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UDC 681

AUTONOMOUS DISINFECTION ROBOT WITH ROBOTIC ARM FOR PRECISION CLEANING

Denzel C. Ndavambi[1], Kelvin Chihota[1], Doubt Simango[1], Makusha D. T.[2]

[1]Chinhoyi University of Technology, Chinhoyi, Zimbabwe
[2]Harare Institute of Technology, Harare, Zimbabwe

Abstract. Hospital-acquired infections (HAIs) remain a major challenge to patient safety and healthcare efficiency. This project presents the design and implementation of an autonomous disinfection robot equipped with a 6-degree-of-freedom robotic arm for precision sanitization in healthcare environments. The robot integrates a LiDAR-based SLAM system for navigation, mecanum wheels for omnidirectional mobility, and an electrostatic spray system for targeted disinfection. A database-linked user interface allows authorized personnel to monitor, schedule, and control disinfection processes remotely. Simulation and prototype results confirm that the system effectively maps environments, avoids obstacles, and performs adaptive surface cleaning with minimal human intervention.

Keywords: autonomous robotics, disinfection robot, SLAM, mecanum wheels, robotic arm, hospital sanitation.

Correspondence address: Doubt Simango, Chinhoyi University of Technology
e-mail: dsimango@cut.ac.zw

Introduction. Hospital-acquired infections affect millions annually, posing serious risks to both patients and healthcare workers (CDC, 2024). Manual disinfection methods often lack consistency and fail to reach concealed surfaces. Robotics, coupled with UV-C or electrostatic disinfection, offers improved efficiency and reduced human exposure (WHO, 2020).

This project develops an autonomous robot capable of navigating hospital rooms, identifying contaminated zones, and executing targeted disinfection using an articulated robotic arm. Unlike conventional fixed-spray robots, the proposed system reaches under beds and around complex medical setups with enhanced precision.

Methodology.

1. Mechanical Design.

The mobile platform employs mecanum wheels, providing full 360° mobility for maneuvering in tight hospital spaces. A 6-DOF robotic arm, driven by Dynamixel servos, performs surface-level disinfection with accurate motion via inverse kinematics. The frame uses carbon fiber polymer for reduced weight and rigidity.

2. Sensor and Control System.

The system integrates LiDAR for obstacle detection and SLAM for real-time mapping and localization. An onboard microcontroller (Arduino Mega) manages motion planning and sensor data. A* path planning ensures optimal trajectory between rooms.

3. Disinfection System.

A diaphragm pump drives disinfectant to an electrostatic nozzle, producing uniformly charged droplets (40–80 μm) that adhere to surfaces, maximizing coverage while minimizing chemical waste.

4. Database and User Interface.

The UI allows hospital staff to log room occupancy and monitor the robot's status. The Room Status and Users tables manage disinfection scheduling and system access. Only authorized personnel can activate or halt the robot's operation, ensuring safety compliance.

Results and Discussion. Simulation and testing were performed in CoppeliaSim and MATLAB. The robot successfully generated a 3D environmental map using LiDAR and autonomously planned paths around obstacles. Inverse kinematics ensured smooth arm movement, maintaining reachability while avoiding collisions.

Trajectory control results showed minimal position and orientation errors, confirming accurate navigation. The database interface functioned effectively – automatically initiating disinfection in empty rooms and restricting access during occupancy.

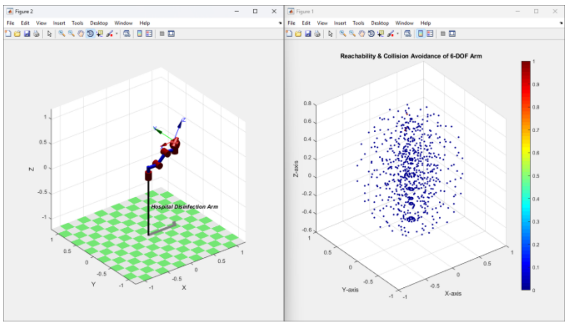

Figure 1 – Reachability and Collision Avoidance of the Robotic Arm

These outcomes demonstrate the system's potential to complement hospital cleaning operations, reduce infection transmission, and enhance sanitation efficiency through autonomous operation.

Conclusion. The autonomous disinfection robot represents a major advancement in hospital hygiene management. By combining AI-based navigation, robotic arm precision, and user-integrated control, it minimizes human exposure to pathogens and ensures consistent cleaning standards. Future work will focus on integrating AI pathogen detection and real-time environmental feedback for adaptive disinfection.

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UDC 681

DESIGN AND PROTOTYPING OF A LOW- COST MYOELECTRIC-CONTROLLED PROSTHETIC HAND

Muchena M., Pondani T., Amos F., Chireshe H.

Harare Institute of Technology, Harare, Zimbabwe

Abstract. Upper-limb amputations present a significant barrier to independence, especially in developing regions where advanced prosthetic technologies are either unavailable or prohibitively expensive. This project addresses that gap by designing and implementing a low-cost prosthetic hand controlled through surface electromyographic (sEMG) signals. A single Advancer Technologies Muscle Sensor v3 was used to capture electrical activity from the flexor digitorum profundus muscle in the forearm. The analog signals were processed by an ATmega328P microcontroller using real-time filtering and threshold logic to control servo motors corresponding to finger movement. A custom-assembled printed circuit board (PCB) integrated all electronic components, and the physical hand was fabricated from lightweight PVC and aluminium, ensuring low cost and mechanical durability. The final prototype demonstrated that EMG-based systems can be a practical and replicable solution for upper-limb amputees, particularly in low-resource settings such as Zimbabwe.

Keywords: prosthetics, electromyography (EMG), servo actuation, upper-limb rehabilitation, affordable assistive technology.

Correspondence address: Taurayi Pondani, Harare Institute of Technology
email: tpondani@hit.ac.zw

Introduction. Myoelectric prosthetic hands translate electrical activity from muscles into finger movements, offering improved functionality for amputees compared to conventional devices [1; 2]. Commercial systems, such as Otto Bock and Touch Bionics, achieve high accuracy but are often costly and inaccessible in low-resource settings [3]. Low-cost EMG sensors, such as the Advancer Technologies Muscle Sensor v3, provide a practical alternative for affordable prosthetic control, though they face limitations in durability and signal quality [4–6]. Implementation challenges of advanced prosthetics in regions such as Sub-Saharan Africa include cost, maintenance, and training requirements [7]. The work presents a cost-effective, single-channel EMG-controlled prosthetic hand, integrating hardware, firmware, and mechanical design to achieve basic yet reliable multi-finger motions suitable for low-resource environments.

Literature review. Prosthetic hand design has progressed from body-powered mechanical devices to myoelectric systems that use surface EMG to translate muscle activity into actuator motion [1–3]. Advances in digital signal processing and pattern recognition have enabled proportional and more natural control, but commercial systems remain expensive and hard to maintain in low-resource settings [3; 7]. Recent work and reviews show that low-cost approaches using microcontrollers (e. g., ATmega328P) and affordable sensors (e. g., the Muscle Sensor v3) can deliver reliable, simplified control suitable for developing regions such as Zimbabwe [4–9].

System design and methodology.

A. System Overview.

The ATmega328P microcontroller acquires EMG signals from the forearm to control five servo-driven fingers. Signals are sampled, filtered, and classified into rest, partial flexion, or full flexion. Each gesture is validated across multiple readings to prevent false activation, while LEDs indicate system status.

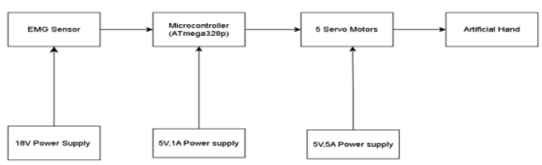

Figure 1 – Block Diagram