Design, Construction, and Testing of a Low-Cost Autonomous Robotic System for Household Cleaning Tasks

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Abstract

The demand for household cleaning robots has surged, driven by the increasing need for convenience and efficiency in performing routine cleaning tasks. However, the high cost of existing autonomous cleaning systems poses a significant barrier to widespread adoption. This paper presents the design, construction, and testing of a low-cost autonomous robotic system specifically tailored for household cleaning tasks. Utilizing off-the-shelf components and open-source software, the proposed system aims to provide an affordable, yet effective solution for automated floor cleaning. The robot features a modular design for easy maintenance and upgrade, incorporates sensors for obstacle avoidance and path planning, and uses a simple, efficient cleaning mechanism. Through a series of tests conducted in various household environments, the robot demonstrated effective cleaning capabilities, efficient battery usage, and robust obstacle navigation. This study contributes to the field by offering a viable alternative to expensive commercial cleaning robots, making autonomous cleaning technology accessible to a broader audience.

Background

The evolution of robotic technology has led to significant advancements in autonomous systems capable of performing household tasks, with cleaning robots being among the most popular and practical applications. Despite their benefits, the high cost of these systems limits their accessibility. Addressing this gap, our research focuses on the development of a cost-effective autonomous robotic system designed to perform basic household cleaning tasks such as sweeping and vacuuming. The system combines affordability with functionality, leveraging low-cost components and efficient software algorithms to navigate and clean effectively.

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Main Findings

1. **Design Principles**: The robot was designed with simplicity, modularity, and cost-effectiveness in mind. It features a compact, lightweight frame constructed from affordable materials, and modular components that can be easily replaced or upgraded.
2. **Construction**: Utilizing readily available components, including low-cost microcontrollers, motors, and sensors, the construction process emphasizes the use of open-source hardware and software to minimize costs. The cleaning mechanism relies on simple, yet effective brushes and a suction system to ensure thorough cleaning.
3. **Navigation and Control**: The robotic system employs a combination of ultrasonic and infrared sensors for obstacle detection and avoidance, enabling it to navigate complex household environments. A basic path-planning algorithm allows the robot to cover the maximum area without repeated cleaning.
4. **Testing and Evaluation**: Extensive testing in various household settings demonstrated the robot's effectiveness in removing dust and debris from hard floors and carpets. Battery life tests confirmed the efficiency of the power management system, allowing for extended cleaning sessions. User feedback highlighted the robot's ease of use and maintenance.
5. **Challenges and Limitations**: While the robot successfully met its design goals, challenges such as navigating tight spaces and transitioning between different floor types were identified. Future work will focus on improving the navigation algorithm and exploring more efficient cleaning mechanisms.

Conclusion

This research presents a significant step towards making autonomous cleaning technology more accessible by demonstrating that a low-cost robotic system can effectively perform household cleaning tasks. The design, construction, and testing of the robot highlight the potential for open-

source components and software to reduce costs without compromising on functionality. By addressing the financial barrier to entry, this work paves the way for broader adoption of autonomous cleaning solutions in homes. Future developments will aim to enhance the robot's capabilities, including improved navigation, efficiency, and user interaction, further bridging the gap between high-cost commercial models and the needs of the average consumer.

References

[1] S. Khanna and S. Srivastava, "The Emergence of AI based Autonomous UV Disinfection Robots in Pandemic Response and Hygiene Maintenance," *International Journal of Applied Health Care Analytics*, vol. 7, no. 11, pp. 1–19, Nov. 2022.

[2] S. Khanna and S. Srivastava, "Human-Robot Collaboration in Cleaning Applications: Methods, Limitations, and Proposed Solutions," *Eigenpub Review of Science and Technology*, vol. 6, no. 1, pp. 52–74, Oct. 2022.

[3] S. Khanna and S. Srivastava, "Path Planning and Obstacle Avoidance in Dynamic Environments for Cleaning Robots," *Quarterly Journal of Emerging Technologies and Innovations*, vol. 8, no. 2, pp. 48–61, 2023.