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Development of an Automated Mattress Cleaning and Disinfectant Machine

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ABSTRACT

Mattresses are used daily and can accumulate dust and loose particles over time. Regular cleaning is important for maintaining a hygienic sleeping environment, but manual cleaning may require considerable time and effort. This project presents the development of an automated mattress cleaning and disinfectant machine that uses a motorized rail mechanism to move a cleaning assembly across a mattress. The prototype consists of two-wheel motors, one motor for moving the cleaning assembly along horizontal rails, a cordless rechargeable vacuum cleaner, a UV-C light source, and electrical control components.

The fabricated prototype was tested on a mattress measuring 6 ft 6 in in length and 3 ft in breadth. Three trials were conducted to observe the machine's movement, vacuum operation, UV-C light operation, and overall functioning. The cleaning operation took approximately 12 minutes. The motorized mechanism operated without observed movement problems, while the overall cleaning performance was rated as average. The vacuum cleaner collected dust, but the quantity removed was not measured. Similarly, the UV-C light switched on successfully, but its wavelength and effectiveness against microorganisms were not experimentally verified. The results demonstrate the basic functional operation of the prototype and identify areas for further improvement.

Keywords: Automated cleaning, mattress cleaning, vacuum cleaner, UV-C light, motorized mechanism, prototype testing.

I. INTRODUCTION

Hospital mattresses are frequently reused by different patients and can accumulate dust, skin particles, body fluids, bacteria, viruses, fungi, and other harmful microorganisms. Since mattresses remain in direct contact with patients for long periods, maintaining their cleanliness is an important part of hospital hygiene and infection-control practices. Improper or insufficient cleaning may increase the possibility of cross-contamination and create an unhealthy environment for patients and healthcare workers.

Traditional mattress cleaning methods mainly depend on manual wiping, washing, vacuuming, and chemical disinfection. These methods require considerable time and human effort and may not provide uniform cleaning over the complete mattress surface. Repeated use of chemical disinfectants can also cause residues, odour, and possible deterioration of mattress-cover materials. Therefore, an automated system is required to make the cleaning process more consistent,

efficient, and convenient.

The proposed system has high-suction vacuum cleaning to remove dust, dirt, hair, fibres, and other physical contaminants from the mattress surface. After the mechanical cleaning stage, the mattress undergoes UV-C disinfection inside an enclosed chamber. UV-C radiation is used to reduce microbial contamination without depending on chemical disinfectants. The combination of physical cleaning and disinfection provides a more comprehensive approach to mattress sanitation.

An Arduino-based control system is used to automate the complete cleaning cycle. Sensors detect mattress positioning and monitor safety conditions, while door interlocks prevent UV-C operation when the enclosure is open. The controller vacuum, UV-C lamps, timing, and completion indicators. These features help reduce manual intervention and provide a standardized cleaning procedure.

Overall, the proposed automated mattress cleaning and disinfectant machine provides a practical and economical approach to improving hospital mattress hygiene. By integrating, vacuuming, UV-C disinfection, sensors, and safety mechanisms, the system aims to reduce cleaning effort and improve consistency while supporting infection-control practices in hospitals, clinics, nursing homes, and other healthcare facilities.

II. AIMS & OBJECTIVES

Aim:

To design, fabricate and experimentally evaluate an automated mattress cleaning and disinfectant machine using a movable mechanical assembly, vacuum cleaning and UV-C light.

Objectives:

1. To develop a motorized mechanism for moving the machine across a mattress.
2. To provide horizontal movement of the cleaning assembly using a motor-driven rail arrangement.
3. To integrate a cordless rechargeable vacuum cleaner for dust collection.
4. To provide a UV-C light source as an additional component of the cleaning system.
5. To fabricate a functional prototype using available components.
6. To evaluate the movement, vacuum operation, light operation, and overall functioning of the prototype.
7. To identify the limitations of the developed machine and suggest possible improvement

III. LITERATURE SURVEY

The development of hospital mattress cleaning and disinfection has gradually progressed from simple manual cleaning methods to automated and technology-based solutions. The related projects are mentioned below:

Research of System Design and Automatic Detection Method for Excretion Nursing Equipment, January 2023.

This paper presents the design and development of excretion nursing equipment for elderly and bedridden patients to improve urine and stool detection and personal care. The system uses a split mechanical design and modular control method, along with Dempster–Shafer (D-S) evidence theory, to accurately identify urine and stool. Functional testing demonstrated that the proposed recognition method achieved 90% accuracy, improving the success rate by 20%

compared with traditional methods. The developed equipment provides an effective solution for automated excretion care, enhancing patient comfort, hygiene, and nursing efficiency.

Development of An Automated Floor Cleaning Machine for Domestic Application – A Review, November 2024.

This paper presents the design and development of an automated floor cleaning machine for domestic use to reduce manual effort and improve cleaning efficiency. The proposed system uses an Arduino UNO microcontroller, L293D motor driver, geared motors, ultrasonic sensors, and Bluetooth connectivity to enable autonomous movement, obstacle detection, and smartphone-based control. The machine integrates both dry sweeping and wet mopping functions, providing a convenient and efficient solution for household cleaning. The system aims to save time, reduce physical effort, and enhance the convenience of floor cleaning in modern smart homes.

Development of an Automated Floor Cleaning Machine, November 2025.

This paper presents a compact and energy-efficient automated floor-cleaning machine that performs sweeping and mopping simultaneously with minimal human effort. The system is powered by a 12V rechargeable DC battery and uses a mopping unit, chain-sprocket mechanisms, and bevel gears to clean different floor surfaces. Its lightweight and modular design ensures portability, easy maintenance, and user-friendly operation. The machine is suitable for homes, offices, and institutions, offering improved cleaning efficiency and reduced manual labour, with future scope for integrating smart sensors, obstacle detection, autonomous navigation, and mobile application control.

RSSI-Based Localization of Smart Mattresses in Hospital Settings, January 2026.

This paper presents a Bluetooth Low Energy (BLE)-based localization system for tracking smart mattresses in hospitals using Received Signal Strength Indicator (RSSI) measurements. The system was tested with 266 mattresses across 101 rooms over 42 hours to evaluate its accuracy and reliability in detecting mattress locations and movements. The results demonstrated effective room-level identification, reduced manual tracking efforts, and improved nursing efficiency. Although occasional location mismatches occurred when receivers were offline, the system provides a cost-effective and scalable solution for hospital asset tracking, with future improvements focusing on receiver monitoring and system reliability.

IV. METHODOLOGY

The proposed system is developed by integrating vacuum cleaning, UV-C disinfection, sensors, and Arduino-based automation into a single machine. The mattress is first positioned on the machine platform, where sensors detect its presence and alignment. After mechanical cleaning, the mattress is enclosed inside a UV-C chamber and exposed to controlled UV-C radiation for a predetermined time. An Arduino controller manages the complete sequence and monitors safety conditions through sensors and door interlocks. The enclosed design ensures that UV-C radiation does not directly reach the operator during operation. After completion of the cleaning and disinfection cycle, the system switches off automatically and

provides an indication that the mattress is ready for removal.

Working

1. **Mattress Loading:** The mattress is placed correctly on the machine platform or conveyor. Sensors detect its presence and confirm proper positioning.
2. **Safety Check:** The Arduino checks the sensor and enclosure/interlock conditions. The system starts only when all required safety conditions are satisfied.
3. **UV-C Disinfection:** After mechanical cleaning, the mattress is enclosed in the UV-C chamber. UV-C lamps operating are activated for a preset duration to reduce microbial contamination on exposed surfaces.
5. **Safety Monitoring:** During UV-C operation, the Arduino continuously monitors the enclosure and safety sensors. If the door is opened or an abnormal condition is detected, the UV-C lamps are immediately switched off.
6. **Completion and Reset:** After the programmed cycle are completed, the UV-C lamps and cleaning mechanisms are switched off. An indicator informs the operator that the process is complete, after which the mattress can be removed and the machine resets for the next cycle.

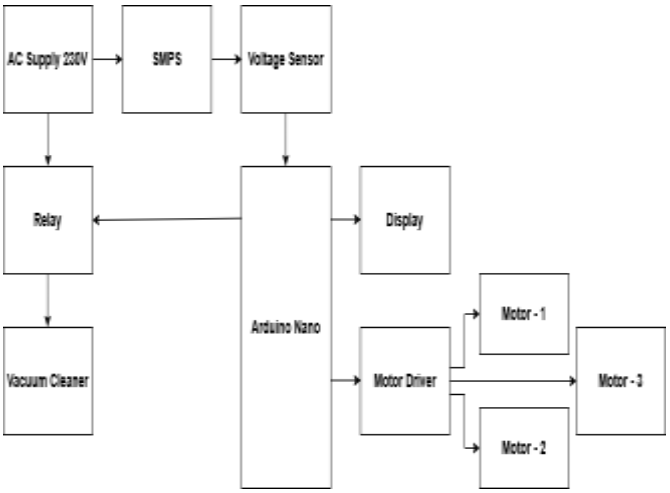


Figure 1: Block Diagram of the proposed system

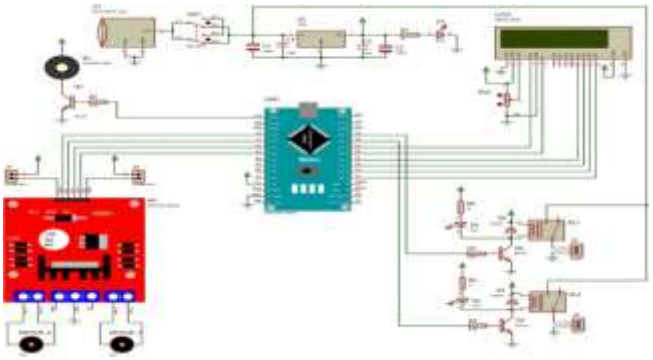


Figure 2: Circuit Diagram of the proposed system

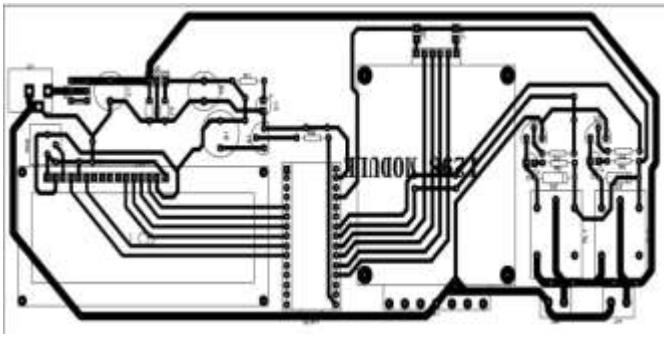


Figure 3: PCB Layout of the proposed system

Experimental Procedure:

The fabricated automated mattress cleaning and disinfectant machine was tested to evaluate its basic functioning and overall performance. The experimental procedure was carried out as follows:

1. The machine was positioned over the mattress, and the mechanical assembly was checked before testing.
2. The wheel motors were operated to observe the

movement of the machine.

3. The motor responsible for horizontal movement was operated to check the forward and backward movement of the cleaning assembly along the rails.
4. The cordless rechargeable vacuum cleaner was switched on to observe its operation and dust collection from the mattress surface.
5. The UV-C light source was switched on to verify its basic operation.
6. The complete machine was operated to observe the functioning of the movement mechanism and cleaning components.
7. The overall performance of the machine was observed during operation, including its movement, vacuum cleaning, and UV-C light functioning.
8. The observations obtained during testing were recorded and reviewed to identify the functional performance and limitations of the developed prototype.



Figure 4: Experimental setup of proposed system

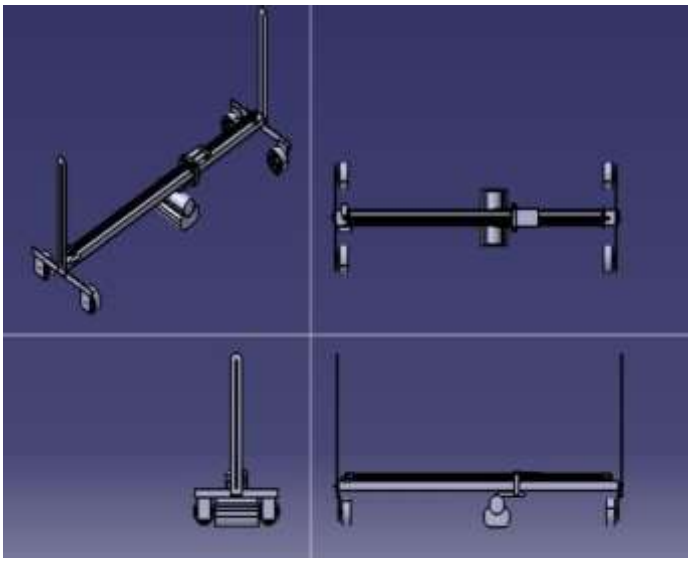


Figure 5: CAD Design - 1

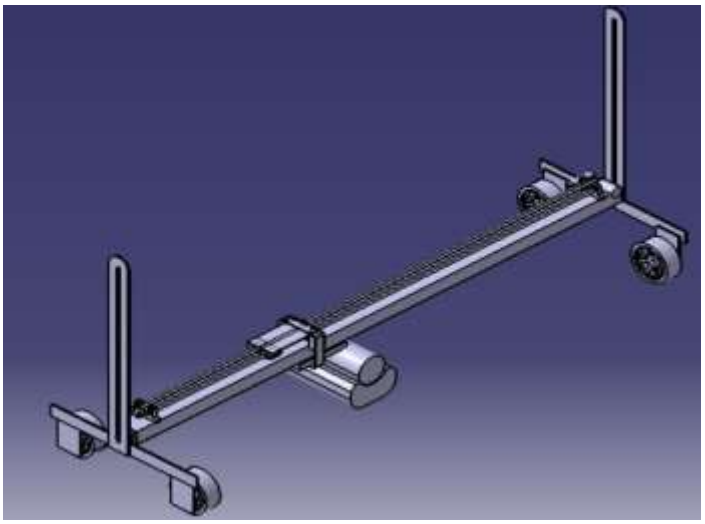


Figure 6: CAD Design - 2

V. RESULTS

Functional Testing Results

The prototype was tested in three trials using a mattress measuring 6 ft 6 in × 3 ft. During testing, the motors operated without any observed movement problems, the vacuum cleaner collected dust from the mattress surface, and the UV-C light switched on successfully. The cleaning operation took approximately 12 minutes.

Movement Performance

The wheel motors and horizontal movement mechanism operated successfully during the three testing trials. No movement problems were observed during operation, indicating that the prototype's movement system performed its basic intended function under the tested conditions.

Vacuum Cleaning Performance

The vacuum cleaner successfully collected dust from the mattress surface. However, the overall cleaning performance was rated as average. The quantity of dust collected was not measured; therefore, the dust-removal efficiency of the prototype could not be determined quantitatively.

UV-C Light Performance

The UV-C light switched on successfully during testing, demonstrating that the light source and its basic electrical operation were functional. However, the wavelength of the light was not independently verified, and no microbiological tests were conducted. Therefore, the disinfection effectiveness of the prototype could not be confirmed.

Overall Discussion

The prototype demonstrated the basic functioning of its movement mechanism, vacuum cleaner, and UV-C light source during the three testing trials. The cleaning operation took approximately 11.5 minutes, and no movement problems were observed. Although the vacuum cleaner collected dust and the UV-C light switched on successfully, further evaluation is necessary to determine the machine's cleaning efficiency and disinfection effectiveness. Future testing should include quantitative measurement of dust removal, verification of the UV-C wavelength, and appropriate microbiological testing to assess disinfection performance.

Experimental Observations

Sr.No.	Parameter Observed	Observations
1.	Mattress Dimensions	6 ft 6 in × 3 ft
2.	Number of trials	3
3.	Wheel motor operation	Operated without observed movement problems
4.	Horizontal movement operation	Forward and backward movement observed
5.	Vacuum cleaner performance	Collected dust; overall cleaning performance was rated as average
6.	UV-C light operation	Light switched on successfully; wavelength not specified
7.	Approximate cleaning time	12 minutes
8.	Microbiological testing	Not performed
9.	Dust removal efficiency measurement	Not performed

Figure 8: Complete prototype of the proposed system.



Figure 9: Circuitry setup of the proposed system



VI. CONCLUSION

- The automated mattress cleaning and disinfectant machine was successfully developed and tested on a mattress measuring 6 ft 6 in × 3 ft. The prototype demonstrated the basic functioning of its wheel motors, horizontal movement mechanism, vacuum cleaner, and UV-C light source during three testing trials. The vacuum cleaner collected dust from the mattress surface, and the UV-C light switched on successfully. The cleaning operation took approximately 12 minutes, while the overall cleaning performance was rated as average.
- However, the dust-removal efficiency was not measured quantitatively, and the disinfection effectiveness of the UV-C light was not verified through microbiological testing. Therefore, further improvements and testing are necessary to evaluate the machine's overall performance. Future work should include quantitative dust-removal measurements, verification of the UV-C wavelength, microbiological testing, and appropriate UV-C safety assessments. Overall, the prototype demonstrates the feasibility of an automated approach to mattress cleaning, with further development required to establish its cleaning efficiency, disinfection effectiveness, and safe operation.

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