BRAC UNIVERSITY

CSE461: Introduction to Robotics

Lab Project Report

Title: Smart Hospital Cleaning, Sanitization, and Mosquito-Control Robot

by

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Abstract

Smart Hospital Cleaning, Sanitization, and Mosquito-Control Robot is an autonomous indoor service robot designed to maintain hygiene and infection control in healthcare environments where continuous manual cleaning is inefficient and exposes workers to health risks. The robot is responsible for automated floor cleaning, surface sanitization, and mosquito control in hospital corridors, wards, waiting rooms, intensive care units, and operating theaters, all without requiring direct human intervention.

The system integrates a four-wheel autonomous mobile platform with ultrasonic-based obstacle avoidance, an optical dust sensor for adaptive cleaning, and a rotating floor brush mechanism for effective dust collection. A sanitizer spraying module driven by a micro pump enables automatic disinfection. A microwave motion sensor ensures human-safe operation by pausing sanitization and mosquito spray when motion is detected. Mosquito control is achieved through scheduled aerosol spraying, reducing the risk of mosquito-borne infections such as dengue, malaria, and chikungunya in hospital premises.

All sensing, decision-making, and actuation are controlled by an Arduino Uno R3 microcontroller, ensuring reliable coordination between navigation, cleaning, sanitization, and safety mechanisms. Prototyping and functional testing demonstrate effective autonomous navigation, responsive obstacle avoidance, adaptive dust removal, safe sanitizer deployment, and reliable mosquito spray operation.

From a sustainability and impact perspective, the proposed system reduces repetitive human labor, minimizes cross-contamination risks, optimizes chemical usage, and provides a low-cost automation solution suitable for hospitals in developing countries. By enabling continuous and autonomous hygiene maintenance, the robot contributes to improved patient safety, public health protection, and sustainable healthcare automation.

Keywords

autonomous robot, hospital sanitization, embedded systems, infection control, sustainability

1. Introduction

Hospitals are highly sensitive environments where hygiene and infection control are critical for patient safety and public health. High human traffic, frequent surface contact, and exposure to biological contaminants significantly increase the risk of infection transmission. In many healthcare facilities, especially in developing countries, cleaning and sanitization are primarily performed manually, exposing cleaning staff to harmful pathogens and resulting in inconsistent hygiene maintenance.

Additionally, mosquito-borne diseases such as dengue, malaria, and chikungunya remain a serious concern in hospital environments, particularly in tropical regions. Conventional mosquito control methods are often irregular, labor-intensive, and unsafe when applied in occupied areas. These challenges highlight the need for an automated system capable of maintaining cleanliness, ensuring safe sanitization, and controlling mosquito presence without disrupting hospital operations.

The objective of this project is to design and implement a low-cost autonomous robot capable of performing floor cleaning, surface sanitization, and mosquito control in hospital environments. The proposed system uses ultrasonic sensors for navigation and obstacle avoidance, an optical dust sensor for adaptive cleaning behavior, and a microwave motion sensor to detect human presence and ensure safe operation. A rotating floor brush mechanism enables effective dust collection, while a sanitizer spraying module and timed aerosol-based mosquito control system enhance overall hygiene and safety.

This project is directly relevant to Computer Interfacing, as it involves the integration of multiple sensors, actuators, and control modules through a microcontroller-based embedded system. Real-time data acquisition, decision-making, and actuator control demonstrate practical hardware–software interaction in solving real-world healthcare automation problems. The system's affordability, adaptability, and autonomous functionality make it a promising solution for improving hygiene standards and reducing health risks in hospitals and similar indoor environments.

2. Related Work/ Inspiration

Even though the majority of them are focused on a single task, the market still has autonomous systems for cleaning, sterilization, and mosquito control. One example is ultrasonic sensors that can allow multiple Arduino robots to explore and dodge barriers. For the most part, these gadgets are employed merely to demonstrate basic house cleaning or navigation and do not have any mosquito control or sanitizing components.

An example of an automatic disinfecting pump system illustrates how a servo or a pump can squirt out the disinfectant onto a person or an object detected. These systems are stationary, non-mobile, and lack mosquito control; thus, they cannot walk around and clean the floor at the same time.

Likewise, Arduino-operated domestic robots would usually perform the functions of hospital sanitation with the use of mosquito spraying, ultrasonic dust sweeping, and navigation.

There are also Arduino-based solutions for mosquito repellers that can utilize external inputs from sensors for automatic timing and spraying of repellent. In certain cases, they get their cue from human detection for switching off the spray whenever people are present. These systems are more like ours and have inspired our Mosquito Spray Mode that allows the robot to spray 2-3 times a day without the danger of us and then stop to let the people in.

The difference between our system and the current projects is that we have packaged multiple chores inside one robot. Our pump will gently clean the floor, and we have a timer to spray mosquitoes; this will only be activated when human presence is detected. Moreover, our robot is equipped with ultrasonic sensors that allow it to detect barriers and navigate through its environment. This coordination of a complete, robot-like body can be applied in low-resource hospitals, businesses, or schools as the robot would then be able to collaborate to complete all tasks.

3. Technical Approach

Components Used

Hardware Components

1. Arduino Uno R3
2. Ultrasonic Sensor (HC-SR04)
3. RCWL-0516 Microwave Sensor
4. Water Level Sensor / Float Switch
5. Optical Dust Sensor
6. L298N Dual DC Motor Driver
7. 16 GA-050 12V DC Gear Motor
8. DC Motors (Chassis motors)
9. Servo Motor
10. Micro Pump Motor
11. 4WD Smart Robot Car Chassis
12. 12V 2800mAh Lithium Battery
13. 830-point Breadboard
14. Jumper Wires Kit
15. Dust Container
16. Rotating Floor Brush
17. Refillable Spray Pump Bottle
18. 4mm Flexible PVC Tube
19. Antibacterial Floor Cleaner Liquid
20. Aerosol / Mosquito Spray

Software Tools

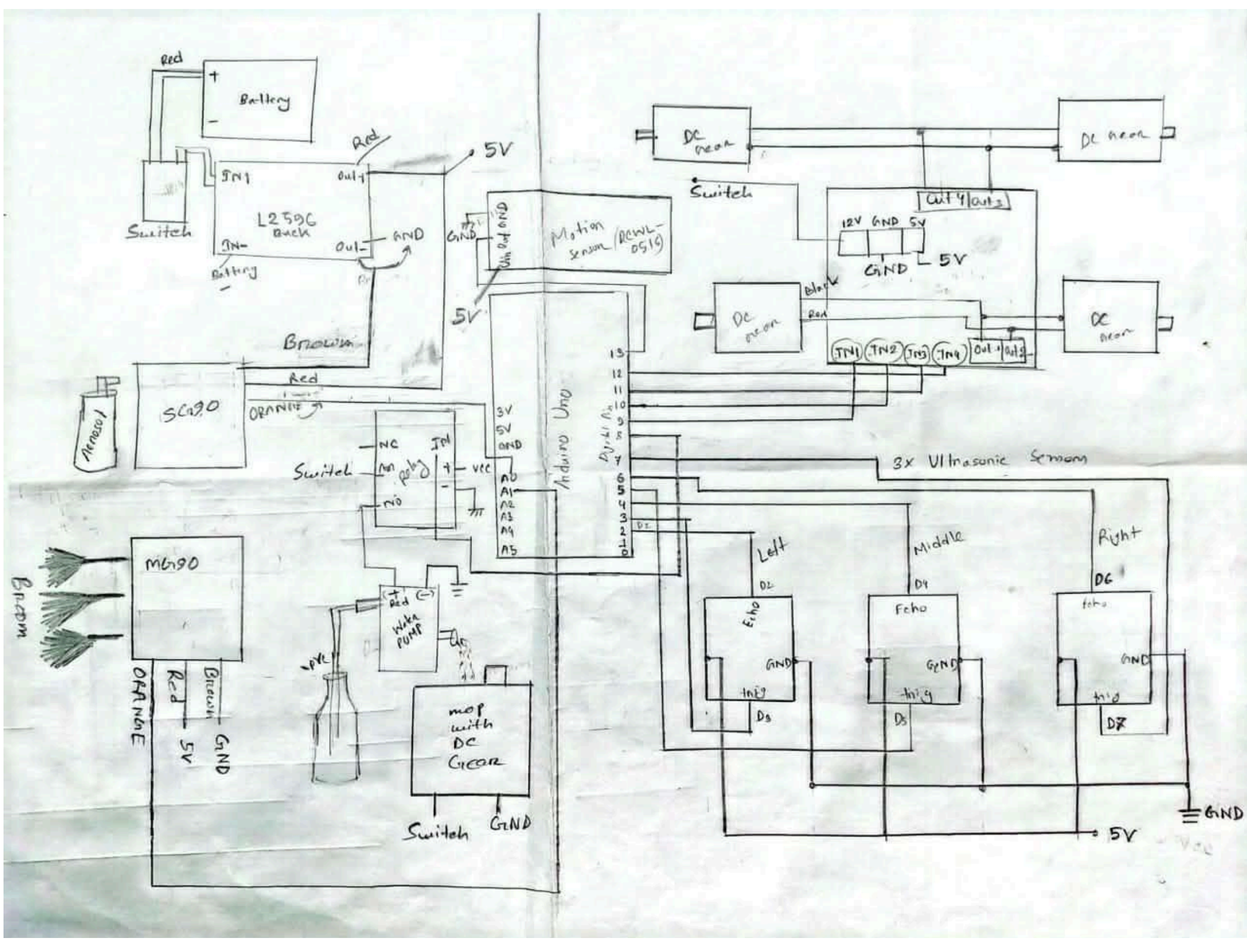
1. Arduino IDE
2. Embedded C/C++
3. Serial Monitor

Components	Unit Cost	Total
Arduino Uno R3	891	891
Ultrasonic HC-SR04	3*83.74	251.22
RCWL-0516 Microwave module	101.53	101.53

Float Switch Water Level Controller/ Water Level Sensor Float Switch (Small)	65.00-495.04	65.00-495.04
Optical Dust Sensor	680	680
L298 Dual DC Motor Controller	484.82	484.82
Servo Motor	180-360	180-360
16 GA-050 12V DC Gear Motor	690	690
830-point Breadboard	150-300	150-300
4WD Smart Robot Car Chassis/4-wheel Robot Frame	900- 1200	900- 1200
Jumper Wires Kit	150-200	150-200
Dust Container	50-150	50-150
Rotating floor brush	200-400	200-400
Antibacterial Floor Cleaner Liquid	200-600	200-600

aerosol	250-400	250-400
refillable spray pump bottle	200-600	200-600
4 mm Flexible PVC Tube	200-300	200-300
12V lithium 2800mAh battery	1500	1500

Total ≈ 7144-9604 TK



- [ ] Functionality:
  The goal of the robotic system is to utilize an intelligent robot capable of total autonomy that moves forward and at all times uses an ultrasonic sensor and a motion sensor for continuous inspection of its environment. Initially, in the configuration stage, all the hardware parts of the robot are energized, including motors, ultrasonic sensors, servos, relays, and motion sensors. When the system of the robot enters the loop, it will begin the process of automatic movement. The left, middle, and right ultrasonic sensors will be used to measure how far the objects are. These sensors are vital for the robot to understand if there is a physical barrier beside or in front of it. Likewise, there is a totally autonomous system that is activated by the motion sensor to sense when a person is active. The robot will momentarily halt as it detects a person, then the SG90 servo will assist in activating the spray mechanism, and the robot will continue moving after that. Thus, the robot accomplishes its sanitizing goal while not posing any threat. After the robot has moved to the location of the spray, it will then turn to the next spot immediately, so that there is no pause in the operation. To enhance the area covered, another servo motor (MG90) will perform a sweep after each set time. This would not physically hinder the robot's movement, but the effect created would be significant in spraying the disinfectant wider. To avoid obstacles, the middle ultrasonic sensor will come into play. In case an object is detected within the allowed distance, the robot will quickly back off. The distance on the left and the right sides will then be measured, and the turning will be towards the side where there is more space. Once the robot has turned, it will go ahead. The whole operation is a cycling loop, and the robot is capable of making its own movement, avoiding obstacles, detecting motion, and disinfecting wherever needed.

Problems and Solutions:

One significant issue was that the robot had to perform several activities at the same time, which were spray, obstacle detection, and movement. First, when the robot was spraying, it would stop moving completely, and this would slow down the whole operation. However, by controlling the delays tightly and quickly restarting the motors after spraying, the problem was solved. The other challenge was that the ultrasonic sensors were giving very unstable distance readings. Sometimes the sensors would give zeros or wrong values, which would causea mistake in detecting the obstacle. To overcome this problem, a timeout was introduced in the distance measurement so that the system would be safe enough to manage the wrong results. Another challenge that the servo control presented, especially in cases when the two servos are used simultaneously, was the sudden movements caused by timing and vibrations. The erratic servo movements were halted, and the servo movements were changed from continuous to intermittent, thus solving this. Lastly, the separation of the two processes made it hard to decide how to detect motion and avoid obstacles simultaneously. To ensure that obstacle avoidance, sweeping, and spraying worked in harmony, the proper sequence of conditions within the loop was established.

Code -

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

```
#define IN1 9
#define IN2 10
#define IN3 11
#define IN4 12

#define TRIG_LEFT 3
#define ECHO_LEFT 2
#define TRIG_MID 5
#define ECHO_MID 4
#define TRIG_RIGHT 7
#define ECHO_RIGHT 6

#define RELAY_PIN 8
#define MOTION_PIN 13



#define SERVO_SG90 A0
#define SERVO_MG90 A1

#define SPRAY_PRESS   40
#define SPRAY_RELEASE 90
Servo sg90;
Servo mg90;
long getDistance(int trig, int echo) {
```

```
  digitalWrite(trig, LOW);
  delayMicroseconds(2);
  digitalWrite(trig, HIGH);
  delayMicroseconds(10);
  digitalWrite(trig, LOW);

  long duration = pulseIn(echo, HIGH, 30000);
  if (duration == 0) return 300;
  return duration * 0.034 / 2;
}


void forward() {
  digitalWrite(IN1, HIGH); digitalWrite(IN2, LOW);
  digitalWrite(IN3, HIGH); digitalWrite(IN4, LOW);
}

void backward() {
  digitalWrite(IN1, LOW); digitalWrite(IN2, HIGH);
  digitalWrite(IN3, LOW); digitalWrite(IN4, HIGH);
}

void turnLeft() {
  digitalWrite(IN1, LOW); digitalWrite(IN2, LOW);
```

```
  digitalWrite(IN3, HIGH); digitalWrite(IN4, LOW);
}

void turnRight() {
  digitalWrite(IN1, HIGH); digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW); digitalWrite(IN4, LOW);
}

void stopMotors() {
  digitalWrite(IN1, LOW); digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW); digitalWrite(IN4, LOW);
}
void sprayOnceSafe() {
  stopMotors();
  digitalWrite(RELAY_PIN, LOW);
  delay(200);
  sg90.write(SPRAY_PRESS);
  delay(150);
  sg90.write(SPRAY_RELEASE);
  delay(350);
}

void sweepMG90() {
```

```
  // Left to Right
  for (int angle = 30; angle <= 150; angle++) {
    mg90.write(angle);
    delay(10);
  }

  // Right to Left
  for (int angle = 150; angle >= 30; angle--) {
    mg90.write(angle);
    delay(10);
  }
}
void setup() {

  pinMode(IN1, OUTPUT); pinMode(IN2, OUTPUT);
  pinMode(IN3, OUTPUT); pinMode(IN4, OUTPUT);
  pinMode(TRIG_LEFT, OUTPUT);  pinMode(ECHO_LEFT, INPUT);
  pinMode(TRIG_MID, OUTPUT);   pinMode(ECHO_MID, INPUT);
  pinMode(TRIG_RIGHT, OUTPUT); pinMode(ECHO_RIGHT, INPUT);

  pinMode(RELAY_PIN, OUTPUT);
  pinMode(MOTION_PIN, INPUT);
  sg90.attach(SERVO_SG90);
  sg90.write(SPRAY_RELEASE);
```

```
  mg90.attach(SERVO_MG90);
  mg90.write(90);

  digitalWrite(RELAY_PIN, LOW); // Pump OFF
}


void loop() {

  // Always try to move forward
  forward();

  // Read distances
  long dLeft  = getDistance(TRIG_LEFT, ECHO_LEFT);
  long dMid   = getDistance(TRIG_MID, ECHO_MID);
  long dRight = getDistance(TRIG_RIGHT, ECHO_RIGHT);

  // Servo sweep ONLY occasionally (non-critical)
  static unsigned long lastSweep = 0;
  if (millis() - lastSweep > 2000) {
    sweepMG90();
    lastSweep = millis();
  }
```

```
  // Motion detected → spray but resume movement
  if (digitalRead(MOTION_PIN) == HIGH) {
    sprayOnceSafe();
    forward();
  }

  // Obstacle avoidance
  if (dMid < 25) {
    backward();
    delay(200);

    if (dLeft > dRight) turnLeft();
    else turnRight();

    delay(200);
    forward();
  }
}
```

4. Sustainability & Impact

- ☐ Sustainability: This particular system discloses an important reduction in the excessive use of chemical disinfectants through controlled and trigger-manner application of sanitizer and mosquito control spray. It has been observed that in manual cleaning practices, large quantities of cleaning agents are employed, containing harmful chemical components. Overuse in a sensitive area like a hospital could make it uncomfortable for the patients and even the environment susceptible to pollution with chemicals having long-term health implications. However, since the robot is automatic, it will not administer more chemicals than what is needed.

Besides, low-energy parts like ultrasonic sensors and motion sensors are responsible for the energy efficiency that is achieved since they all consume very little energy while performing their tasks with great reliability. The microcontroller-based embedded system is designed in such a way that it will only permit the activation of the motor, sprayers, and brush actuators when necessary. Moreover, the robot can be powered by rechargeable batteries, which will not only reduce the dependence on disposable power sources but will also lower the long-term operational costs.

Regarding the materials, the system is made from widely used and reusable components. The build parts of the robot can either be made of recyclable materials, such as aluminum or plastic, that can be reused for making the robot's outer case. The modular design makes it possible to replace only the broken or out-of-date components rather than throwing away the whole system, thus promoting sustainability and cutting down on waste further.

- [ ] Impact: The society, institutions, and communities are going to feel the great impact of this project. The use of robots in hospitals is among the ways to elevate health standards; they would be responsible for cleaning floors, sanitizing surfaces, and even handling mosquitoes, and the whole operation shall be very reliable and uniform. Hospital-acquired infections (HAIs) is considerably reduced, which consequently results in patient safety and, thus, better recovery outcomes.

  From the perspective of society, the greatest benefit that the system provides is the reinforcement for the cleaning workers by keeping them away from the germs and the chemical disinfectants to the largest extent. The cleaning machines taking care of the high-risk areas is one of the ways, and thus occupational health risks are minimized while safe working conditions are sustained. This inexpensive solution, in the case of developing countries where hospitals are frequently short-staffed and undersupplied, offers a practical alternative to labor-intensive cleaning methods that are still manual.

  On the other hand, the project is a testament to the great potential of embedded systems and robotics to participate in the automation of healthcare. It raises a plethora of low-cost medical robotics innovations and the very fact that opens up the possibility of local manufacture, customization, and installation in small clinics, isolation wards, and health facilities, especially during public health emergencies.

- [ ] Future Work: The current system makes an outstandingly effective trio of cleaning, disgusting, and mosquito control, yet the advancements are already set in the minds of the researchers as the next cutting-edge application. The use of AI-based vision systems will not only provide better obstacle and dirt detection, but also the utilization of advanced navigation techniques like SLAM (Simultaneous Localization and Mapping) could lead to the development of an excellent route planning and cleaning area location system.

The primary feature of IoT connectivity opens the door for remote monitoring, planning, and recording of data through mobile or web applications. Similarly, besides monitoring maintenance status, hospital managers will also be able to monitor the level of cleaning effectiveness.

The potential for scalability could come from either the embedding of the larger hospital sites or the establishment of a system for the coordination of several robots. The various modules that participate in the adaptive and user-friendly design include changing sanitization intensity, self-docking and charging stations, and UV-C germicidal.

Limitations: The method that is being brought up has a lot of shortcomings, yet at the same time, it is a very popular method. The usage of inexpensive sensors might result in less accuracy in some cases, such as shiny surfaces or crowded areas, when it comes to hardware. The continuous operation time of the device is determined by the battery life, which also necessitates regular recharging.

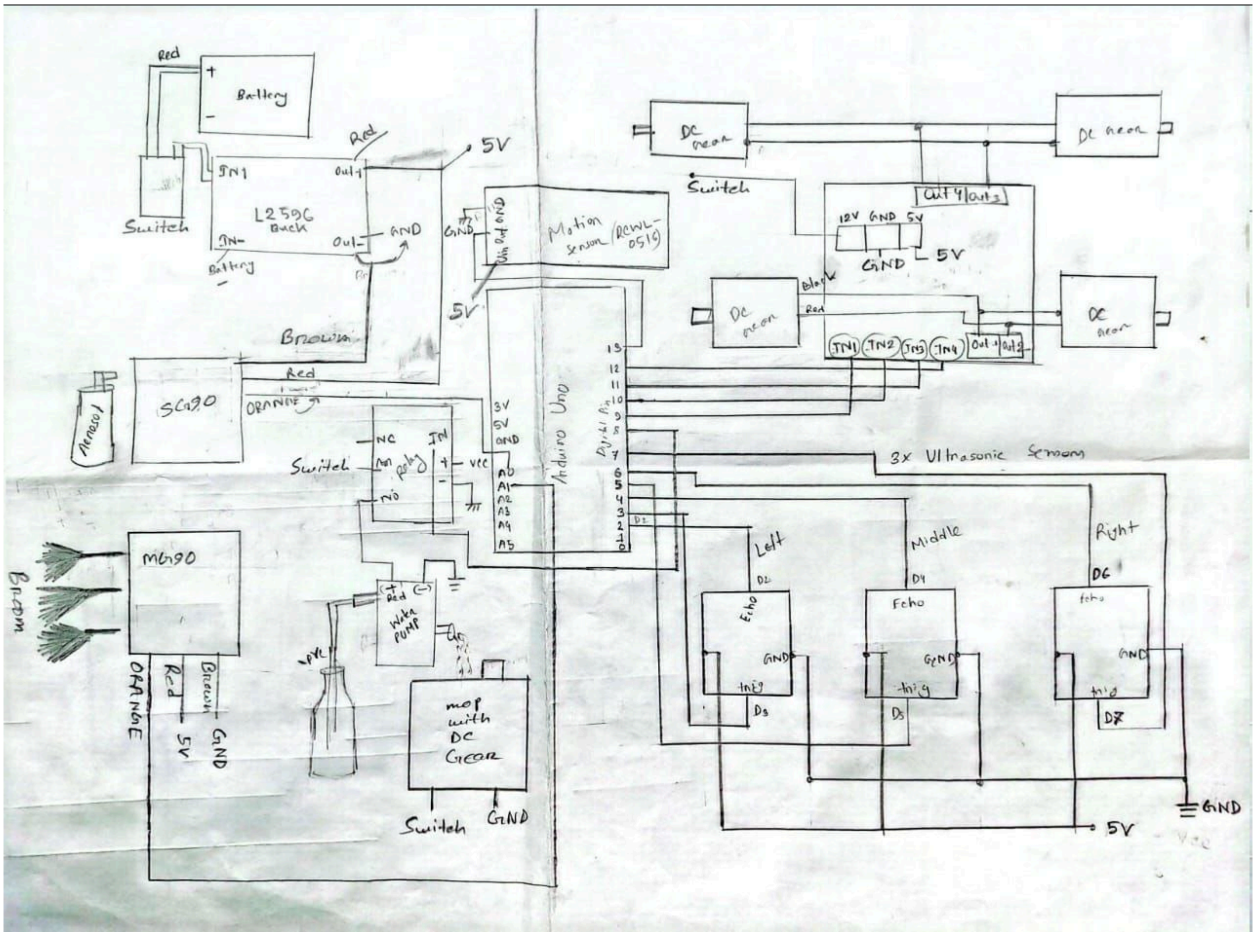
One of the software limitations is that the basic navigational logic cannot function properly in dynamic hospital situations or complex layouts. The system's present inability to vary its performance according to previous cleaning cycles is a significant disadvantage.

In addition, the mosquito management method that is based on time intervals rather than real-time mosquito monitoring sometimes leads to unnecessary pesticide application. The robot was not able to perform properly on uneven floors or stairs, but it is mainly meant for flat interior surfaces.

All these limitations not only point out the need for future innovations but also the role of automation in changing the traditional system of cleaning hospitals into a hygienic and efficient one.

5. Results & Discussion

The wheels have issues rotating because of the weight. There are some technical error but otherwise, all the DC motor, mopping, sanitizing, and dusting, and mosquito control are working properly.



6. Conclusion

The Smart Hospital Cleaning, Sanitization, and Mosquito-Control Robot offers a safe, cost-effective, and autonomous solution to the problem of ensuring the cleanliness of the healthcare setting. It will save lives by incorporating sweeping, mopping, sanitizing, and mosquito control into one system that will reduce the risk of infection, safeguard personnel, and maintain a high level of cleanliness. Its affordability, flexibility, and autonomy qualify it to be used in hospitals and to be extended to the general use of the facilities at large. In general, the current project is a practical, critical problem solution based on automation, which largely contributes to enhancing the level of health, safety, and company efficiency.

7. Contribution

Name	ID	Role(s) / Responsibilities	Specific Contributions
MD. HAFIZUR RAHMAN	23301197	Circuit build	Built the circuit & proposed idea, generated code
SANJIDA NOSHIN OMI	23301280	Circuit design component	Designed the diagram, helped building circuit, proposed the idea, and made the poster
Ahana Fairuz Zara	22301212	Component buy & help building the circuit	Helped with building the circuit, made this report
Nusrat Jahan Madhurzo	24241129	Helped build the circuit	Data visualizing, made this report, and proposed ideas
AFSANA AKTER MIM	22101881	Helped build the circuit	Data handling, made this report, and proposed ideas.

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