sensing, shading mechanisms, and their symbiotic relationship within the context of architecture. We will investigate the sensors, data processing algorithms, and actuation systems that enable the seamless transition between Manual and Automatic modes. Additionally, we will analyze the potential environmental impact, energy savings, and user experience improvements that can be achieved through the implementation of such a system in diverse settings.

In the following chapters, we will discuss related works, methodologies, experiments, and results, all of which contribute to a comprehensive understanding of the Rain Sensing Automatic Rain Shed System. Through this exploration, we aim to provide valuable insights into the practicality and effectiveness of rain-sensing shading as a versatile solution for creating more adaptable, sustainable, and user-centric architectural environments.

The integration of rain-sensing technology into shading systems represents a significant stride towards creating buildings and spaces that are not only aesthetically pleasing but also responsive to the ever-changing natural environment. By offering both Manual and Automatic modes, the Rain Sensing Automatic Rain Shed System demonstrates its potential to be a transformative solution across industries, fostering a future where architecture seamlessly coexists with nature to enhance both human experiences and ecological balance.

1.2 Objectives of This Study

The main objectives of this study are given below:

- To explore the various rain sensing technologies available, including sensors, data processing methods, and their applications.
- To design and implement a Rain Sensing Automatic Rain Shed System capable of functioning in both manual and automatic modes.
- To Test the Rain Sensing Automatic Rain Shed System in different environments. Assess its adaptability, performance, and usability across diverse scenarios to validate its versatility.
- To suggest avenues for further research and innovation in the field of rain-sensing technology.

1.3 Summary

This thesis project focuses on the subsequent actions regarding the design functions, and development phases of the prototype hardware entity along with the amalgamation of control automation of the rain-sensing automatic rain shed system.

CHAPTER 2

LITERATURE REVIEW

The integration of rain-sensing technology into architectural shading systems represents a significant advancement in the field of responsive architecture. This section reviews existing literature on rain-sensing technology, automatic shading systems, and their applications within various contexts.

Rain Sensing Technology:

Rain sensing technology has evolved considerably over the past decades, offering a range of sensor types capable of accurately detecting rain events. Capacitive, optical, and piezoelectric sensors are commonly utilized for rain detection. Capacitive sensors, which measure changes in electrical capacitance caused by rain droplets, have been explored for their sensitivity and reliability in detecting precipitation [1, 2]. Optical sensors, utilizing light scattering or reflection principles, provide real-time rain detection and can be applied to both indoor and outdoor environments [3, 4]. Additionally, piezoelectric sensors, sensitive to mechanical vibrations induced by raindrops, have demonstrated effectiveness in detecting light to heavy rainfall [5].

Automatic Shading Systems:

The concept of automated shading systems has gained traction as a means of enhancing building energy efficiency and occupant comfort. Sunlight-responsive shading systems have been extensively studied, with various control strategies such as sun tracking algorithms and light sensors [6, 7]. However, integrating rain-sensing capabilities into shading systems introduces an additional layer of complexity. A research [8] presents a rain-responsive shading system that utilizes data from rain sensors to trigger the adjustment of shading devices, effectively preventing rain ingress into outdoor spaces. This integration demonstrates the potential for combining environmental sensors with shading systems to create more versatile architectural solutions.

Applications and Contexts:

The Rain Sensing Automatic Rain Shed System finds applications across diverse contexts. In the agricultural sector, rain-sensing shading can protect crops from sudden downpours, preventing waterlogging and enhancing yield quality [9]. Open restaurants and outdoor event spaces benefit from rain-sensing shading by offering customers a comfortable experience regardless of weather conditions [10]. In the realm of sustainable building design, automatic rain-sensing shading contributes to energy conservation by dynamically adjusting indoor lighting and cooling loads based on rain intensity [11]. Sports stadiums also stand to gain from rain-sensing shading systems, as they ensure spectator comfort during outdoor events [12].

User Experience and Acceptance:

Studies focusing on user experiences with rain-sensing shading systems highlight the importance of seamless transition between Manual and Automatic modes. A study [13] emphasizes user preferences for manual control during transitional weather conditions, allowing occupants to make real-time adjustments. However, the convenience of automatic mode is underscored during heavy rainfall, ensuring quick response without user intervention [14].

Future Directions:

While research on rain-sensing shading systems is burgeoning, there are opportunities for further exploration. Integration with other smart building technologies, such as weather forecasting systems and automated HVAC controls, can enhance the system's effectiveness [15]. Additionally, advancements in machine learning algorithms could optimize rain prediction accuracy and enable more sophisticated response strategies [16].

CHAPTER 3

METHODOLOGY

3.1 Introduction

To create a smart solution addressing rain-related challenges economically, the methodology section elucidates the approach to developing an "Automatic Rain Shed." The steps undertaken and the rationale behind their selection are expounded. The pursuit is to ensure the rain shed's broad functionality and adaptability, aligning with the project's objectives.

This section not only delineates the methods and strategies selected to achieve the research objectives but also justifies their choice based on their relevance to the project's scope and the goal of providing a multifunctional and accessible solution.

A key aspect of our methodology involves the integration of rain-sensing technology. This integration will leverage state-of-the-art sensor systems that can accurately detect rainfall and trigger the automatic shed mechanism. The selection of sensors will be guided by a rigorous evaluation of cost, precision, and compatibility, ensuring a reliable rain detection mechanism that caters to diverse scenarios.

In addition to rain-sensing technology, our methodology includes the implementation of a manual direction mechanism. This feature will enable users to control the opening and closing of the shed based on their preferences, even in the absence of rain. The design of this mechanism will prioritize ease of use and accessibility, making it a versatile solution for a variety of applications.

Our intention revolves around identifying an optimal design that harmonizes economic viability with effectiveness within the creation of the rain-sensing automatic rain shed system. A prototype rain sensing automatic rain shed system is developed in this study.

3.2 Block Diagram of the System

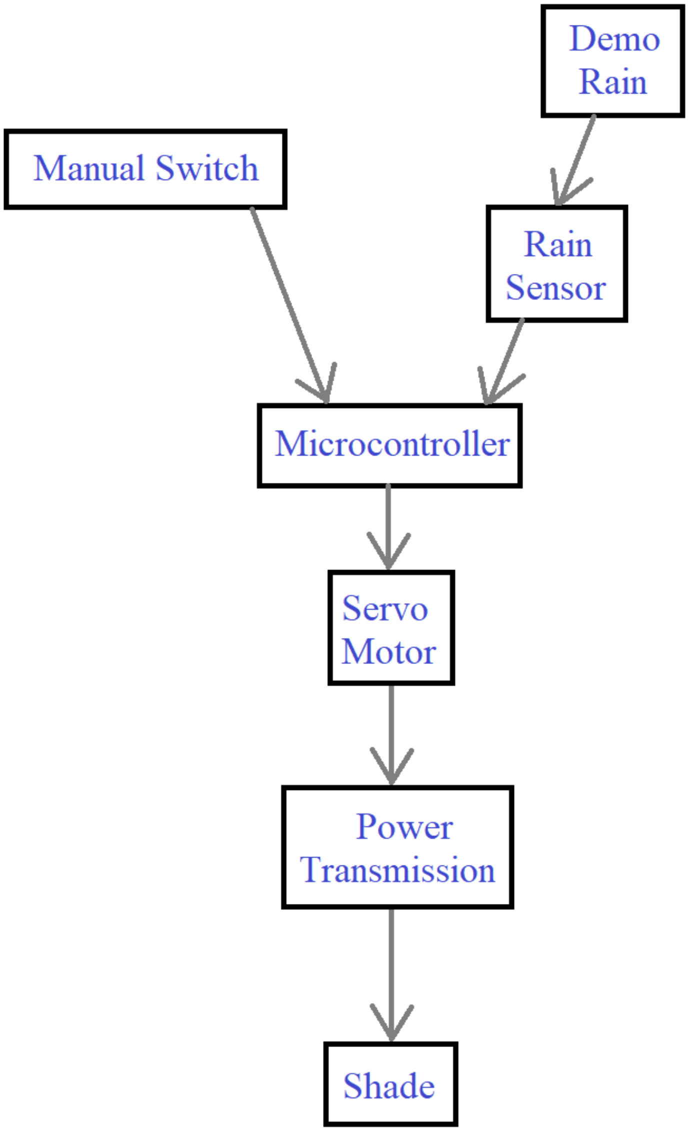


Figure 3.1: Block Diagram of the System

3.3 Controlling Modes of Shed

The "Automatic Rain Shed" system offers two distinct controlling modes to cater to user preferences and environmental conditions: Manual and Automatic.

1. Manual Mode:

In the manual mode, users have direct control over the operation of the rain shed. This mode allows for the independent opening and closing of the shed based on user commands. By simply engaging the manual controls, users can choose to shelter an area from rain or expose it to the elements. This hands-on approach provides flexibility and convenience, allowing users to customize the rain shed's status as needed, regardless of weather conditions.

2. Automatic Mode:

The automatic mode introduces a sophisticated rain-sensing mechanism that responds dynamically to rainfall conditions. This mode relieves users from the need to monitor weather changes and make adjustments manually. Instead, the system relies on state-of-the-art rain-sensing technology to detect precipitation. Depending on the intensity of rainfall detected, the rain shed will autonomously determine whether to open or close.

3.4 Rain Simulation Mechanism

To facilitate comprehensive testing and validation of the "Automatic Rain Shed" prototype system, a rain simulation mechanism has been devised. This rain simulation is accomplished using a pump system, which emulates the conditions of rainfall for controlled testing scenarios. The primary objective of the rain simulation mechanism is to subject the "Automatic Rain Shed" prototype to a range of rain conditions in a controlled environment. This controlled testing allows for the systematic evaluation of the system's responsiveness, accuracy, and effectiveness in detecting rainfall and initiating the opening or closing of the shed.

3.5 Rain Sensing

In the pursuit of creating a sophisticated "Automatic Rain Shed" system, the incorporation of rain-sensing capabilities is of paramount importance. Rain sensor module, a pivotal component of the system, employs advanced technology to discern the presence and intensity of rainfall. This module comprises specialized sensors that are designed to be highly sensitive to changes in moisture levels. When raindrops come into contact with the sensor's surface, changes in electrical conductivity occur due to the conductive properties of water. This alteration is promptly detected by the sensor, which then transmits a signal indicating the presence of rainfall.

Upon receiving signals from the rain sensor module, the "Automatic Rain Shed" system springs into action. If the rain intensity surpasses a predefined threshold, the system initiates the automated closing of the shed to shield the area beneath from the rain. Conversely, when the rain intensity diminishes, signaling the end of the precipitation, the system orchestrates the shed's automatic opening, restoring access to the sheltered area.

3.6 Frame Design and Fabrication

The foundational structure of the "Automatic Rain Shed" system plays a critical role in its stability, functionality, and overall aesthetic. The frame's design journey begins with SolidWorks 2018, a sophisticated 3D modeling software. This digital platform empowers engineers and designers to create intricate structures that adhere to precise specifications.

Frame Dimensions:

- Length: 915 mm
- Width: 482.5 mm
- Height: 330 mm

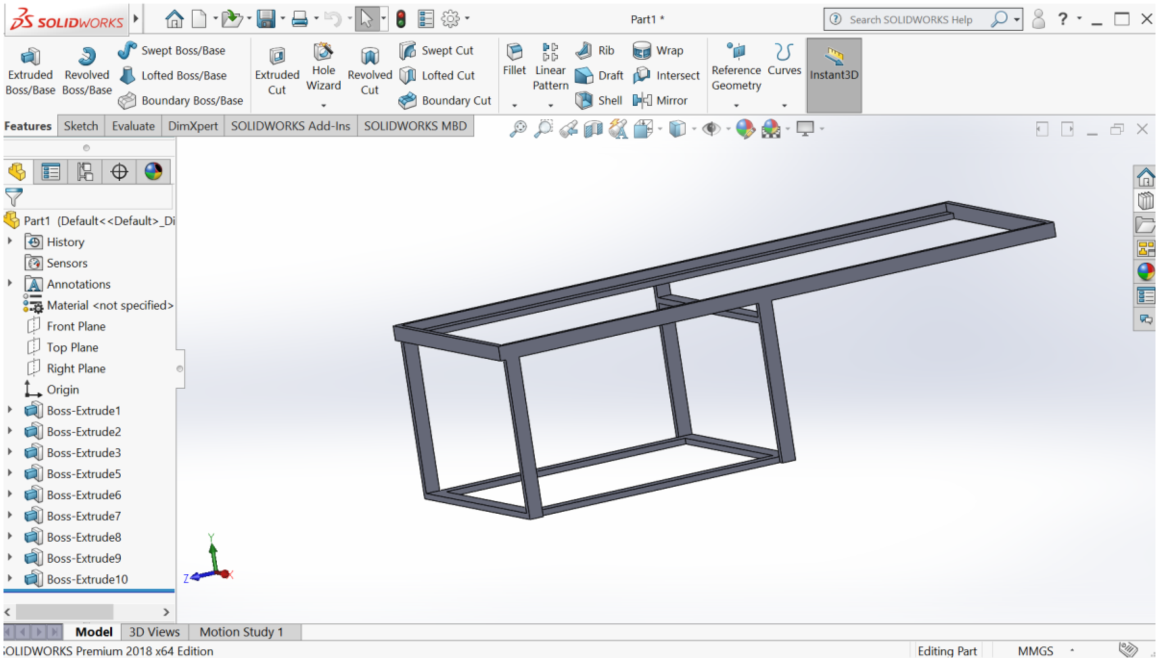


Figure 3.2: Designing frame in SOLIDWORKS 2018

With the SolidWorks design as the blueprint, the frame materializes in the form of wood bars meticulously selected for their durability and workability. Wood, a timeless and versatile material, strikes a harmonious balance between strength and aesthetics. The bars are cut, shaped, and assembled according to the SolidWorks model, creating a tangible framework that closely mirrors the digital design.

3.7 Power Transmission Design and Fabrication

Efficient power transmission lies at the core of the "Automatic Rain Shed" system's functionality. After careful evaluation of various power transmission methods, the rack and pinion system emerged as the optimal choice for the "Automatic Rain Shed." This system excels in translating rotational motion into linear motion, making it well-suited for the controlled opening and closing of the rain shed. Its simplicity, precision, and effectiveness align seamlessly with the project's objectives.

To facilitate the conversion of rotational motion from the motor to linear motion of the rain shed, a spur gear was meticulously designed using SolidWorks. This advanced 3D modeling software enabled the creation of a gear profile that ensures smooth engagement and minimal wear during operation. The gear's teeth geometry, pitch, and diameter were carefully calculated to guarantee efficient power transmission.

With the SolidWorks-designed spur gear as the blueprint, the fabrication process comes to life through 3D printing. This additive manufacturing method offers precision and versatility, translating the digital design into a tangible and functional gear. The printing process ensures that intricate gear teeth geometry is accurately reproduced, contributing to optimal meshing and performance.

The 3D-printed spur gear excels in precision, providing accurate tooth profiles that facilitate smooth and efficient meshing with the rack. The meshing process is a pivotal aspect of power transmission, ensuring minimal energy loss and maximum power transfer from the motor to the rain shed's movement mechanism.

3.8 Programming Flow Chart

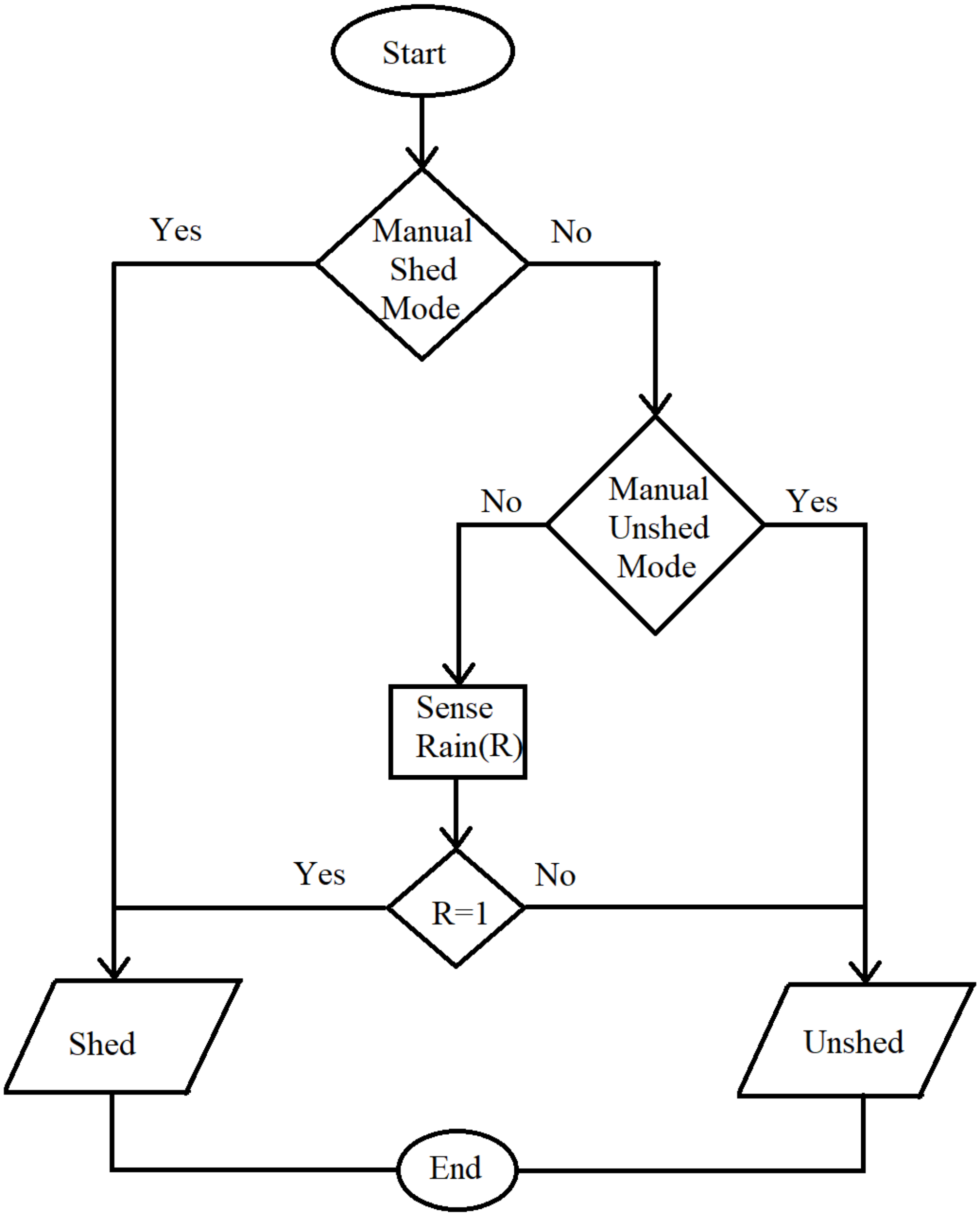


Figure 3.3: Programming Flow chart

3.9 Close Loop Controlling of Shed Position

In the pursuit of precision and accuracy in the operation of the "Automatic Rain Shed" system, a closed-loop control mechanism is employed to monitor and regulate the position of the shed during its opening and closing cycles. Closed-loop control entails a continuous feedback loop where the system's output is monitored and compared to a desired reference value. In the case of the rain shed, closed-loop control ensures that its position aligns precisely with the intended state, whether fully open or fully closed. Any deviations from the desired position are detected in real time, allowing for immediate corrective actions.

The integration of an ultrasonic sensor serves as the key sensory component of the closed-loop control system. During the process of opening or closing the shed, the ultrasonic sensor continuously measures the distance between itself and the shed. This real-time data is then compared to the target position. If any deviation is detected, the closed-loop control system triggers the necessary adjustments to ensure the shed reaches the intended position accurately.

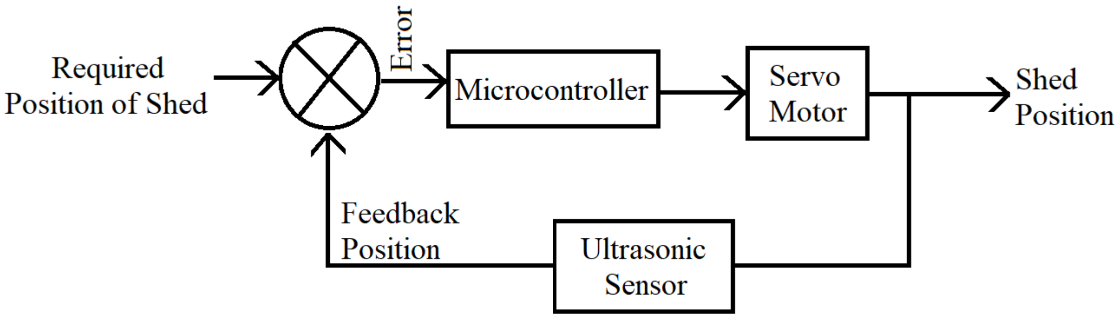


Figure 3.4: Close loop controlling of shed position

By integrating closed-loop control with an ultrasonic sensor, the "Automatic Rain Shed" system guarantees seamless and accurate movement of the shed. Whether opening or closing, the shed's position remains consistent with the desired configuration, regardless of factors such as load variations or minor disturbances.

CHAPTER 4

EQUIPMENTS

4.1 Introduction

In this chapter, we will discuss the materials, components, devices, and tools utilized to construct the machine. As it is a synergistic combination of mechanical, electrical, and control systems, all three types of components are used in this project.

4.2 Materials and Instruments

Instruments used in this project can be classified into two categories which are

- a. Hardware and materials
- b. Control tools and software

4.3 Hardware

The required hardwires are mainly,

1. Power Supply
2. Rain Sensor
3. Ultrasonic Sensor
4. Shed
5. Structure Frame
6. Spur Gear
7. Rack
8. Roller
9. Pump
10. Pipe Line
11. Switches

The integration of hardware components with control tools and software amplifies the "Automatic Rain Shed" system's capabilities. This harmonious collaboration ensures that the system operates cohesively, delivering effective rain protection, precise positioning, and user-friendly functionality.

4.3.1 Power Supply (SMPS)

Switched-mode power supplies are electronic supplies that incorporate switching regulators to convert electrical power efficiently. They are widely used in a range of modern applications thanks to characteristics like efficiency, low cost, and adaptability.

Figure 4.1: SMPS

A 5V 5A DC SMPS Power Supply is used in the setup. A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. This power supply convertor is built for such purposes. This circuit board converts 220V AC current to 12V DC output voltage. It is used in many small equipment and components such as computers, Television, Cathode ray Oscilloscope, etc. It has inbuilt over-voltage, over current, and short circuit protection. The board is perfectly designed to provide high output performance. This board has an inbuilt LED indicator.

Specification:

1. Input voltage: 220V AC
2. Output voltage: 5V DC
3. Output current: 5A
4. Frequency: 50HZ/60HZ
5. Dimension: 108mm x 54mm x 25mm
6. Inbuilt over voltage, over current, and short circuit protection

4.3.2 Rain Sensor

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer. The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and DO output is high. When dropping a little amount water, DO output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level.

The rain sensor is used to detect water and it can detect beyond what a humidity sensor can. The FC-37 rain sensor is set up by two pieces: the electronic board and the collector board that collects the water drops.

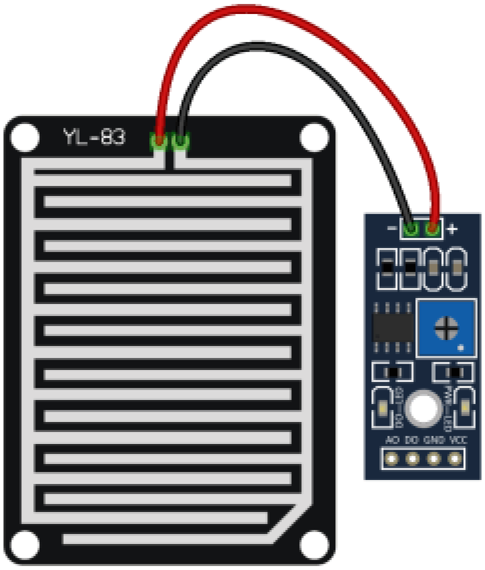


Figure 4.2: Rain Sensor

Specifications:

1. Model name: FC-37
2. Area: 5cm x 4cm nickel plate on side.
3. Anti-oxidation, anti-conductivity, with long use time.
4. Comparator output signal clean waveform is good, driving ability, over 15mA.
5. Potentiometer adjust the sensitivity.
6. Working voltage 5V.
7. Output format: Digital switching output (0 and 1) and analog voltage output AO.
8. Bolt holes for easy installation.
9. Small board PCB size: 3.2cm x 1.4cm.
10. Uses a wide voltage LM393 comparator.

4.3.3 Ultrasonic Sensor

An ultrasonic sensor is a device that uses sound waves to detect the presence and proximity of objects. In the realm of sensor technology, the HC-SR04 Ultrasonic Sensor emerges as a remarkable protagonist, offering a glimpse into the world of accurate distance measurement and object detection.

The HC-SR04 sensor consists of two main components: a transmitter and a receiver. The transmitter emits ultrasonic waves, while the receiver listens attentively for the return echoes. This harmonious interplay enables the sensor to calculate distances by measuring the time it takes for the ultrasonic waves to travel to the object and back.

Figure 4.3: Ultrasonic Sensor

The HC-SR04 sensor's versatility extends across diverse domains, from robotics and automation to distance sensing and security systems. In robotics, it acts as the eyes of autonomous machines, enabling them to navigate their environment and avoid obstacles. In automation, it assists in precise positioning and proximity detection. Security systems utilize its ability to detect motion and presence.

Specifications:

1. Model Name: HC SR-04
2. Operating Voltage: DC 5V
3. Operating Current: 15mA
4. Operating Frequency: 40KHz
5. Max Range: 4m
6. Min Range: 2cm
7. Ranging Accuracy: 3mm
8. Measuring Angle: 15 degree
9. Trigger Input Signal: 10µS TTL pulse
10. Dimension: 45 x 20 x 15mm

4.3.4 Shed

The shed plays a pivotal role in the project as it responds to rain conditions by automatically opening or closing. For the prototype phase, the shed has been constructed using PVC.

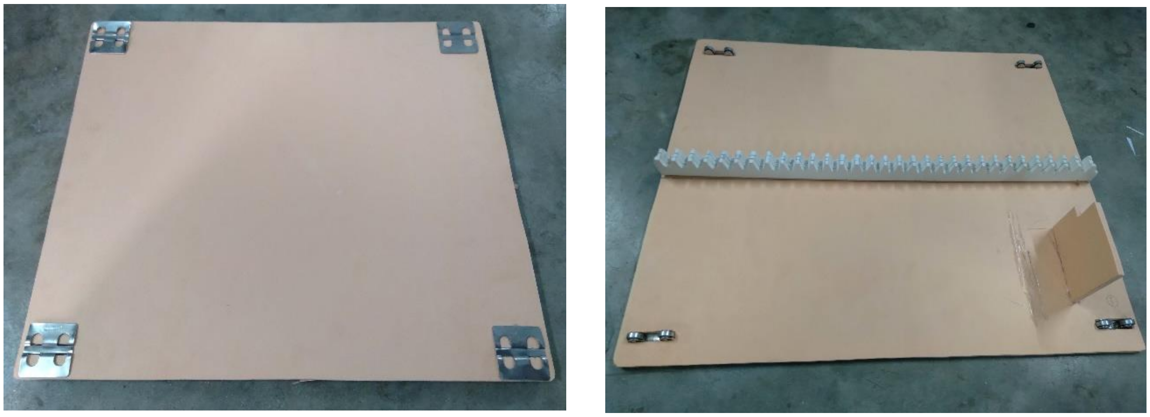


Figure 4.4: Shed

4.3.5 Structure Frame

The foundational structure of the "Automatic Rain Shed" system plays a critical role in its stability, functionality, and overall aesthetic. The frame materializes in the form of wood bars meticulously selected for their durability and workability. Wood, a timeless and versatile material, strikes a harmonious balance between strength and aesthetics. The bars are cut, shaped, and assembled according to the SolidWorks model, creating a tangible framework that closely mirrors the digital design.

Figure 4.5: Structure Frame

Frame Dimensions:

- Length: 915 mm
- Width: 482.5 mm
- Height: 330 mm

4.3.6 Spur Gear

In a rack and pinion system, the "rack" is a linear gear, while the "pinion" is a rotary gear. Spur gears have straight teeth that are parallel to the gear's axis, making them the simplest type of gear. They provide high mechanical efficiency, with minimal energy loss in power transmission. Their simple design and manufacturing process make them cost-effective and readily available. Spur gears offer precise and consistent motion transmission.

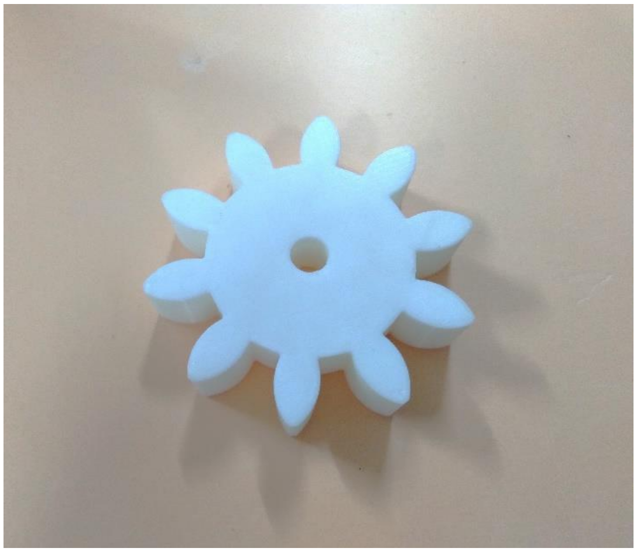


Figure 4.6: Spur gear

Spur gears offer excellent mechanical efficiency due to their simple tooth geometry, resulting in minimal friction and energy loss. Spur gears are commonly used for transmitting rotational motion and power in various machines and equipment, such as gearboxes and transmissions in automobiles.

Specifications:

1. Type: Spur gear
2. Module: 5
3. Pressure Angle: 20 degree
4. Number of teath: 10
5. Pitch Diameter: 50 mm
6. Width: 15mm

4.3.7 Rack

A rack is an essential component in a rack and pinion system, where it serves as the stationary linear gear. The rack is a toothed or threaded bar that meshes with the pinion, a rotating gear, to convert rotational motion into linear motion or vice versa. This mechanical arrangement is commonly used in various applications, including steering systems in vehicles, CNC machines, and automation systems.

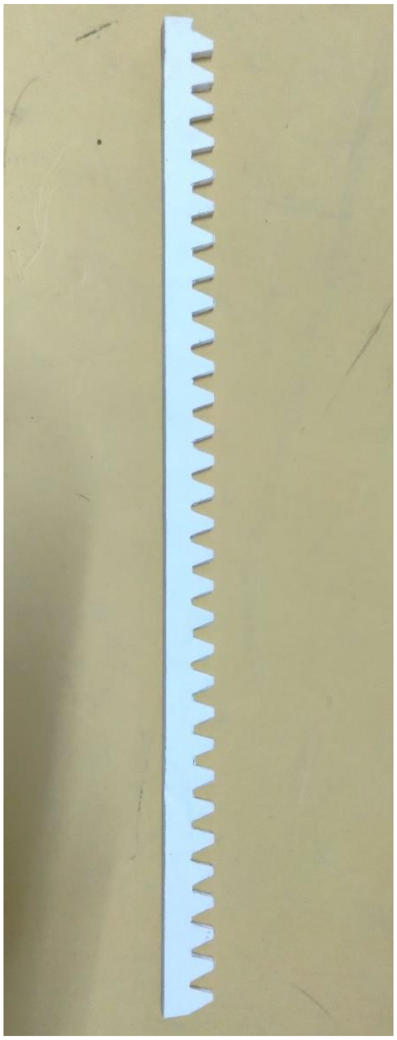


Figure 4.7: Rack

Rectangular Rack is the most common type of rack, where the teeth are arranged along a straight, flat bar. It's suitable for applications requiring linear motion in a single direction.

Specifications:

7. Type: Rectangular Rack
8. Module: 5
9. Pressure Angle: 20 degree
10. Number of teath: 31
11. Length: 487 mm
12. Width: 15mm

4.3.8 Roller

Sliding rollers, also known as sliding bearings or plain bearings, are used in various mechanical and engineering applications where two surfaces need to slide or roll against each other while minimizing friction. They help reduce friction and wear in moving parts, improving the overall efficiency and longevity of the machinery. Sliding rollers require minimal maintenance compared to other types of bearings, such as ball or roller bearings. Sliding rollers can handle heavy loads and high pressures, making them suitable for applications involving significant weight or force.

Figure 4.8: Roller

4.3.9 Pump

Mini Water Pump 5V DC: This 5V DC Mini Water Pump or Micro Submersible Water Pump DC 3V-6V can be easily integrated into your water system project. The water pump works using the water suction method which drains the water through its inlet and released it through the outlet.

Figure 4.9: Pump

A 5V DC mini water pump is a small water pump designed to operate on a 5-volt direct current (DC) power supply. These pumps are commonly used in various applications where a compact and low-power water pumping solution is required.

Specifications:

1. DC Voltage:2.5-6V
2. Maximum lift:40-110cm / 15.75"-43.4"
3. Flow rate:80-120L/H
4. Outside diameter of water outlet: 7.45mm / 0.3" (our 7mm inner diameter tube is ok for this pump)
5. Inside diameter of water outlet: 4.7mm / 0.18"
6. Diameter:Approx. 24mm / 0.95"

7. Length:Approx. 45mm / 1.8"
8. Height:Approx. 33mm / 1.30"
9. Material:engineering plastic
10. Driving mode: brushless dc design, magnetic driving

4.3.10 Pipe Line

Figure 4.10: Pipe line

PVC clear hose is flexible, durable, and non-toxic, without odor. And it’s resistant to high pressure and erosion. Clear PVC Pipe has smooth interior walls for unimpeded flow and reduced sediment buildup; non-contaminating for purity applications; and ease of handling and installation. Clear PVC hose makes it easier to view the liquid inside the tubes, which can prevent kinks and the incorrect transfer of liquids through certain lines.

4.3.11 LED Indicators

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroencephalogram, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. LEDs are typically small (less than 1 mm2) and integrated optical components may be used to shape the radiation pattern.

These are a very basic 5mm LED. It has a typical forward voltage of 2.0V and a rated forward current of 20mA.

Figure 4.11: LED indicators

4.4 Control Tools and Software

In the design of the automatic rain shed system, control elements include a Servo Motor and an Arduino Nano. The operation of the system involves the use of a 360-degree servo motor to manipulate a rack and pinion mechanism for the opening and closing of the shed. Sensor data, pertaining to rainfall conditions, is read and analyzed by the Arduino Nano, which subsequently transmits control signals as required. This passive rain sensing system is characterized by its ability to autonomously respond to varying levels of precipitation, ensuring the protection of users from inclement weather.

4.4.1 Servo Motor (MG995)

A servo motor is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a servo mechanism. If motor is powered by a DC power supply then it is called DC servo motor, and if it is AC-powered motor then it is called AC servo motor. For this tutorial, we will be discussing only about the DC servo motor working. Apart from these major classifications, there are many other types of servo motors based on the type of gear arrangement and operating characteristics. A servo motor usually comes with a gear arrangement that allows us to get a very high torque servo motor in small and lightweight packages.

Figure 4.12: Servo motor

MG995 servo motors are widely used in robotics, remote-controlled vehicles (RC cars and planes), model aircraft, and various automation and mechatronics projects where precise control of angular position is required. They are often compatible with various microcontrollers and control boards, such as Arduino, Raspberry Pi, and other platforms with PWM capabilities. MG995 servo motors are typically controlled using a PWM (Pulse Width Modulation) signal. The duty cycle of the PWM signal determines the position of the servo's shaft. It comes with a standard 3-pin female header connector that is compatible with most servo motor connectors. The pins are typically labeled as Power (VCC), Ground (GND), and Signal (PWM).

Table 4.1 Specification of Servo Motor

General Specification	
Operating Voltage (VDC)	4.8 ~6.6
Temperature Range	0°-55°C
Stall Torque @ 4.8V (kg-cm)	9.4
Stall Torque @ 6.6V (kg-cm)	11

Operating Speed @ 4.8V	0.19sec/60°
Operating Speed @ 6.6V	0.15sec/60°
Dead Bandwidth	1µs
Gear Type	Metal
No. of Teeth	25
Length (mm)	40.7
Width (mm)	19.7
Height (mm)	42.9
Weight (gm)	55
Shipment Weight (kg)	0.059
Shipment Dimensions (cm)	5×3×5

4.4.2 Microcontroller (Arduino Nano)

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. A microcontroller is embedded inside of a system to control a singular function in a device. It does this by interpreting data it receives from its I/O peripherals using its central processor. The temporary information that the microcontroller receives is stored in its data memory, where the processor accesses it and uses instructions stored in its program memory to decipher and apply the incoming data. It then uses its I/O peripherals to communicate and enact the appropriate action.

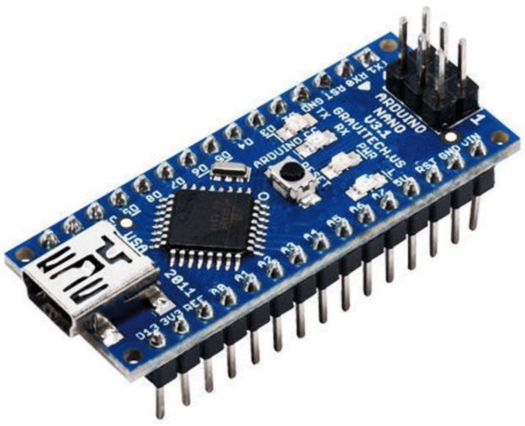


Figure 4.13: Arduino Nano

The Arduino Nano is an open-source breadboard-friendly microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor.

Table 4.2 Specification of Arduino Nano

General Specification	
Microcontroller	Microchip ATmega328P
Operating Voltage (VDC)	5
Input voltage (VDC)	5-20
Digital I/O pins	14 (6 optional PWM outputs)
Analog input pins	8
DC per I/O pin (mA)	40
DC for 3.3 V pin (mA)	50
Flash memory (KB)	32
SRAM (KB)	2
EEPROM (KB)	1
Dimensions in mm (L×W)	45×18
Weight (gm)	7
Clock speed (MHz)	16
USB	Mini-USB Type-B
DC Power Jack	No

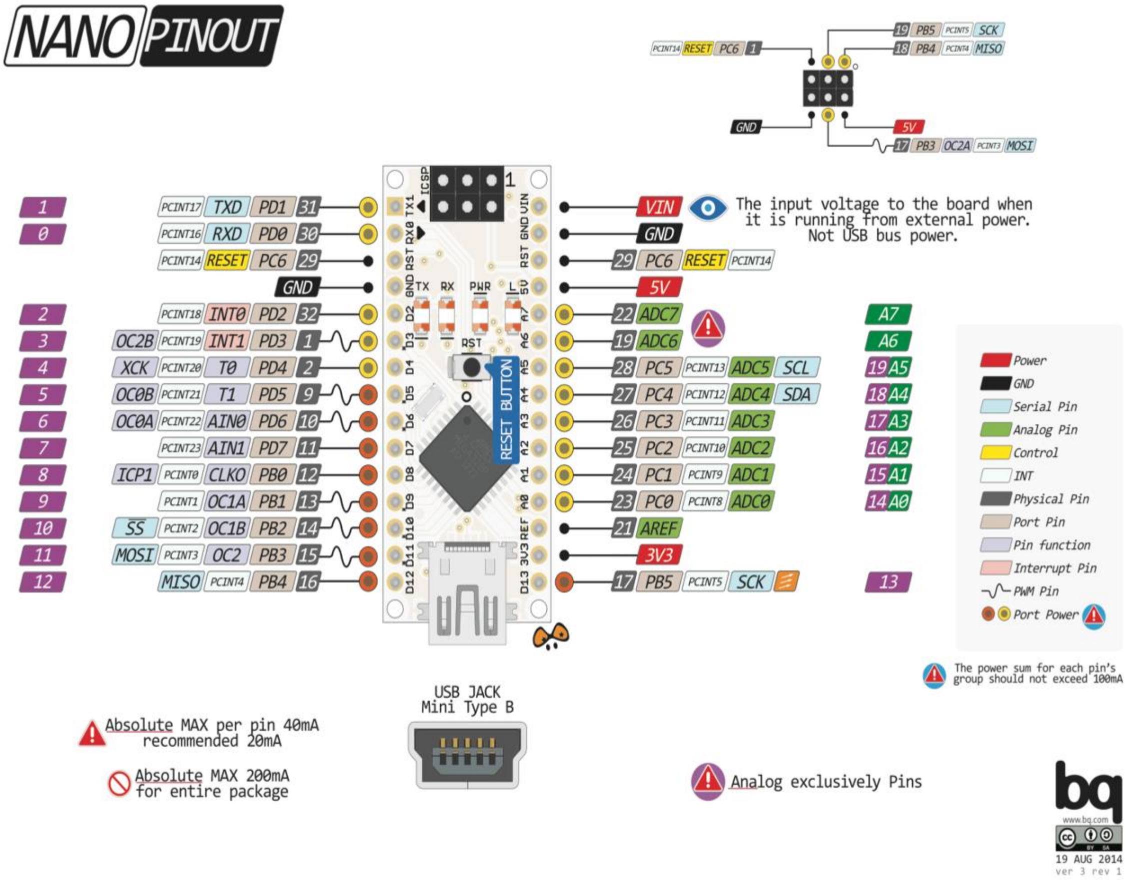
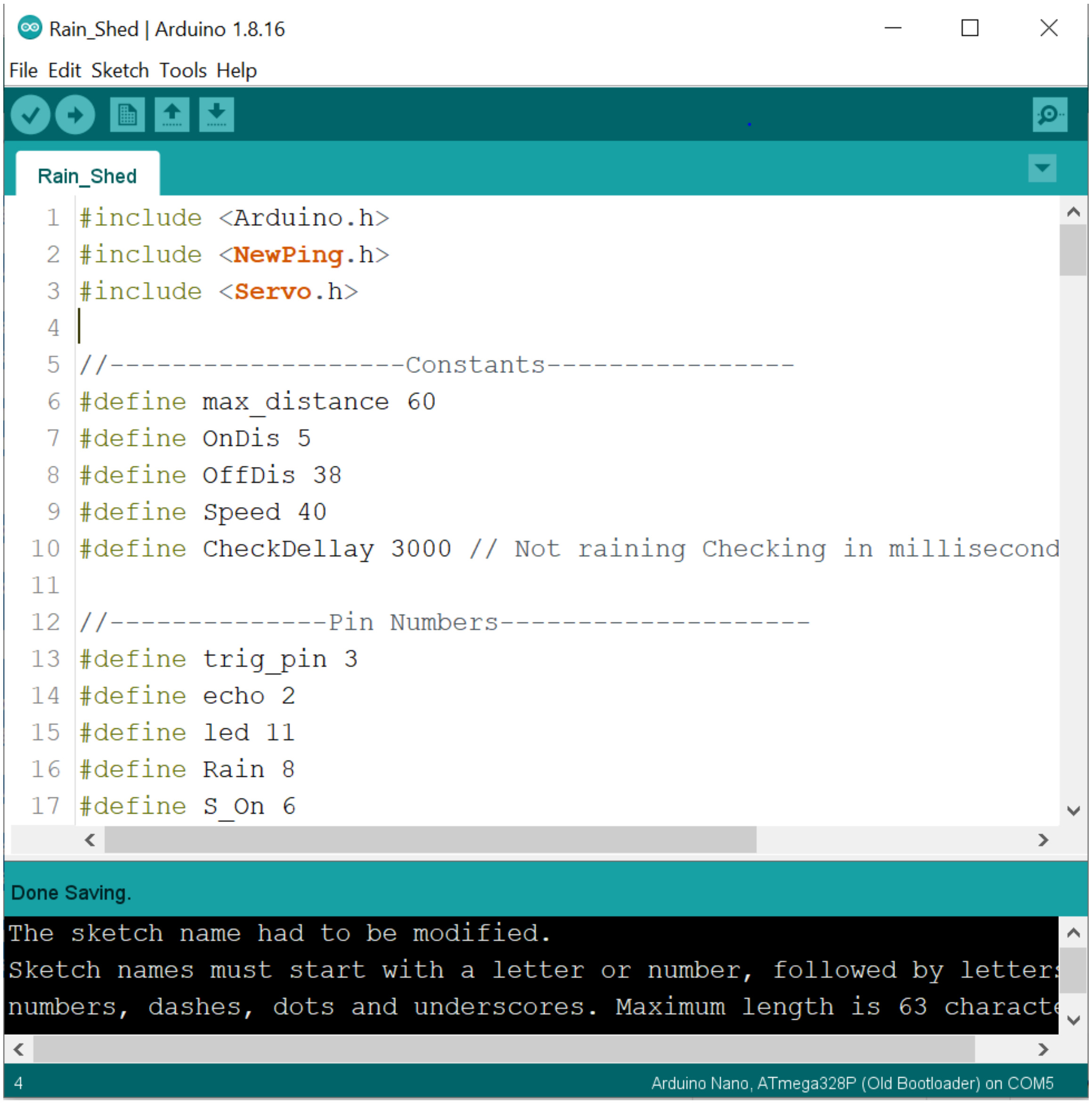


Figure 4.14: Pin layout of Arduino Nano

4.4.3 Coding Environment

There are numerous coding environments to take into account while designing an automatic rain shed system using a microcontroller. Here we chose Arduino Integrated Development Environment (IDE) Version 1.8.16.



```
#include <Arduino.h>
#include <NewPing.h>
#include <Servo.h>

//-------------------Constants----------------
#define max_distance 60
#define OnDis 5
#define OffDis 38
#define Speed 40
#define CheckDellay 3000 // Not raining Checking in millisecond

//--------------Pin Numbers--------------------
#define trig_pin 3
#define echo 2
#define led 11
#define Rain 8
#define S_On 6
```

Done Saving.

```
The sketch name had to be modified.
Sketch names must start with a letter or number, followed by letter
numbers, dashes, dots and underscores. Maximum length is 63 characte
```

Figure 4.15: Arduino IDE

The Arduino Integrated Development Environment (IDE) offers a user-friendly environment for creating and uploading code to Arduino boards. Arduino is a popular platform for microcontroller programming. It supports a range of microcontrollers, including models like the Arduino Uno or Arduino Mega that are frequently used in steam boiler applications.

4.5 Cost of the Project

Table 4.3: Cost of the project

SL	Equipment Name	Cost
1	Rain Sensor	100/-
2	Power Supply	820/-
3	Main Structure	2500/-
4	PVC Board	1020/-
5	Acrylic Board	780/-
6	360 Degree Servo Motor	890/-
7	Microcontroller	2100/-
8	Ultrasonic Sensor	220/-
9	Spur Gear	540/-
10	Rack	530/-
11	Roller	150/-
12	Pump	270/-
13	Bowl, Pipe line	80/-
14	Wire	360/-
15	Plug, Switches	150/-
16	Miscellaneous	1000/-
	Total Cost	**11510/-**

4.6 Setup of Final Project

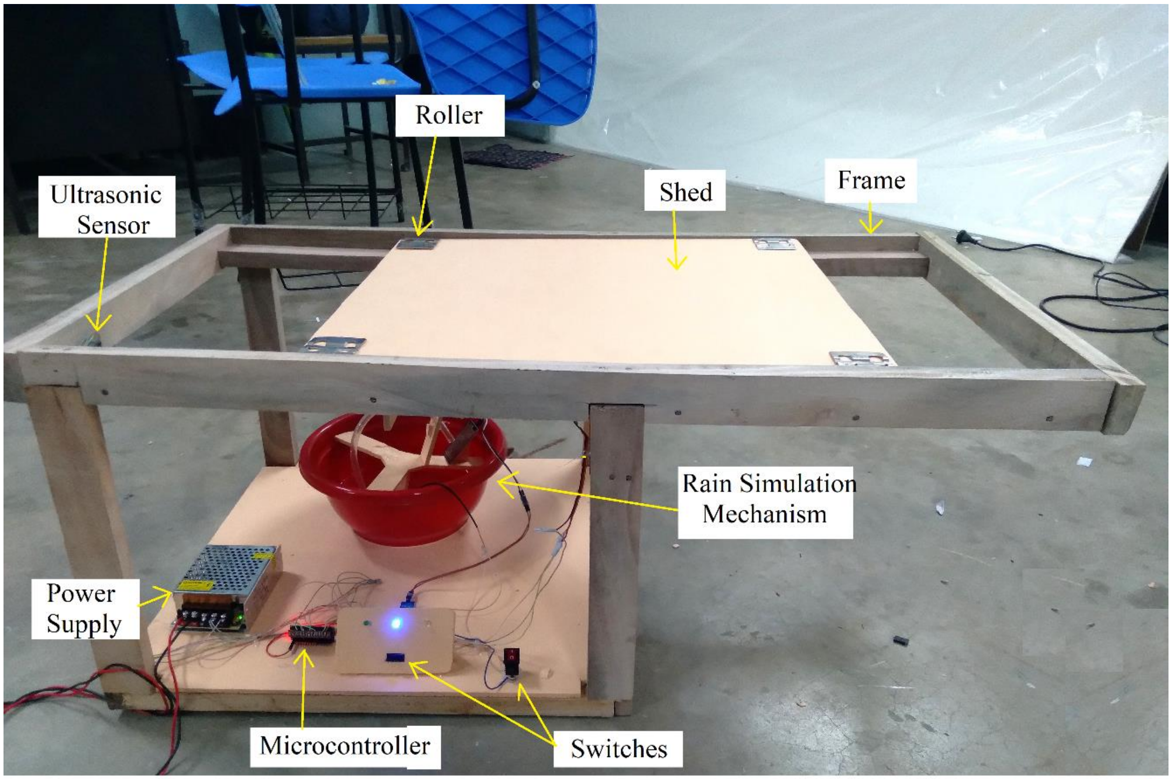


Figure 4.16: Setup of final project

4.6.1 Rain Simulation Mechanism

To facilitate comprehensive testing and validation of the "Automatic Rain Shed" prototype system, a rain simulation mechanism has been devised. This rain simulation is accomplished using a pump system, which emulates the conditions of rainfall for controlled testing scenarios. The primary objective of the rain simulation mechanism is to subject the "Automatic Rain Shed" prototype to a range of rain conditions in a controlled environment.

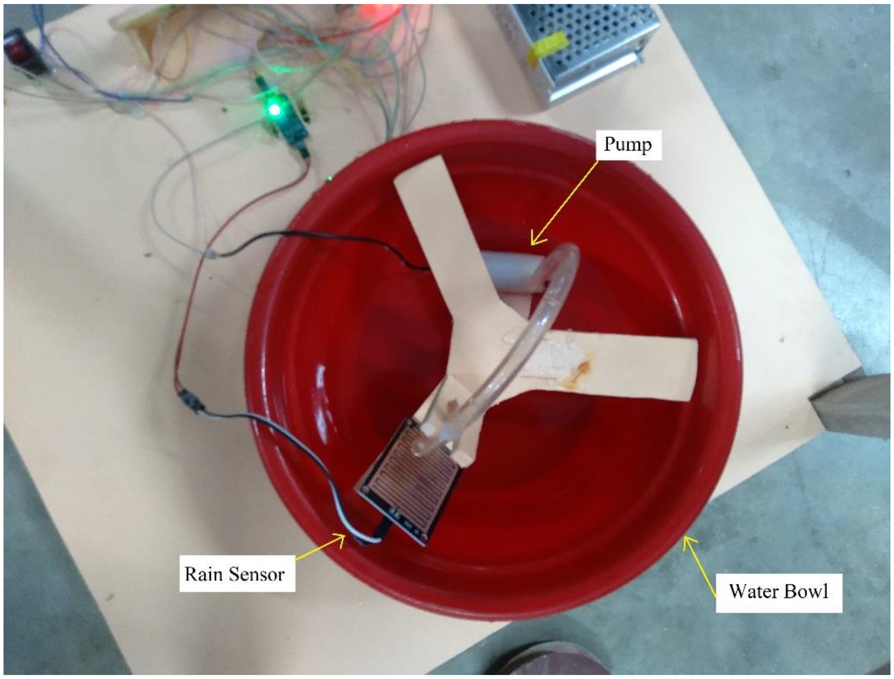


Figure 4.17: Rain Simulation mechanism

4.6.2 Manual Control Unit

The "Automatic Rain Shed" system offers two distinct controlling modes to cater to user preferences and environmental conditions: Manual and Automatic.

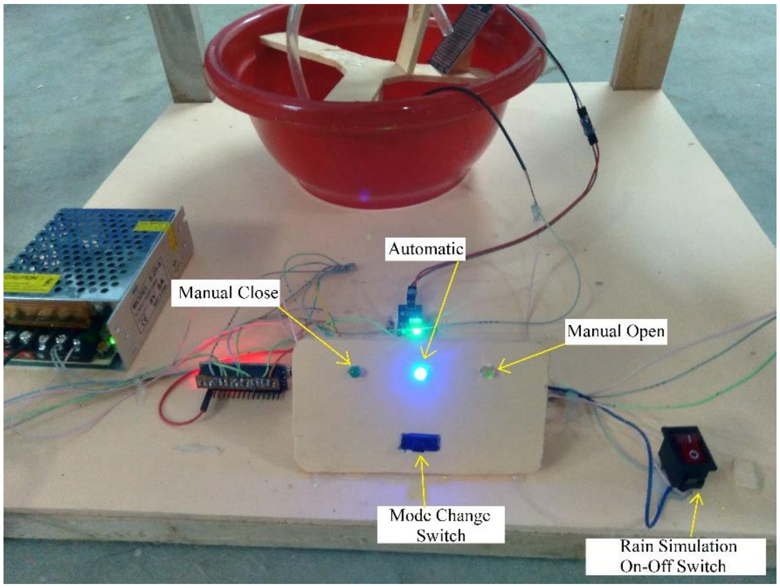


Figure 4.18: Manual control unit

CHAPTER 5

RESULT & DISCUSSIONS

Functionality of the Prototype Rain Shed

The prototype automatic rain shed is being examined as a system that is operated seamlessly. Rain is detected by it, and the analysis of raining conditions is carried out effectively using a microcontroller. Right decisions are made based on this analysis. The movement of the shed is skillfully controlled for opening or closing by a servo motor and a rack and pinion mechanism. The servo motor is employed to provide precise and controlled motion, while the rack and pinion mechanism is used for the transformation of the motor's rotary movement into linear motion. This ensures the smooth and accurate operation of the shed.

The shed's movement is ensured to be flawless by an ultrasonic sensor. This sensor is responsible for emitting high-frequency sound waves and measuring the time it takes for these waves to bounce back when they encounter an object. By this method, obstacles are detected, and the shed's movement is adjusted accordingly to maintain safety and reliability.

Table 5.1: Shed Positions in Different Scenarios

S.L	CONTROL MODE SWITCH POSITION	RAINING CONDITION	SHED
1	Automatic	Not raining	Open
2	Automatic	Raining	Close
3	Manual Open	Not raining	Open
4	Manual Open	Raining	Open
5	Manual Close	Not raining	Close
6	Manual Close	Raining	Close

Time-sensitive Performance data

Table 5.2: Time-sensitive Performance data

TASK	REQUIRED TIME
Closing the shed	**3.10 seconds**
Opening the shed	**3.30 seconds**
Response after starting rain	**0.05 seconds** (Average)
Response after stopping rain	**10 seconds** (Average)

Difficulties and Solutions

Problems and difficulties have arisen during the development process, and several solutions have been implemented. The first challenge involved the creation of an appropriate design. A prototype that could be employed for various purposes requiring a rain shed was designed.

Different methods of power transmission were considered, and the selection of the rack and pinion mechanism was made. However, appropriately sized rack and pinion components were not found readily available in the market. In response, a decision was made to produce them using 3D printing technology.

To facilitate a comprehensive visualization of the rain shed's functionality, a rain simulation mechanism was introduced as part of the solution. This mechanism allows for realistic rain simulation, aiding in testing and validating the rain shed's performance under various conditions.

CHAPTER 6

CONCLUSION & FUTURE STUDY

6.1 Conclusion

Our project has successfully met its objectives. We embarked on a journey to explore the realm of rain sensing technologies, delving into a myriad of sensors, data processing techniques, and their practical applications. Subsequently, we designed and implemented an ingenious Rain Sensing Automatic Rain Shed System, distinguished by its ability to seamlessly operate in both manual and automatic modes.

Our comprehensive testing across a diverse array of environments has underlined the system's adaptability, high-performance standards, and user-friendliness. It is readily evident that this technology has the potential to significantly benefit a wide spectrum of sectors, from open restaurants requiring immediate shelter during unexpected rains to the agricultural and industrial domains where weather can profoundly impact operations, and even in large-scale stadiums ensuring spectator comfort.

Beyond these immediate applications, our project also lays the foundation for future research and innovation within the realm of rain-sensing technology. The possibilities for further enhancing the precision and versatility of such systems are vast and promising.

In conclusion, our Rain Sensing Automatic Rain Shed System is not only an accomplishment in its own right but also a stepping stone towards a more weather-resilient future, where technology seamlessly interacts with our environment to improve the quality of our lives and enhance our operational efficiency.

6.2 Future Study

Further Study Opportunities:

1. **Expanding Beyond Rain Sensing:**
   - While the current system focuses on rain sensing, future research can explore the integration of additional environmental sensors. This could involve monitoring lighting conditions (e.g., for automatic lighting control during darkness) and temperature conditions (e.g., for adjusting the shed based on temperature extremes). Expanding the system's capabilities to respond to a wider range of environmental factors can enhance its utility and versatility.
2. **Integration of IoT (Internet of Things):**
   - To enable remote control and monitoring, the incorporation of IoT technology is a promising avenue. By connecting the rain shed system to the Internet, users could control the shed remotely using smartphones or computers. This not only enhances convenience but also allows for real-time monitoring and data collection. Users can receive alerts and make adjustments from anywhere, providing a more dynamic and user-friendly experience.

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APPENDIX

Code:

```
#include <Arduino.h>
#include <NewPing.h>
#include <Servo.h>

//-----------------Constants---------------
#define max_distance 60
#define OnDis 5
#define OffDis 38
#define Speed 40
#define CheckDellay 3000 // Not raining Checking in milliseconds

//-------------Pin Numbers------------------
#define trig_pin 3
#define echo 2
#define led 11
#define Rain 8
#define S_On 6
#define S_Off 5

//------------Variables------------------
float distance = 0;
bool Shade = false;
float D = 0;
long long int t = 0;

//------------------Objects-----------------
Servo MyServo;
NewPing Fsonar(trig_pin, echo, max_distance);
```

```
//------------------Sub Functions-----------------
float ReadSonar();
void Shadding();
void UnShadding();

//-------------------Setup--------------------
void setup()
{
  // Pin Setup
  pinMode(Rain, INPUT);
  pinMode(trig_pin, OUTPUT);
  pinMode(echo, INPUT);
  pinMode(S_On, INPUT_PULLUP);  // 5v to this pin
  pinMode(S_Off, INPUT_PULLUP); // 5v to this pin
  pinMode(led, OUTPUT);

  MyServo.attach(9);
  Serial.begin(9600);

  MyServo.write(90);
  delay(500);
  // MyServo.write(80);
  // delay(100000);
  // // MyServo.write(100);
  // // delay(100000);
  // MyServo.write(90);
  // delay(500);
  if ((digitalRead(S_On) == HIGH) && (digitalRead(S_Off) == HIGH))
  {
    digitalWrite(led, HIGH);
```

```
 }
 else if ((digitalRead(S_On) == LOW) || (digitalRead(S_Off) == LOW))
 {
   digitalWrite(led, LOW);
 }
 if (digitalRead(S_On) == LOW) // Manual ---- On
 {
   digitalWrite(led, LOW);
   Shadding();
 }
 else if (digitalRead(S_Off) == LOW) // Manual -----Off
 {
   digitalWrite(led, LOW);
   UnShadding();
 }
 else if ((digitalRead(S_On) == HIGH) && (digitalRead(S_Off) == HIGH)) // Automatic
Mood
 { digitalWrite(led, HIGH);
   if (digitalRead(Rain)) // not raining
   {
     UnShadding();
   }
   else if (!(digitalRead(Rain))) // Raining
   {
     Shadding();
   }
    if( !(digitalRead(Rain))){Shadding();}
 }
}

//-------------------Loop--------------------------
```

```
void loop()
{
 if ((digitalRead(S_On) == HIGH) && (digitalRead(S_Off) == HIGH))
 {
  digitalWrite(led, HIGH);
 }
 else if ((digitalRead(S_On) == LOW) || (digitalRead(S_Off) == LOW))
 {
  digitalWrite(led, LOW);
 }

 //   Serial.println("On ");

 // Serial.println(digitalRead(S_On));
 // Serial.println("Off ");
 // Serial.print("Rain  ");
 // Serial.println(digitalRead(Rain));

 D=ReadSonar();
 Serial.println(D);

 // delay(500);

 if ((digitalRead(S_On) == LOW) && (Shade == false))
 {
  digitalWrite(led, LOW);
  Shadding();
 }
 else if ((digitalRead(S_Off) == LOW) && (Shade == true))
 {
  digitalWrite(led, LOW);
```

```
    UnShadding();
  }
  else if ((digitalRead(S_On) == HIGH) && (digitalRead(S_Off) == HIGH)) // Automatic Mood
  {
    digitalWrite(led, HIGH);
    if ((Shade == true) && (digitalRead(Rain))) // not raining and there is shade
    {
      t = millis();
      while ((digitalRead(Rain)) && (millis() - t) < CheckDellay)
      {
      }
      if ((digitalRead(Rain)) && (millis() - t) >= CheckDellay)
      {
        UnShadding();
      }

    }
    else if ((Shade == false) && !(digitalRead(Rain))) // Raining and There is no Shade
    {
      Shadding();
    }
    if( !(digitalRead(Rain))){Shadding();}
  }
}
//-----------------Sonar Reading------------------
float ReadSonar()
{
  delay(5);
  unsigned int uS = Fsonar.ping();
  distance = Fsonar.convert_cm(uS);
```

```
  //  Serial.print("font_distance");
  //  Serial.println(front_distance);
  return distance;
}
//-----------------Actions------------------------
void Shadding()
{
  D = ReadSonar();
  while (D > OnDis)
  {
    MyServo.write((90 - Speed));
    D = ReadSonar();
    if ((digitalRead(S_On) == LOW) || (digitalRead(S_Off) == LOW))
  {
    digitalWrite(led, LOW);
  }
    // Serial.print("Dis ");
    // Serial.println(D);
  }
  MyServo.write(90);
  Shade = true;
}

void UnShadding()
{
  D = ReadSonar();
  while ((D < OffDis))
  {
    MyServo.write((90 + Speed));
    D = ReadSonar();
    if ((digitalRead(S_On) == LOW) || (digitalRead(S_Off) == LOW))
```

```
  {
    digitalWrite(led, LOW);
  }
    // Serial.print("Dis ");
    // Serial.println(D);
  }
  MyServo.write(90);
  Shade = false;
}
```