

# Research and Design of a Novel Hygiene Protection Handrail Based on Pyroelectric Infrared Sensing

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**Abstract:** This article focuses on the widespread prevention of public health incidents and the promotion of smart cities, proposing a low-cost and widely accessible intelligent health protection railing based on pyroelectric infrared sensing. The railing consists of three main components: power supply, monitoring, and operation. In terms of power supply, the intelligent railing can be divided into solar-powered and electric-powered types depending on its usage. The monitoring part is mainly composed of pyroelectric infrared sensors, which constantly monitor the movement of individuals to determine whether to activate the ultraviolet disinfection function. The core of the operation part is the design of ultraviolet disinfection. When the sensors detect human movement, the railing automatically activates the ultraviolet disinfection function. These three components are organically integrated into the railing body and controlled by a 51 microcontroller. The various power supply options, strong applicability, high safety, and superior effectiveness of ultraviolet disinfection complement each other, making the railing widely applicable and highly functional. The design of this new type of health protection railing, with the advantages of low cost, high efficiency, and broad applicability, allows the general public to complete disinfection and protection without affecting their normal behavior, thus serving the purpose of preventing public health incidents and assisting in the advancement of smart cities.

**Key words:** multifunctional integration; intelligent railing; smart city; 51 microcontroller; health protection

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## 1. Introduction

Once a public health incident occurs, it will cause widespread and long-lasting issues related to people's safety and social damage. The accompanying problems include unemployment, price hikes, and economic difficulties, greatly affecting the quality of life for the entire population and the country's development. In response to this issue, we have decided to propose a widely applicable disinfection handrail that aims to enhance hygiene protection effectively. This handrail can adapt to different geographical environments and usage scenarios, while providing convenience. It ensures completion of disinfection protection without causing inconvenience to the flow of people. In summary, this disinfection handrail is designed to address the safety issues and societal risks caused by public health incidents. Additionally, it helps alleviate problems such as unemployment, price increases, and economic challenges. Ultimately, it significantly improves the quality of life for the entire population and contributes to the country's development.

## 2. Research Background

Initially, handrails were primarily used for defense against external enemies and safety protection. In the 1990s, modern-style handrails were introduced. In the early stages, the industry had outdated equipment, processes, low efficiency, and low product quality. With the introduction of technology and equipment in the handrail industry, there has been a significant improvement in overall standards. Regarding public health incidents, the commonly adopted hygiene protection method is to use various types of hand sanitizers, such as hand sanitizing alcohol, to achieve disinfection through hand washing. It is particularly important to pay attention to protection in areas with high human traffic. However, in crowded places such as bus stops and pedestrian bridges, disinfection and sterilization items are often not provided, and the impact of high footfall makes it difficult for people to have suitable conditions and opportunities for hand washing. Therefore, the development of a new type of handrail that is fast, convenient, adaptable, and widely applicable becomes an essential requirement.

### 3. Device Design Principle

This new type of handrail can be divided into four parts based on its working effectiveness: the handrail body, power supply device, infrared monitoring device, and disinfection device. The material and appearance of the handrail body can be similar to traditional handrails, with small gaps incorporated into the structure. The design of the power supply device can vary depending on the application scenario. For instance, at bus stops, solar energy or geothermal energy can be used as the energy source. The infrared device is positioned between the outer and inner layers of the handrail. When someone holds onto the handrail, the infrared device detects the contact and triggers the ultraviolet disinfection device to start working. All four components are organically integrated using a 51 microcontroller. The diagram below illustrates the working principle of the device (using geothermal energy as an example).

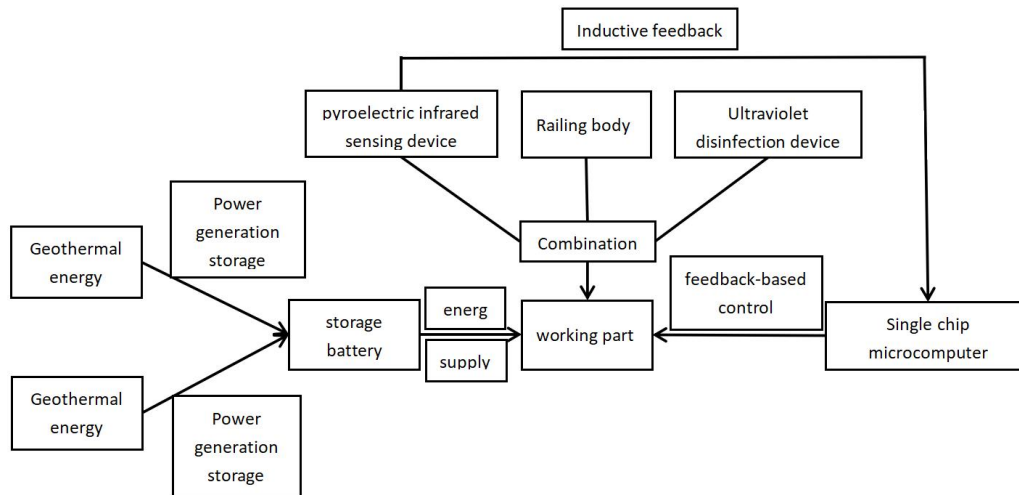


Figure 1. Functional principle.

### 4. Functional Design

#### 4.1 Wide range of energy sources

Due to the wide applicability of the new type of handrail compared to conventional handrails, it can be designed with different energy supply methods to adapt to various installation locations. Therefore, it possesses strong popularization potential. The primary energy supply methods include geothermal energy, solar energy, and other non-polluting sources. These sources of energy do not emit harmful substances such as carbon dioxide during usage, thereby enhancing the safety and reliability of the new handrail design<sup>[1]</sup>. This aligns with the national energy policy on low-carbon emissions reduction.

Based on the statistical data presented in the figure, it is evident that each province in China receives abundant solar radiation annually, far exceeding the amount we currently harness<sup>[2]</sup>. Therefore, the utilization of solar energy and geothermal energy in the operation of the new type of handrail improves energy efficiency and increases social benefits at a low cost.

#### 4.2 Ultraviolet disinfection function

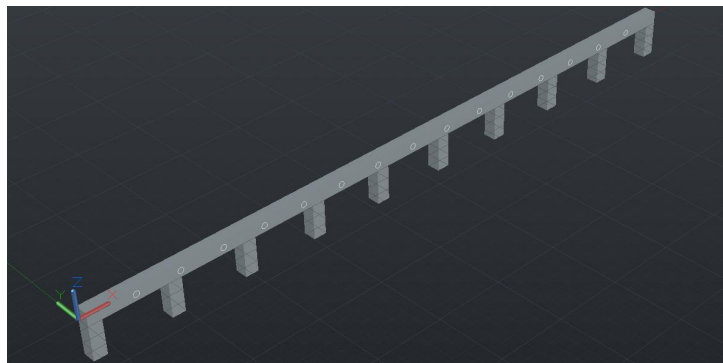
The main new feature added by the new type of handrail is the ultraviolet (UV) disinfection function. The UV disinfection method used by the new type of handrail has advantages, especially in crowded areas. The disinfection function is located inside the handrail. When pedestrians pass by, they only need to hold onto the handrail. The infrared sensors detect this contact and send feedback to the microcontroller. Then, the gate opens, and the UV section starts working. By controlling the intensity and duration of the released UV light, it can be made safe and beneficial<sup>[3]</sup>. This increases the efficiency and popularity of hygiene control measures<sup>[4]</sup>. The infrared sensor detection circuit is used to determine whether there are pedestrians passing by, which utilizes the E18-D80NK infrared obstacle avoidance sensor, and integrates transmission and reception in one pyroelectric infrared sensor<sup>[5]</sup>. The detection distance can be adjusted according to requirements.

#### 4.3 Smart city development

The development of smart cities aims to improve the quality of life for citizens and optimize the ecological environment. Innovation, coordination, greenness, openness, and sharing are its main characteristics. As ubiquitous elements in our daily living environment, handrails must keep pace with and contribute to the rapid construction of smart cities. The new type of hygienic and protective handrail innovatively integrates hygiene and disease prevention into a widely accessible and environmentally friendly solution. The folding structure of the handrail ensures efficient use of space, making it cost-effective, convenient for transportation, and highly efficient. This greatly reduces the challenges associated with mass disinfection efforts and promotes the development of smart cities. By incorporating the new type of handrail into the smart city infrastructure, its benefits are not limited to promoting hygiene, but also contribute to achieving the overall goals of innovation, sustainability, and convenience in urban development. The integration of this technology enhances public health, safety, and well-being while supporting the efficient and sustainable growth of smart cities.

### 5. Physical Design

In terms of physical design, the system can be divided into two main components: software and hardware. The software component consists of the Keil5 code embedded in the 51 microcontroller. The hardware component, on the other hand, can be further divided into three parts: the power supply section, the functional section, and the handrail body. These three parts are organically integrated to form the new type of handrail, presenting an intelligent control system for the UV disinfection function based on the microcontroller's monitoring results.



**Figure 2.** Three-dimensional render of the handrail.

## 5.1 Overall planning

For the three hardware components, we have adopted a modular design approach for combination. The power supply section includes two options: solar energy generation and geothermal energy generation, depending on local conditions. The handrail body features a folding structure with a hollow interior, perforations on the surface, and gate flaps. The UV disinfection section consists of the functional part and the pyroelectric infrared monitoring part. The pyroelectric infrared sensors are placed at regular intervals behind the perforations of the handrail body, while the UV disinfection device is positioned behind each gate.

## 5.2 Software design

This device utilizes Keil5 to write the code that implements its functionalities and embeds it into the 51 microcontroller. The system uses pyroelectric infrared sensors to monitor if there are pedestrians passing by. When detected, the infrared radiation received through the Fresnel lens is converted into an electrical signal and fed back to the control hub microcontroller. The microcontroller processes the signal within its own program, opens the gate flap, and activates the UV disinfection section. After reaching the time threshold, the UV disinfection device and the gate flap are closed. The following is a simulation design:

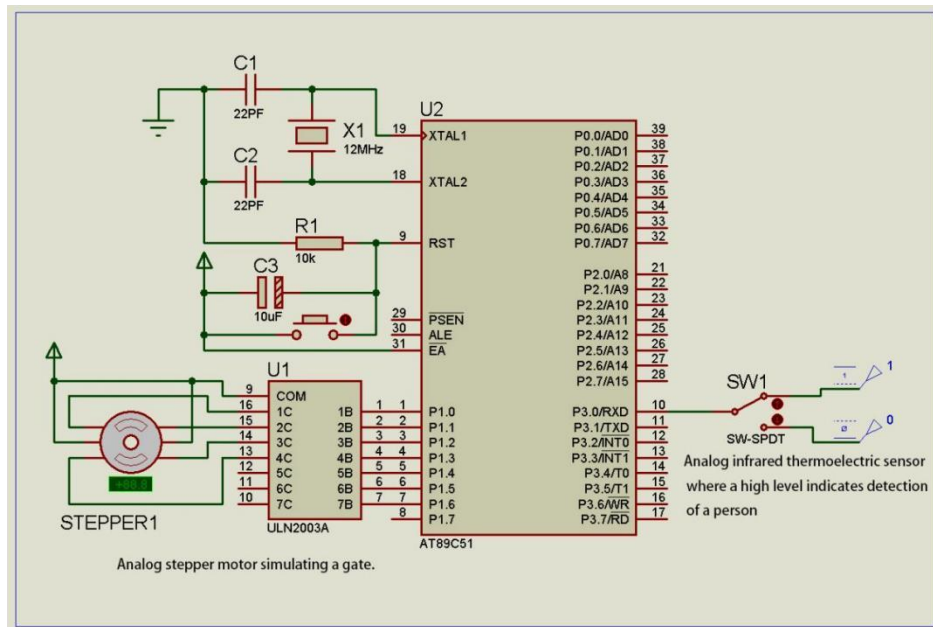


Figure 3. Proteus simulation design.

## 6. Application Prospects

This new type of handrail can provide an additional layer of security for people's travel safety at a low cost, while achieving widespread disinfection without causing any inconvenience to pedestrians. With further research and development, the energy consumption, safety, and functionality of this handrail are expected to evolve in a more advanced direction. In an era where hygiene and prevention measures are increasingly important, this device can demonstrate even more remarkable benefits.

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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