# Innovative Experiment for Electronic Systems - Design of Intelligent Disinfection Robot

Zhiying Yu*, Chang Liu, Lina Zhou

Dalian Maritime University, Dalian 116026, China

*Corresponding author: merry@dlmu.edu.cn

**Abstract.** In order to cultivate applied undergraduate talents with innovative abilities, an innovative experimental project for electronic systems has been designed. This experimental project has changed the current situation of designing only microcontroller systems. It Integrates ROS robot operating system, IoT technology, and emerging artificial intelligence technologies. This is an intelligent home disinfection robot experimental project based on ROS operating system. It has functions such as indoor disinfection, bed mite removal, human body disinfection, and storage disinfection. You can also use a mobile APP to control the machine to perform tasks with just one click. The intelligence, visualization, and transparency of household integrated disinfection robots have been achieved. This project is closely related to practical life applications, integrating multiple knowledge points and easily stimulating students' creative interest. The hierarchical design of experimental tasks has improved students' ability to solve practical problems and innovate experiments to varying degrees, and the teaching effect is good.

**Keywords:** Problem Solving Ability; Innovation Ability; ROS Operating System; Intelligent Disinfection Robot.

## 1 Introduction

The new engineering disciplines have put forward high requirements for the cultivation of students' comprehensive qualities. In order to better serve society and cultivate applied talents who meet the needs. We need to keep up with the pace of the times, continuously introduce current hot application projects into practical teaching, and cultivate students' innovation and engineering application abilities [1-3].

After the outbreak of the COVID-19 in 2020, not only the demand for disinfection equipment in medical institutions increased sharply, but also the demand of public families. This has brought benefits to the disinfection product industry. The demand for disinfection products accompanies medical and subsequent home disinfection for a long time. The epidemic has awakened public awareness of health consumption, and the popularity of intelligent disinfection products has greatly increased. The demand for products in the market is constantly increasing. Intelligent disinfection products have become essential items for home use.


D. Hu et al. (eds.), *Proceedings of the 2024 5th International Conference on Modern Education and Information Management (ICMEIM 2024)*, Atlantis Highlights in Social Sciences, Education and Humanities 29,
https://doi.org/10.2991/978-94-6463-568-3_55

At present, most household intelligent disinfection robots use long-term repeated spraying of disinfectant water and continuous strong irradiation of purple light disinfection lamps to automate disinfection according to predetermined paths. Due to its single functionality, high cost, and high error rate, it is difficult to enter thousands of households, let alone meet the needs of daily epidemic prevention and diversified disinfection and sterilization for home use.

In order to closely connect with real-life situations and based on market demand and practicality, the design project of intelligent disinfection robots is introduced into the innovative design experiment of electronic systems. This article designs an intelligent home integrated disinfection robot based on ROS operating system. Let students design specific application cases in their daily lives during experiments and apply what they have learned. This can effectively stimulate students' interest in learning and creativity, improve their subjective initiative, exercise their practical abilities, and enhance teaching effectiveness [1-3].

## 2 Experiment Overall System Structure

The structure diagram of the intelligent disinfection robot is shown in Figure 1. The main control adopts Jetson Nano, and the main control is externally connected to the expansion board through a ribbon cable. The expansion board integrates a microcontroller, which mainly manages the component drivers on the expansion board. The driving content includes: robotic arm, buzzer, six axis attitude sensor, PWM servo gimbal, LED searchlight, motor, etc. The microcontroller and Jetson Nano communicate through a serial port. The microcontroller will respond accordingly when receiving serial port information. The expansion board contains multiple IO interfaces, power output, and OLED interfaces.

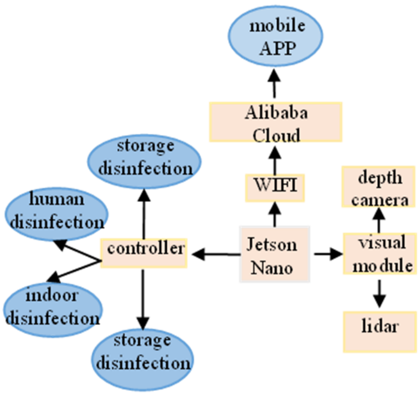


**Fig. 1.** Overall system structure diagram.

The control module is connected by an expansion board, and by configuring a motor interface, the motor is driven in both forward and reverse directions to achieve smooth operation of the robot track base. The main control operates the serial bus and controls steering engine. It reads three steering engine angles at once and controls the mechanical arm to move up, down, left, and right. The expansion board connects IO communication and controls various disinfection functions. The visual module uses depth cameras and lidar to transmit data through internal communication of Jetson Nano. Using OPENCV for calibration and image processing to achieve visual communication. By connecting to the Alibaba Cloud platform, Jetson Nano's internal WIFI module receives commands to the cloud, enabling the mobile APP to control the robot's operation. And regularly push disinfection reminders based on data to improve the disinfection system.

## 3 Experiment Functional Design and Implementation

Based on market demand and practicality, design an intelligent home integrated disinfection robot based on ROS operating system. It can achieve storage disinfection, indoor disinfection, and human disinfection functions, and can also achieve APP cloud control.

### 3.1 Basic Function - Storage Disinfection Design

The robot is equipped with a disinfection chamber, which can disinfect personal items. The disinfection chamber is equipped with ultraviolet lighting fixtures. Intelligently control the turn on and turn off of the purple light to achieve the effect of effective disinfection, regular disinfection and sterilization and easy access. An infrared detection module is installed at the top of the disinfection chamber to detect if there is any obstruction within ten centimeters and to switch the disinfection chamber on and off. When the human body comes into contact with the disinfection chamber at a distance of ten centimeters, the steering engine is automatically controlled to rotate and open the chamber door. After the person takes away the item, the infrared detects that there is no obstruction within ten centimeters of the top for five seconds, and the warehouse door automatically closes.

### 3.2 Expanded Function - Human Disinfection

Convey instructions to the Nano controller and call the Astra depth camera. Use Astra related API to obtain camera image data and depth point cloud information data. Implement window display using OpenCV. Combining dense optical flow, Kalman filtering Meanshift and Camshift, Multi object tracking and search algorithms detect multiple images in each frame. By running a tracking and search algorithm, human leg tracking [4, 10] can be achieved to achieve target recognition. Figure 2 shows the overall structural design of human disinfection.

The depth camera system collects scene image information, and through effective information extraction and feature detection, identifies the target object and obtains its initial position and pose. Due to the real-time motion of the target, stereo vision is also collecting image information in real-time. The robot controller adjusts the posture of the actuator during the motion process based on the posture of the moving target object. Realize the tracking of human legs by robotic arms.

Based on the above process, the Lucas Kanade algorithm is added and a Kalman filter is used to estimate the motion state of the moving target. To improve the accuracy of the predicted values, the Lucas Kanade algorithm is used to optimize the parameters of the Kalman state vector and observation vector, enhancing the system's ability to estimate the target's motion state at the next moment [9].

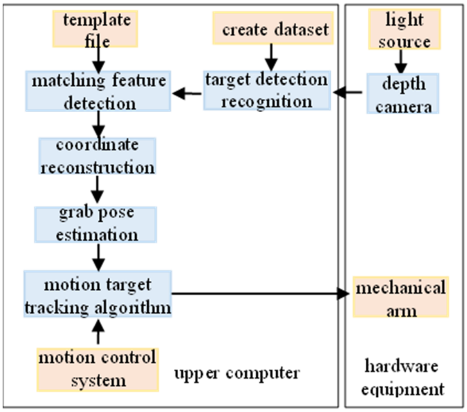


**Fig. 2.** Overall identification structure design.

### 3.3 Expand Function - Indoor Disinfection

By transmitting instructions to the Nano controller and calling the Astra depth camera, it can automatically recognize objects and avoid obstacles. Place three disinfection control nozzles on both sides of the intelligent disinfection chamber and at the front end of the robotic arm. At startup, the main controller Nano controls the expansion board IO port to enable and disable the nozzle. And it keeps synchronized with the robot movement in real time, that is, the robot does disinfection and sterilization when it moves, and does not disinfection and sterilization when it stops.

For commonly used positioning systems, such as GPS, when performing tasks indoors or encountering obstacles, problems such as inaccurate positioning and failure to recognize the location of the area may occur, making it impossible for the machine to move to the destination. To address this issue, SLAM laser mapping using ROS system was employed. According to the SLAMTEC radar triangulation principle, the distance between an object and the baseline is measured by the displacement distance of the light spot. Implement map construction using Gmapping algorithm [5-8]. Gmapping is a particle filtering algorithm based on RBPF, which separates the localization and mapping processes and performs localization before mapping. Construct a map algorithm by occupying grids (grids). In actual indoor disinfection mapping navigation, Gmapping divides the surrounding environment into grids and constructs maps based on its state, which can reduce computational pressure and achieve high accuracy.

In actual indoor accuracy measurement indicators, software evaluation methods are used and cartographer tools are borrowed. The cartographer uses the idea of graph optimization, which leads to the existence of loops in the cartographer, and each loop is actually a calibration of accuracy. The pose relationship metric proposed in this evaluation allows the cartographer to generate ground truth from trajectories with closed loops. Use the optimized trajectory with closed-loop detection as the input for ground truth generation. The absolute translation error of the disinfection robot indoors is around 0.01944+/-0.01819 m, and the accuracy is completely suitable for household scenarios. In household situations, improving algorithms can enhance accuracy and precision under smart home conditions, significantly improving detection performance.

Obstacle avoidance uses laser radar. The SLAMTEC laser radar is mainly composed of four core components: laser, receiver, signal processing unit, and rotating mechanism. The laser is the laser emitting mechanism in the laser radar. During the working process, it will light up in a pulsed manner. The signal processing unit is responsible for controlling the emission of the laser and processing the signals received by the receiver. Calculate the distance information of the target object based on this information. Triangle ranging method, TOF time-of-flight ranging method, etc. are used in the principle of single line lidar.

## 4 Implementation in Experimental Teaching

In experimental teaching, in order to meet the personalized needs of students with different abilities, a hierarchical teaching design is adopted. The basic functional requirement is that the storage disinfection compartment door automatically senses personnel, opens the compartment door cover automatically, and disinfects the items inside the compartment. This section requires students to complete. Students can freely choose to implement one of the expanded functions. Such as human tracking disinfection, indoor disinfection, or custom functions. Interested students can also develop mobile APP features. Implement mobile APP to control robot operation and regularly push disinfection reminders.

During the experiment, students had a strong interest in the experiment and designed works with rich functions. Student works have different implementation methods and diverse functions. Satisfied the ability cultivation needs of students at different levels, improved their hands-on practical ability, and achieved significant teaching results. This has laid a solid foundation for students' academic competitions such as integrated circuit design competitions, computer design competitions, and electronic design competitions.

## 5 Conclusions

Closely integrated with engineering practice and based on intelligent living, this article designs an intelligent disinfection robot project and applies it to innovative design experiments of electronic systems. Students need to comprehensively apply knowledge related to motors, infrared sensors, microcontrollers, lidar, etc. to design and make intelligent disinfection robots. The experiment is student-centered, and the entire process of product design and development is independently completed, with the teacher only playing an auxiliary and guiding role. Students in the experiment can freely choose the required devices and modules. Encourage students to freely explore and design extended functions based on their hobbies while completing basic functions. This greatly develops students' innovative thinking. The experimental content is moderate in difficulty and easy to carry out in practice. The experimental projects are closely related to real-life situations, greatly enhancing students' interest in experiments and their ability to solve real-life problems, resulting in good teaching effectiveness. The student's innovation project based on this background was awarded a national level project and concluded with excellence.

## Acknowledgments

Fund Projects: 2024 Dalian Maritime University Teaching Reform Project (BJG-C2024038, BJG-C2024032, BJG-C2024035); 2023 Ministry of Education Industry School Cooperation Collaborative Education Project (230704988134313).

## References

1. CUI Chengyi, CHEN Jing, GAO Qinghua: Design of Intelligent Window in Integrated Design Experiment of MCU. Experimental Technology and Management 37(9),71-74(2020).
2. Chengyi Cui: Design of Single Chip Microcomputer Control System Based on Ability Training. Research and exploration in laboratory 37(9), 143-146 (2018).
3. Chengyi Cui: Design of Single Chip Microcomputer Control System Based on Ability Training, Research and Exploration in Laboratory37(9), 143-146(2018).
4. Ronneberger, Olaf, Philipp Fischer, and Thomas Brox: "U-net: Convolutional Networks for Biomedical Image Segmentation." In International Conference on Medical Image Computing and Computer-assisted Intervention, pp. 234-241. Springer, Cham (2015).
5. TIAN Ye, CHEN Hongwei, WANG Fasheng: Overview of SLAM Algorithms for Mobile Robot. Computer Science 48(9), 223-234(2021).
6. SHI Jingjing, REN Mingrong, WANG Pu, MENG Juan: Research on PF-SLAM Indoor Pedestrian Localization Algorithm Based on Feature Point Map. Micromachines (2018).
7. M. V. Dileep, S Kamath, VG Nair: Ascent Phase Trajectory Optimization of Launch Vehicle Using Theta-Particle Swarm Optimization with Different Thrust Scenarios. International Review of Aerospace Engineering (2016）.
8. LIU Yi: Improvement and Application Research of Particle Swarm Optimization Algorithm. Xi'an University of Electronic Science and Technology (2014).
9. Y. N. Wang, J. N. Zhou: A Lucas-Kanade Moving Object Detection Algorithm Based on Gaussian Mixture Background Modelling. 2014 International Conference on Civil, Urban and Environmental Engineering (CUEE2014).
10. MZ Alom,M Hasan, C Yakopcic, Tarek M. Taha, and Vijayan K. Asari. Recurrent Residual Convolutional Neural Network Based on U-net (r2u-net) for Medical Image Segmentation. arXiv:1802.06955 (2018).