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Remote Environment Exploration and Measurement Technique via Transmission of Real-Time Video

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Abstract This study intends to use remote control technology to conduct environment exploration and create a measurement tool that can effectively protect measurement personnel from harm caused by negative environmental factors. In a detected environment, there are various negative environmental factors, such as radioactive rays, gases, or other unknown factors, thus, the safety of traditional manual detection is a concern. This study proposed a mobile exploration tool for solving the above problem. The tool integrates a smart system, a 4G network, WIFI transmission, a radiation sensor circuit, and a wireless IP camera. The concept of remote control cars is used for design and manufacture. After correction, the overall error rate of the system is 4.2%. The proposed tool can realize cross-regional control and provide an unmanned omnibearing tool for preliminary environment exploration and measurement.

Keywords: *WIFI transmission, radiation detection, remote monitoring, environmental monitoring*

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1. Introduction

In recent years, greater attention has been paid to radiation issues; for example, Japan's Fukushima nuclear accident caused global fear regarding nuclear energy. Thus, there is opposition to nuclear energy in Taiwan. In recent years, Taiwan has often faced power supply shortages. Currently, coal products, oil, and natural gas are mainly for power generation in Taiwan. The costs for such power generation are increased due to the scarcity of materials, and the carbon dioxide pollution emitted from power generation is not in line with the consensus of global environmental protection. In contrast, the unit cost of nuclear power generation is much lower than that of other types of power generation, and there is no concern about resource shortages. During nuclear power generation, no carbon dioxide is emitted. Nuclear power generation features high efficiency and low air pollution. When the high cost of power generation and power supply shortages are reflected in electricity fares and daily necessities, society may once again consider nuclear power. When this occurs, various imported radioactive minerals shall be properly stored and monitored, and the public will require further relevant radiation knowledge to take protection measures.

WIFI transmission technology is difficult to achieve cross-regional operation. If the characteristics of monitored objects, such as long distance and high hazard radioactive rays, which must be detected, the distance provided by common WIFI transmission technology cannot protect measurement personnel from the harm of negative environmental factors. In consideration of the above, this study develops and manufactures an environment exploration and measurement tool to replace manual measurement.

2. System Architecture

As seen in Figure 1, when a user operates and writes the smart system program, a program command is sent through a WIFI transmission circuit to a Web Server, where the MCU captures the Web Server source command in real-time, and triggers the motor control circuit to make a remote control car move in the direction specified by the user. The environment factor sensor circuit in the remote control car can transmit the sensed changes to the MCU. Then, calculus and ADC are used to convert the pulse frequency or voltage of each sensor into digital values, which are transmitted to a Web Server through WIFI, and captured by the smart system for display by the interface program. In this process, the IP Camera in the tool synchronously returns the video of the field-of-view to the interface program, in order that the user can remotely control the activity.

2.1. Hardware

The proposed system uses radiation sensor components [1,2,3], and a Geiger counter is selected as the radiation sensor component of the system, which is the most common and frequently used gas ionization sensor. In the process, relevant data [4] are referenced. As the sensor is very sensitive to radiation changes in an environment, it is an ideal tool to find and sense the sources of radioactive rays. The circuit designed in the proposed system meets the conditions required by the Geiger counter, and can provide adequate and stable power supply to drive the Geiger counter to work properly.

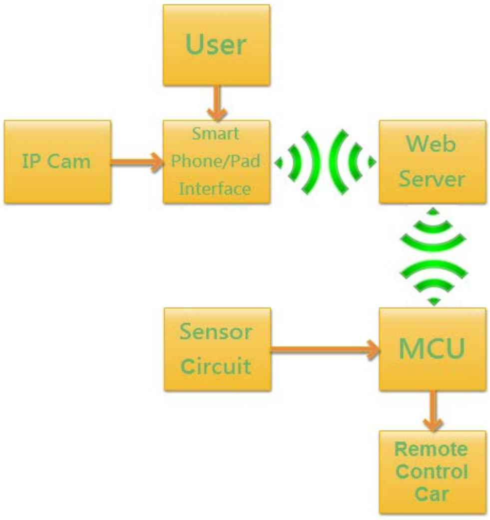

Figure 1. System architecture

The motor control circuit uses two NPN and PNP transistors to construct an H-bridge. MCU is used to control the external output voltage, and high/low output voltage will trigger the H-bridge circuit to control the positive and negative rotation of the motor.

Long-distance transmission settings denote the completion of the initialization of MCU, as well as the wireless transmission modules through UART transmission. The wireless module is connected to a wireless router, which exchanges data with Web Server, in order that the long distance transmission can be completed.

2.2. Firmware

As shown in Figure 2, the timer, the external interruption counter, and the motor are stopped, and remain stationary to avoid damaging the system. When the radiation sensor hardware circuit is activated, the system delays several seconds until the sensor circuit output voltage is stable. The proposed system is preset to convert the pulse frequency of the Geiger counter into a digital value every 60s. This method is used to measure the voltage pulse signal of the Geiger counter to count the pulse number via the MCU external interruption counter, which then synchronously transmits the time and pulse number through wireless transmission to the device specified by the user. If the time of the Geiger counter is returned to zero, the measurement procedure is repeated until completion of the process.

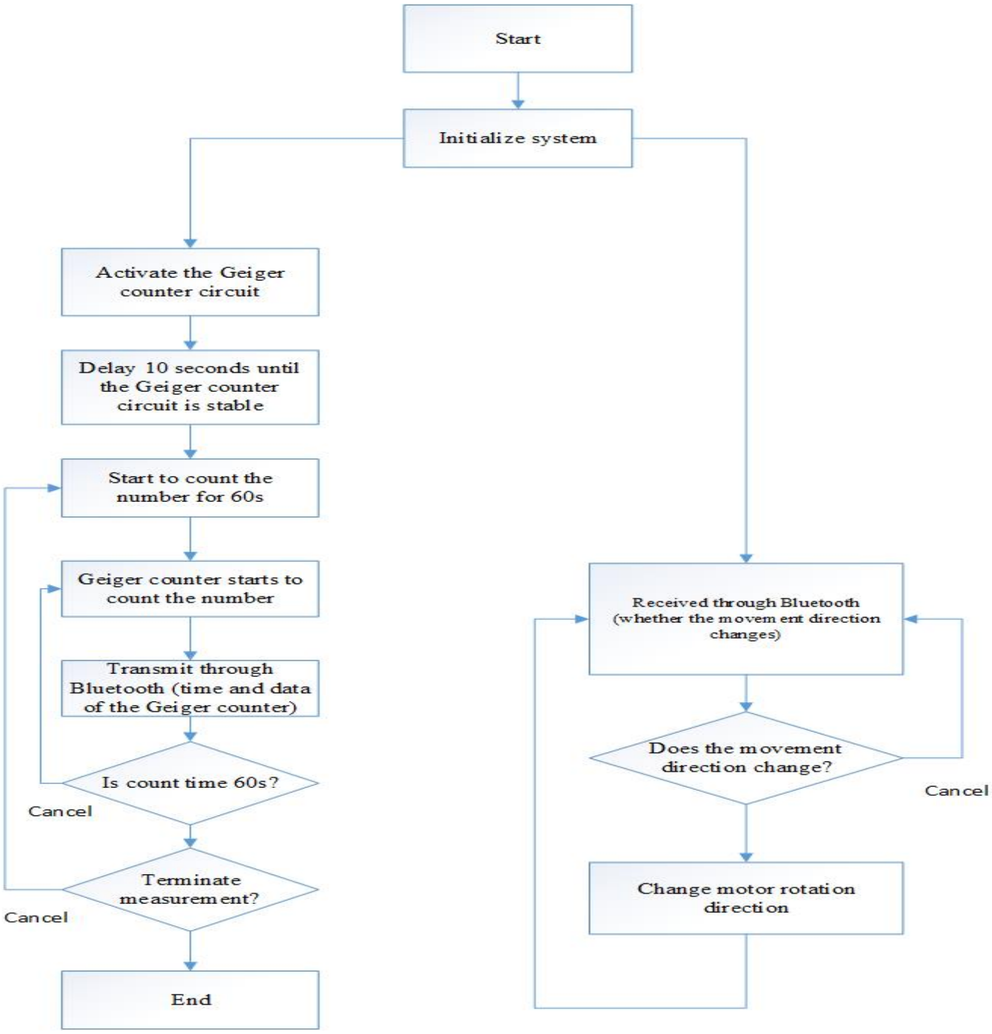

Figure 2. Firmware process

When the wireless transmission module successfully receives the movement direction data from the Web Server, the change in movement state can be identified. When the movement state changes, the state of the motor movement is changed immediately

2.3. Software

As shown in Figure 3, when the IP CAM video streaming address is successfully connected, the smart system device is used to receive and play back video streaming, in order to watch a real-time dynamic video. The proposed system can observe the measurement site and significantly increase the safety of the travel path.

When the wireless transmission is successfully connected to the Web Server, the count time and voltage pulse of the Geiger counter can be obtained, and the smart system device is used for the program algorithm. A mathematical formula is used to calculate the voltage pulse frequency as a relative radiation value (SV) [5]. The count time is displayed by the program interface, and if the radiation sensor circuit senses a radiation level above the predetermined safety limit, an alarm is immediately initiated to alert the user, which achieves both warning and prevention. If the environment radiation measurement position must be moved, the user only has to trigger the system's interface arrow key, and the system will transmit the data of the movement direction, as specified by the user, to the Web Server through WIFI transmission; MCU obtains the movement direction specified by the user through WIFI transmission modules, a wireless router, and a Web Server. The movement direction can be changed by activating the H-bridge circuit to change the movement direction of the car.

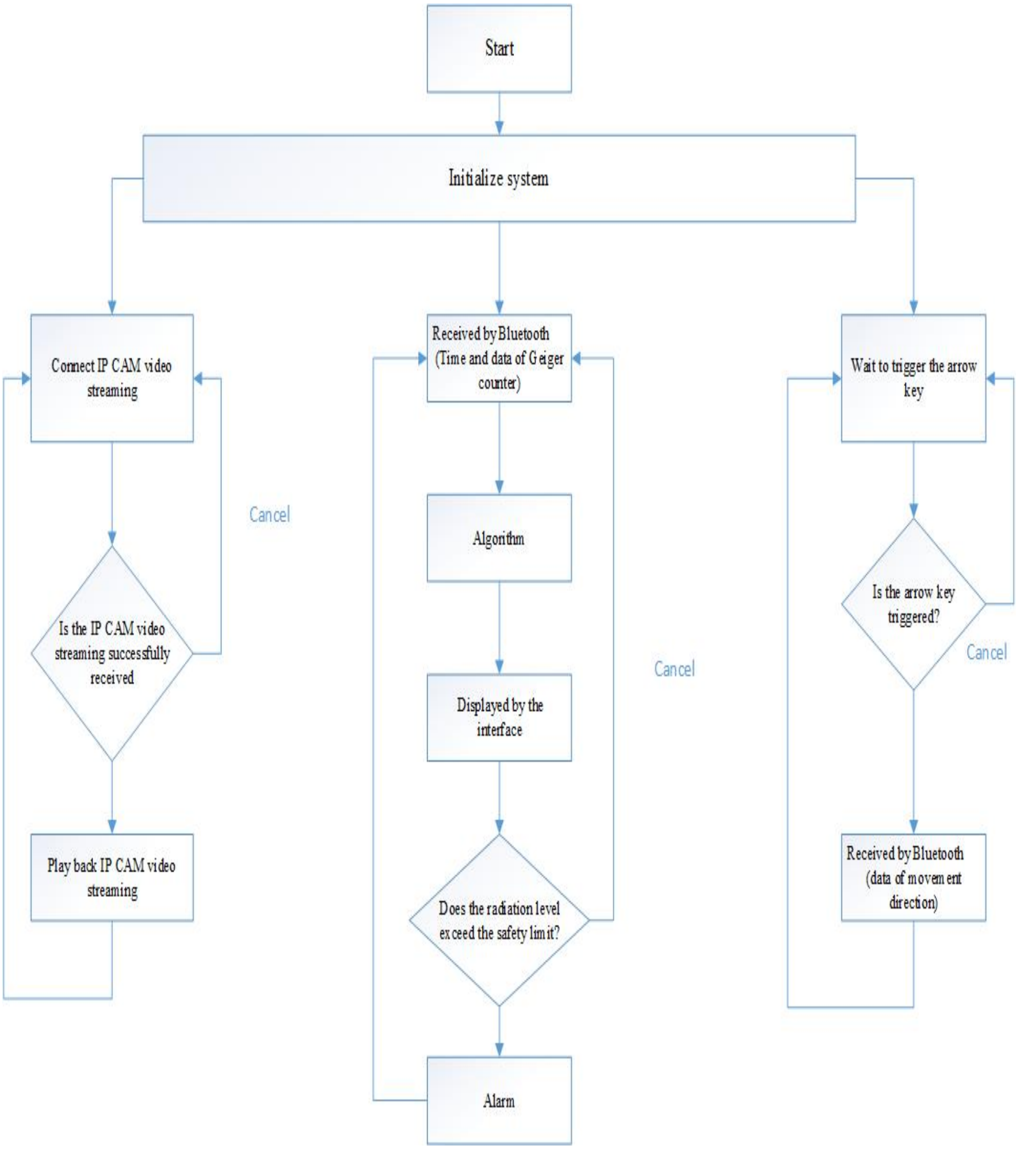

Figure 3. Software process

3. Video Streaming

Video streaming is a real-time video transmission technique that transmits data in segments through the Internet after the compression of a series of videos. This technique does not store the video data on a local PC, but uses a client buffer to store and read the data, which is discarded after the readout. For video streaming, public standards are issued to establish communications protocols, and RTP (Real-Time Transport Protocol) and RTSP (Real-Time Streaming Protocol) are used as the common communication protocols:

1. Real-time transport protocol (RTP)

RTP (Real-time Transport Protocol) is a transport protocol for multimedia data streaming over the Internet. RTP is defined as “one to one” or “one to many” transmission, with the aim of providing time information and synchronized streaming. The upper layer of RTP usually uses UDP to transmit data.

2. Real-time streaming protocol (RTSP)

RTSP (Real Time Streaming Protocol) is used to control voice or video streaming, and allows multicast demand control. During transmission, all network protocols are not within the defined scope. A Web Server can select TCP or UDP to transmit streaming contents, which does not always require time synchronization, thus, it can tolerate network waiting time. In addition to allowing synchronous multicast demand control, Web Server network consumption can be reduced to support video conferencing.

The proposed system can monitor the videos of multiple people at the same time, thus, the IP CAM uses the RTSP protocol. The IP CAM settings are shown in Figure 4, where the IP CAM and wireless router are connected to the Internet through a PC. The VLC Player is used in the real-time video streaming test, as shown in Figure 5. In order to avoid real-time video delay, the quality and size of the video can be adjusted, which can effectively reduce the delay time. When a smart device is used to receive the real-time video, the test framework is shown in Figure 6. RTSP (Real Time Streaming Protocol) streaming is imported by the built-in player software of the smart device, in order to achieve remote video monitoring, as shown in Figure 7.

Figure 4. Architecture for real time streaming received by a PC

Figure 5. VLC Player real-time streaming

Figure 6. Architecture for smart device real-time streaming

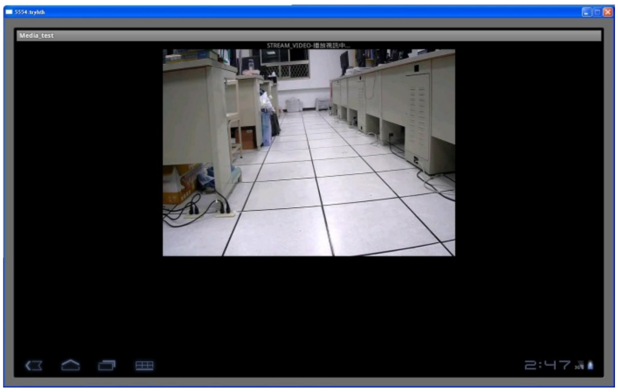

Figure 7. Smart device real time streaming

4. User Interface Design and Measurement Results

As seen in Figure 8, the user can be immediately informed of the environment radiation level, count time, radiation pulse number, and real-time video through the interface. The movement direction of the measurement tool can be remotely controlled by the arrow keys on the program interface, and such real-time video can greatly increase the effectiveness of remote control, as well as the safety of the travel path.

Figure 8. User’s interface

If the measured environmental radiation level is within the safety limit, the displayed energy bar is green, as shown in Figure 9. If the measured level exceeds the safety limit, the displayed energy bar is red, as shown in Figure 10. Meanwhile, the alarm icon and audio alarm remind the users that the environmental radiation value exceeds the safety limit, and they must take protective measures against further harm by radioactive rays.

The proposed system uses the corrected sensed radiation value to compare the results of the dedicated sensors, and the overall error rate is about 4.2%. It has highly sensitive response to changes in local radiation, and other sensor components are calibrated before delivery.

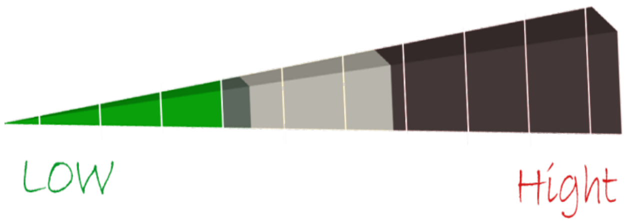

Figure 9. Saving range

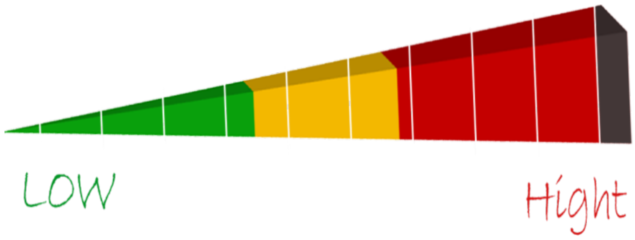

Figure 10. Dangerous range

The proposed system can remotely control and monitor environments covered by the wireless network within the transmission distance, and can ideally achieve cross-regional remote control.

5. Conclusion

During measurement, common sensors usually need to be placed near the sources, and when they enter one regional environment, there are various unknown negative environmental factors. If the environment is exposed to concealed radioactive rays with long distance and high hazards, the detection personnel cannot be protected in real time, and their cells may be irreversibly harmed. Unmanned integrated remote environment detection will become the future trend. This study developed a long-distance unmanned detection tool to replace traditional manual measurement methods, in order to reduce unnecessary casualties.

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