An Improved Gated System that Combines the Techniques of the Internet of Things for Community Security

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Abstract

Residential security is important in today's society. As Taiwan will soon enter a super-aged society, there will be manpower shortages and scheduling problems in the dispatched resident guard service. Hence, how to develop a new security method and business model that uses the techniques of the Internet of Things to improve resident security is a top priority. In addition, in response to the severe global COVID-19 epidemic, residents' access to and from residential areas shall be strictly controlled, such as body temperature records and access records, in order to enhance epidemic prevention within communities. Therefore, this paper proposes an improved gated system that combines the techniques of the Internet of Things (IoT) to ensure community security. In terms of access control, a facial recognition system is designed, which integrates with the functions of body temperature measurement, RFID, and QR codes. The QR code function is mainly used to allow guests to enter residential areas. Regarding the COVID-19 epidemic, the information recorded by the system can help to effectively control the contact history and body temperature of community residents. The advantages of this paper, including practicality, residential security, and integration, are explained in the experimental section.

Keywords: Gated system, Internet of Things, Community security, Residential security, COVID-19 epidemic prevention

1 Introduction

With the advances of science and technology, people are increasingly aware of using intelligent technology to enhance residential security. From intelligent families [1] to intelligent buildings [2-3], scholars and enterprises all over the world have invested in product research and development. In order to provide environment sensing information services [4], the security system for a residential area is usually constructed by a large number of sensors in a heterogeneous network environment. Moreover, with the development of artificial intelligence and machine learning, intelligent surveillance cameras can automatically detect the objects (usually people and cars), events, and activities in target scenes for analysis [5]. Hence, access systems based on the Internet of Things and intelligent monitoring technologies can effectively improve residential security. However, regarding the topic of data transmission, especially for device nodes close to visual data, such as access control cameras, the bandwidth and latency for data transmission shall meet the requests of real-time response. Edge computing [6] and fog computing [7] have been used to solve these problems. Edge computing or fog computing occurs between terminal devices and cloud management platforms, and provides a distributed computing architecture to realize a large number of functions, such as communication, control, storage, highly complex computing, and management, in order to reduce the burdens of resource-constrained terminal devices, overcome the bandwidth limitations of cloud services, and meet the requirements of low latency. The facial recognition system, body temperature measurement, and RFID access control, as suggested in this paper, can provide real-time recognition and detection at terminal devices using an edge computing architecture. By avoiding the need for transmission of data back to an external management system for computing, such a system is able to meet the latency requirements and provide a real time response.

Enterprise Internet of Things (EIoT) [8] will be the future trend of Internet of Things technology. Enterprise Internet of Things provides specialized deployment services with more applications, providing users with a wide range of compatible devices, protocols and customization programming forms and user interfaces. Enterprise Internet of Things systems are often used in smart homes, smart buildings, and smart offices. For enterprises, EIoT involves adding multiple embedded devices, edge devices and sensors, etc., in order to the business process that resulting in innovative business models. In addition, EIoT brings better operational performance and provide good services to the enterprise through intelligent processing and infrastructure support to manage data and service resources to achieve business operation automation. Omar [9] proposed a multi-standard framework consisting of 68 core elements as an indicator for intelligent building assessment and classification. At a deeper level, 8 quality condition elements of intelligent buildings are considered as the main factors, including energy and environment, spatial flexibility, cost effectiveness, customer comfort, work efficiency, security, and cultural and technical factors. In the 8 indicators, system integration, facility management, security, and disaster prevention are directly related to access systems. System integration focuses on the openness of access systems, which can integrate with other automatic service systems in residential areas, in order to reduce the operating costs of residential areas and develop the abilities to control and deal with emergencies. Facility management focuses on reliability, security, and the ease of use of the access systems; while

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security and disaster prevention focus on the detection display and notification performance of access systems. According to [9], there are trends of intelligence, open integration, web, action, and big data analysis for access systems.

As reported by the World Health Organization in 2018 [10], globally, there will be more people over the age of 60 than those under the age of 5 by 2020, meaning the population is aging much faster than in the past. According to the National Development Council, Taiwan became an aging society in 1993, an aged society in 2018, and will enter the stage of a super-aged society by 2025. Thus, there will be various problems, including manpower shortages and manpower scheduling in the dispatched resident guard service. However, as manpower costs increase with the economy, for units with few households or low management costs, the growing manpower costs year by year have brought heavy burdens to property management agency or security service company. Therefore, many property management agency and security service company have reduced the number of security guards, which affects the living security management. Azman et al. [11] pointed out that, in residential areas with security guards, generally, except for residents entitled to free access, other guests can enter the areas providing they have legal certificates and guest information (in paper form). However, sometimes, security guards directly allow guests to enter without properly recording or asking for relevant information, which results in negligence in management. Hence, the main contribution of this paper is based on the concept of EIoT to propose an improved gated system that combines the techniques of the Internet of Things to ensure community security. In terms of access control, a facial recognition system is designed, which is integrated with the functions of body temperature measurement, RFID, and QR codes. RFID is used to integrate the existing access control methods of residential areas. With the QR code function, residents can request one time QR codes through an online web application system, and guests can be allowed to enter the residential areas. In intelligent communities, sensors are installed on public facilities to improve residential security, such as the water pressure detection sensors of water towers, temperature and humidity sensors, and air quality sensors. RESTful API [12] is used in this paper to concatenate the information of these sensors and effectively manage the data. Regarding the COVID-19 epidemic, the information recorded by the system can help to effectively control the contact history and body temperature of community residents. The social link visualization is proposed in this paper through the processing of personnel passage data and the analysis. It can realize the epidemic investigation service of enterprises in the current epidemic situation. By intelligent technology and the techniques of the Internet of Things, this paper improves residential security, achieves highly automatic management, reduces human errors, and provides friendly management platforms. The contributions of this paper are summarized as follows:

1. This paper proposes an improved gated system, integrating face recognition system and body temperature measurement, RFID, and QR code functions to increase the living quality of community.
2. The system proposed in this paper improves the management efficiency of the current epidemic situation, including time cost, labor cost, and labor shortage. In addition, it reduces the risk of human management, optimizes personnel operations, and improves the efficiency of gated management business processes.
3. This paper puts forward the evaluation of social link distance and visualization function to help effectively control the contact history and record body temperature of community residents, so as to reduce the risk of spreading the COVID-19 virus.
4. Through the Internet of Things technology and smart devices, this paper solves the problems of the community's dispatched resident guard service, improves the overall efficiency of the process, promotes the innovation of business models, optimizes personnel operations, realizes highly automated management, reduces human errors, and provides friendly management platform.
5. The system proposed in this paper is practical and integrated, and can be applied to community management, and can also be applied to all public fields, such as schools, hospitals, government agencies, and private enterprises.

Other parts of this paper are, as follows. The second part introduces related works. The third part discusses the main situational architecture and system service processes. The forth part is the implementation details, which demonstrate the system architecture proposed herein. The last part offers the conclusion.

2 Related Work

2.1 Gated System in a Community

Hassan et al. [13] proposed a management system to strengthen access devices. This system divides the people in a residential area into administrators, residents, and guests for control. In order to control guest access, valid QR codes are used to grant access rights. Residents can create guest lists through Web services, and the system sends QR codes for verification. Furthermore, this system provides guest history, which allows administrators and residents to view events and records, in order to correct human errors in management. This system effectively improves and enhances residential security and reduces the risk of unauthorized guests entering the area. However, as any inhabitant can query the access history, this system does not perform well in data privacy protection. In the architecture proposed in this paper, administrators and residents have different authority, and residents can only query the records of their own authorized guests. Ohal et al. [14] proposed a smart gate system that integrated the techniques of the Internet of Things, including RFID tags and smart phones, to achieve automatic access management, which has the purpose of lowering the management costs of security guards and reducing human errors through automation. While this system has significant effects on residents, unauthorized guests still have to be manually controlled in residential areas. Hence, in order to achieve access control for intelligent communities, the architecture proposed in this paper integrates face recognition, RFID, and QR codes. The information of these 3 methods are integrated in the background management system, and various management methods can be provided for different application situations.

2.2 QR Code-Based Access System

As a two-dimensional barcode, Quick Response Codes (QR codes) were invented by DENSO WAVE in Japan in 1994. QR codes have many advantages, including large data storage capacity, quick scan, omni-directional readability, fault-tolerant capability, and different symbols for the different types of QR codes [15]. With the rapid development of mobile devices, QR codes are widely used in many fields, such as marketing, shopping, and downloading, and this technology is also widely used for access control. Rajesh et al. [16] proposed a QR code-based automatic vehicle management system. When a driver enters a parking lot, the system will send a specific QR code to the driver's mail box, and the driver can obtain a specific parking space by the QR code and leave the parking lot with the same QR code. This system can provide the parking management center with more efficient vehicle management, including entry and exit, parking spaces, and payment, and collects a large amount of driver information for big data analysis.

Sa-ngiampak et al. [17] proposed a smart locker system with access sharing called "LockerSwarm", which is part of an intelligent campus program in Thai universities, and locker owners can authorize other people to share by QR codes. Users can find the lockers that are the nearest and available by searching to obtain fast storage services. This is a successful system achieving authorized access by QR codes. [13] is a management system that strengthens access control devices in residential areas by QR codes. Hence, this paper proposes a one-time QR code generation and application process, which authorizes guests to enter residential areas and improves access control flexibility in intelligent residential areas.

2.3 Facial Recognition-Based Access System

In early 2020, the COVID-19 virus spread rapidly around the world via through air and contact [18]. Hence, contact-type identity authentication systems based on passwords or fingerprints may increase the risk of virus infection. During epidemic prevention, people's acceptance of access systems based on facial recognition has greatly improved. During the severe period of the epidemic, many public institution and enterprise have used facial recognition-based access systems and integrated body temperature sensors to prevent the epidemic from worsening. In recent years, due to the rapid development of deep learning, facial recognition technology [19-22] has grown to maturity. However, during the COVID-19 epidemic, as most people wear masks, the performances of many face-related algorithms have been challenged, thus, research topics based on head postures and mask wearing have also become popular. Li et al. [23] proposed a new color space method according to the color and texture analysis of images and lines, in order to improve the accuracy of face recognition under the conditions of multi-angle head postures and wearing masks. Hence, this paper proposes an integrated facial recognition system, including the function of body temperature measurement, which can help to effectively control the contact history and body temperature of community residents during the COVID-19 epidemic.

2.4 Internet of Things-Based Monitoring System

In intelligent communities, sensors are installed on many public facilities to improve residential security. However, in current research literature, there are few direct descriptions regarding the integration of the techniques of the Internet of Things in residences, and the majority of literature is focused on the design and manufacturing of IoT automatic systems for intelligent homes. Jabber et al. [24] proposed an IoT@HoMe system that can monitor, read, and control sensors and household appliances in homes, in order to achieve the effects of intelligent home automation. In addition, as people's requirements for living quality increase, more and more attention is paid to monitoring the air quality of their living environments. Air quality [25], temperature, and humidity monitoring technologies [26], which are based on IoT techniques, also play important roles in intelligent homes. In smart communities, the water pressure detection of water towers is one of the key functions, as abnormal water pressure will affect the daily life of the residents and even lead to water leakages, which endangers living safety and causes economic losses. Hence, RESTful API is used in this paper to concatenate information of these sensors, such as water pressure detection of water towers, temperature, humidity, and air quality, to effectively manage the data. In addition, it is necessary to use lightweight and easy-to-use communication protocols in the field of the Internet of Things. Malina et al. [27] proposed a security-level data transmission method based on the Message Queue Transport Telemetry (MQTT) protocol. In addition to the use of secure transmission protocols, in terms of data protection, Thirumalai et al. [28] proposed a high-efficiency public key production scheme using the Knapsack method for the transmission service between cloud systems and IoT devices. In response to the issue of intrusion detection for Internet-of-things devices, Mothukuri et al. [29] proposed a federated learning (FL)-based anomaly detection method for proactively identifying intrusions in the Internet of Things. The monitoring system of the Internet of Things includes communication protocols, data encryption and anti-attack elements. Hence, this paper uses the WebSocket full-duplex communication mode. The management platform and the IoT devices only need to complete a handshake, and a sustainable connection can be established, and two-way data transmission can be carried out. Add to this, WebSocket in this paper integrates Transport Layer Security (TLS) to improve transmission security.

3 Proposed System

The system architecture proposed in this paper mainly consists of 3 parts: access system, environment sensing system, and management platform, as shown in Figure 1.

The access system is applied at the entrance and exit of a community, such as the front door, back door, and driveway. There are 3 choices for residents to enter a community: face recognition, RFID, and QR codes. If QR codes are to be used, online applications must be made in advance on the web management platform, thus, when guests obtain access by QR codes, it can effectively improve living safety. In addition, as body temperature is recorded by the access system when people enter the community, a good effect can be achieved during community epidemic prevention. In terms of the environment sensing system, this paper designs an IoT gateway to transmit the collected sensor data, such as the water

pressure of the community water towers, ambient temperature, humidity, and air quality, to the management platform, in order to effectively monitor the data of the living environment. The management platform mainly consists of the following important parts: access control device management (multiple), access records, environmental data records, QR code applications, and contact history. In addition, all of the recorded information can be exported to the documents such as CSV, Excel or JSON format. Hence, this paper proposes an improved gated system that combines the techniques of the Internet of Things, which can improve residential security and management convenience. The details of all systems are given in the following subsections.

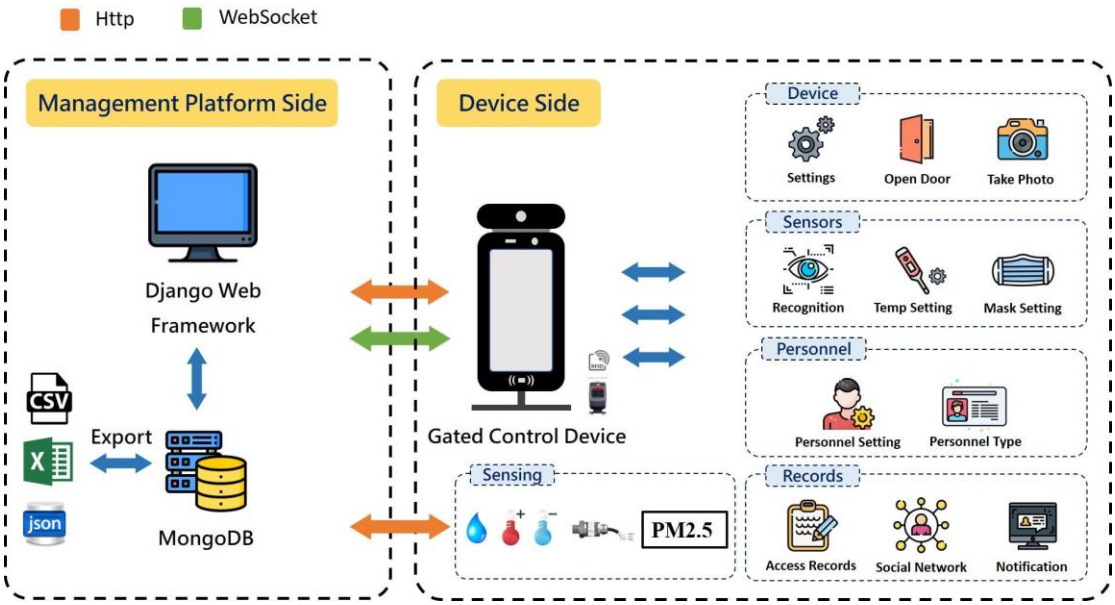

Figure 1. Overview of designed system

3.1 Access System Design

Three methods are integrated in the access system design: face recognition, RFID, and QR codes. The device system also integrates body temperature measurement. In terms of facial recognition, there is detection with and without masks and types of identity (residents, guests, and blacklisted people). Through the identification of personnel and the integration of mask detection and body temperature restrictions, personnel entering the community can be more effectively controlled, especially in the severe situation of the epidemic.Hence, there are many flexible methods for community access control, and these functions can be easily set through the web management platform. The access process is shown in Figure 2.

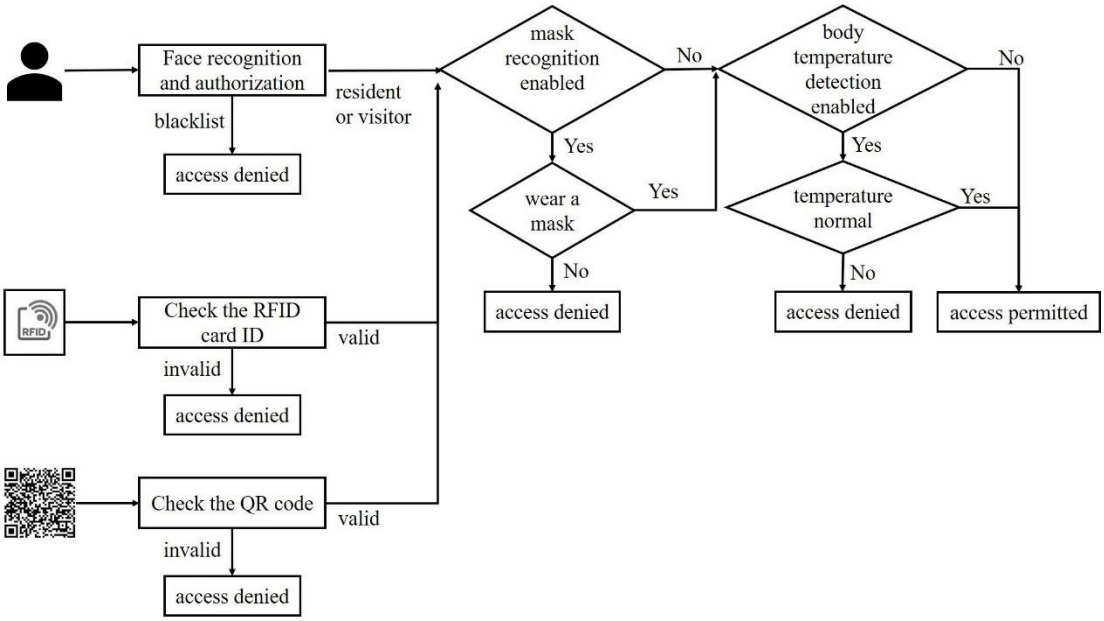

Figure 2. Details of accessing process

3.2 One Time QR Code

In terms of the QR code authorization authentication process, one-time authorization is adopted, that is, the authorization is valid within a certain period of time. Tokenization [30] has been applied in many fields, such as network communications, information security, credit cards, and third party verification. By the tokenization technology, information can be mapped to a token, which is a reference (identification mark) without external meaning or value and applicable to authentication and authorization services. Based on the application information provided by residents, such as user accounts, email, authorization timestamps, and guest names, the system generates QR codes containing hash codes as guests' access authorization through hash algorithm SHA-2 [31] or SHA-3 [32], and such QR codes must be used within a certain time limit. After authorized guests use the access code or go beyond the authorized time, such QR codes will be removed from the system. The detailed process is shown in Figure 3.

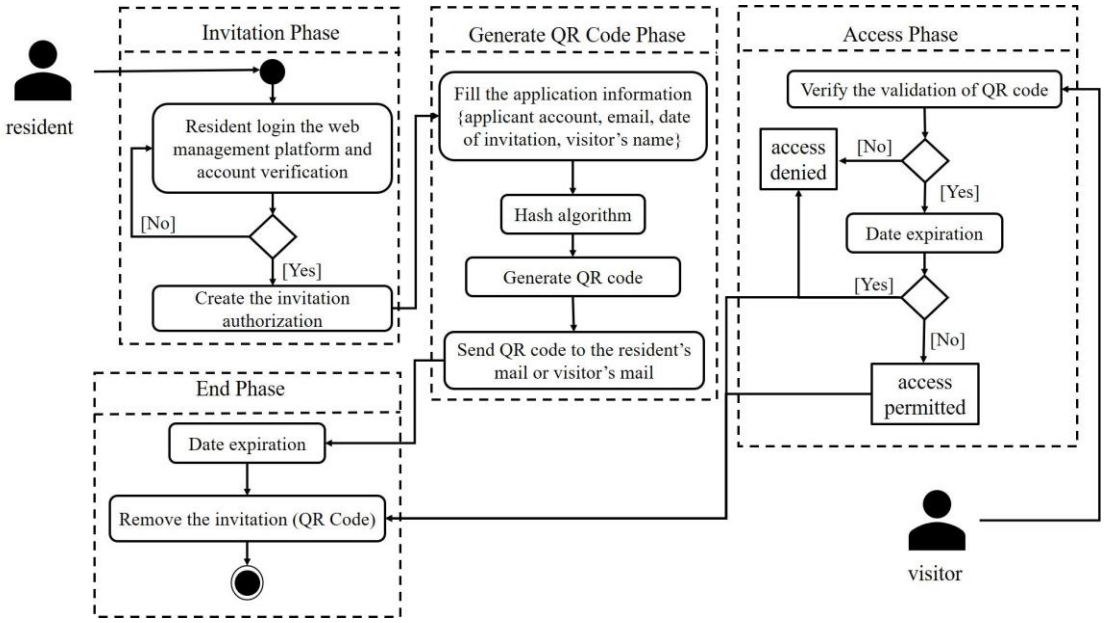

Figure 3. Details of QR Code authorization authentication process

3.3 Design of Monitoring Sensors

In terms of the living environment sensing system, this paper designs an IoT gateway to transmit the collected sensor data, such as the water pressure of the community water towers, ambient temperature, humidity, and air quality, to the management platform, in order to effectively monitor the data of the living environment. Regarding the hardware design, Raspberry Pi 3 model B [33] with network communication function is adopted, and a 40 pin port is used as the IoT gateway. In addition, a DH11 humidity sensor [34], adafruit PM2.5 air quality sensor [35], and dfrobot SEN0257 water pressure sensor [36] are used to sense environmental changes. As the Raspberry Pi 3 model B has no analog input pin, the water pressure sensor data are captured by Arduino UNO R3 [37] and transmitted back to Raspberry Pi by the I2C port. The hardware planning is shown in Figure 4. Regarding data transmission, Raspberry Pi uses the HTTP RestFul API method to aggregate the data into JSON format and send it to the management platform.

3.4 Social Link Visualization

In order to address COVID-19 epidemic issues, people's access is recorded by the system to effectively control the contact history and body temperature of community residents. In this paper, a visual social link graph is drawn based on the information collected, such as the entry location, entry time, and body temperature at the time of entry. U_i^j represents that the resident i entered the community from location j at the time set by the target user, their virtual social distance is d_{ti}, where t is the target user and i is the resident number, and d_{ti} can be calculated by Eq. (1). α is a hyper-parameter used to control the evaluation of the body temperature of the people. When the people's body temperature is higher than the normal value, α is a negative value, otherwise it is a positive value. When the people's body temperature is higher than the normal value, it means people is at risk of feve. The purpose of this concept is to shorten the social link distance calculated by high-risk person with the target user. In this paper, ω represents that the weight is between 0 and 1, which is used to adjust the proportion between the distance and access time offset of residents with target user. The information of temperature, distance and time offset are used to determine how to show the social link graph, as shown in Figure 5. Hence, during epidemic prevention, the contact history of residents can be quickly controlled with this function. The detailed implementation will be discussed in the section of experiment.

$$d_{ti} = \alpha * (temperature_{\text{normal}} - \text{temperature}_i)^2 + \omega * (\text{location}_t - location_i)^2 + (1-\omega) * (time_t - time_i)^2 \quad \textbf{(1)}$$

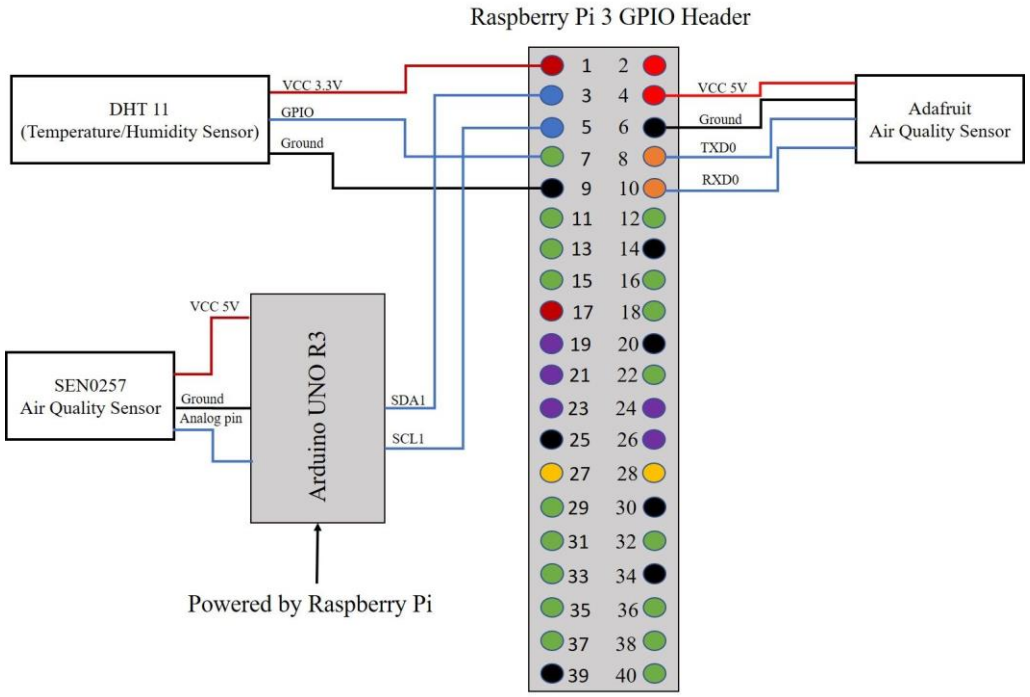

Figure 4. Schematic of sensing module

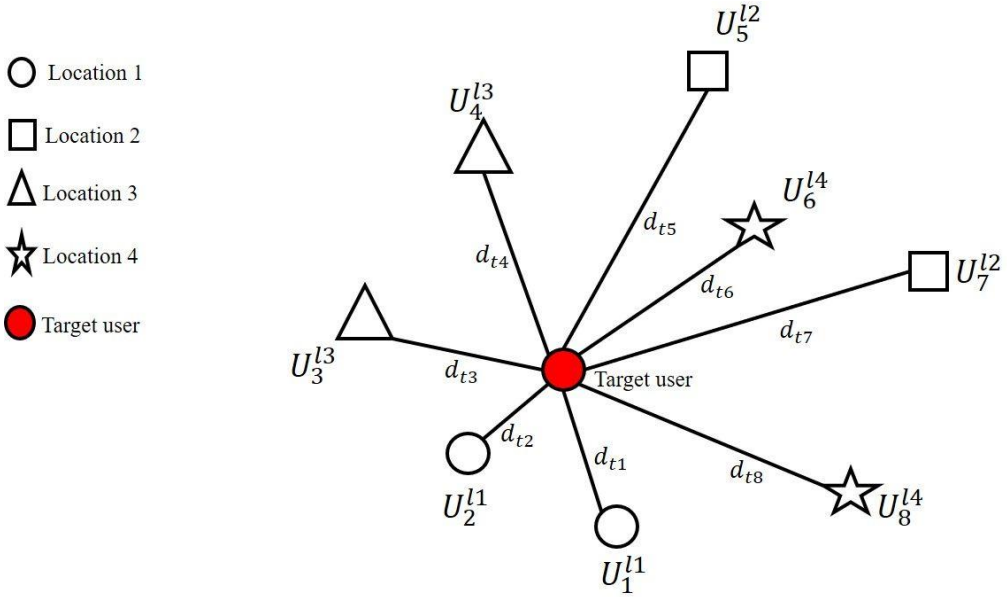

Figure 5. Visualization of social link graph in community

3.5 Management System

In terms of management platform planning, it can be roughly divided into personnel registration, resident access list setting, multi-device management, device setting, access records, application for QR code authorization, sensor data dashboard, and multi-language switching, where the people mainly include administrators and residents. When logging into the management interface as a user, one can only apply for QR code authorization and view the environment sensing data. This paper integrates face recognition, RFID, and QR codes for device management and settings. Facial and RFID comparisons are completed immediately by the device, while QR code comparison is conducted by the background management platform. Hence, due to its small load, the management platform is easily deployed and managed on a large scale. This paper managed multi-devices according to IP-based identification and password, and added the function of location to this device. By this function, devices can be easily installed in appropriate locations in communities and the actual distances among all devices can be clearly known, in order to facilitate social distance calculation. In addition, resident lists, access records, and sensor data can be transmitted back to the background management system through RESTful API for synchronous storage and display. The management platform in this paper is shown in Figure 6, and more details are explained in the experimental section.

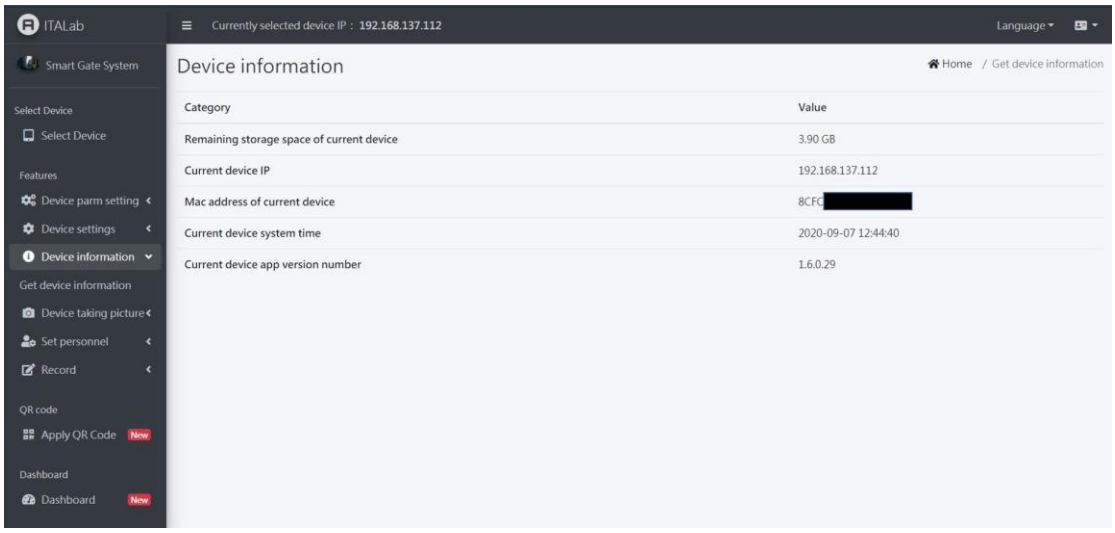

Figure 6. Management system

4 Experiment

4.1 Experimental Environment Setting

In this paper, the Face Recognition Infrared Thermometer SV-1081D [38] of Smart Device Tech is used for face recognition, body temperature detection, and RFID hardware, which has excellent performance in facial recognition and body temperature detection, and supports the establishment of more than 30,000 face data. In terms of the peripheral hardware devices, this system provides Relay output for lock control, Ethernet (RJ45) and WIFI communication, a USB OTG and a USB HOST standard type A port. In addition, Android 7.1.2 is the operating system and a variety of RESTful API are applied for control and settings. Hence, regarding the integration of the QR code device, the USB interface is used to link the device, and an app reading QR code service for background processing is written and installed in the device, where the read QR code is transmitted back to the management platform in real time for comparison through network communications. Environment sensing with IoT can be designed by referring to the design of the monitoring sensors. In the web management platform, Intel (R)Core(TM) i7-6700HQ CPU @ 2.60GHz 2.59GHz is used and Ubuntu 18.04 operating system has RAM 8GB. At the back end of the website, Django[1] is used as the Web server. There are two standard interfaces for hosting the Django application, respectively, for different incoming requests: WSGI [39] and ASGI [40]. Regarding database management, MongoDB[2] (a JSON-like, NoSQL database) and Redis[3] (in-memory data storage structure) are used for real-time data transmission. The actual hardware devices are shown in Figure 7.

Figure 7. Environment setting and devices

[1] https://www.djangoproject.com/
[2] https://www.mongodb.com/
[3] https://redis.io/

4.2 Personnel Establishment and Settings

In order to maintain security in the access system of the community, according to its regulation, new user (resident) accounts can only be created by administrators, as shown in Figure 8. After account establishment, the system automatically sends confirmation letters to the residents' email for confirmation. Providing residents have an account, they can use the function of guest QR code authorization and understand the environment sensing information. When applying for QR code guest access authorization, residents shall complete their resident accounts, including email, starting date of authorization, and guest names in the system. The management platform will immediately generate QR codes and notification messages, as shown in Figure 9 and Figure 10, respectively. Residents can use the mailbox to forward the QR code information to the visitor or use the camera function to save the QR code as a picture and send it to the visitor. Or when applying for the visitor access permission of the QR code, the mailbox address can fill in the visitor's email address. In this way, QR code information can be automatically sent to visitors.

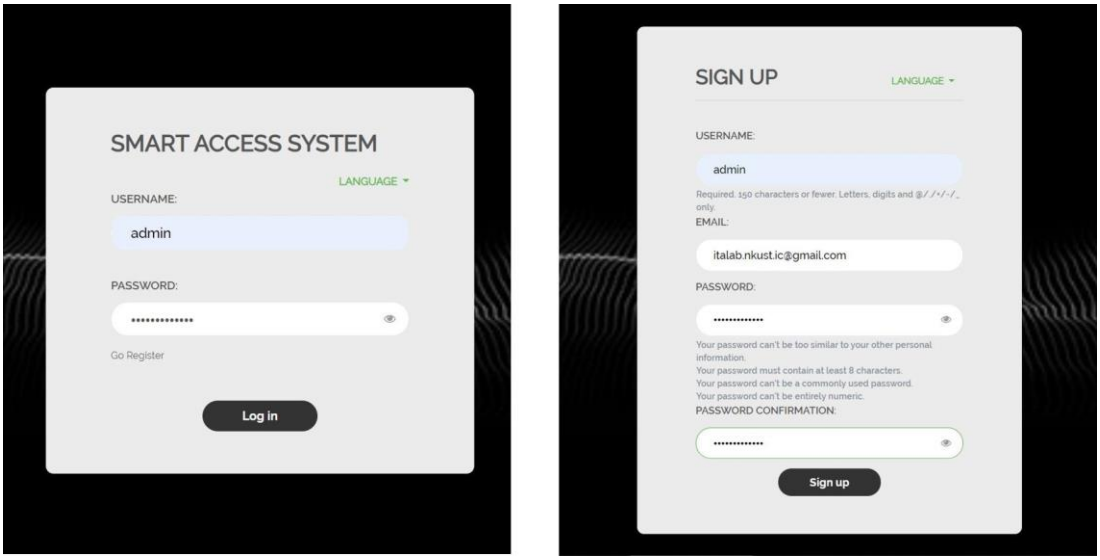

Figure 8. Login page and sign up page

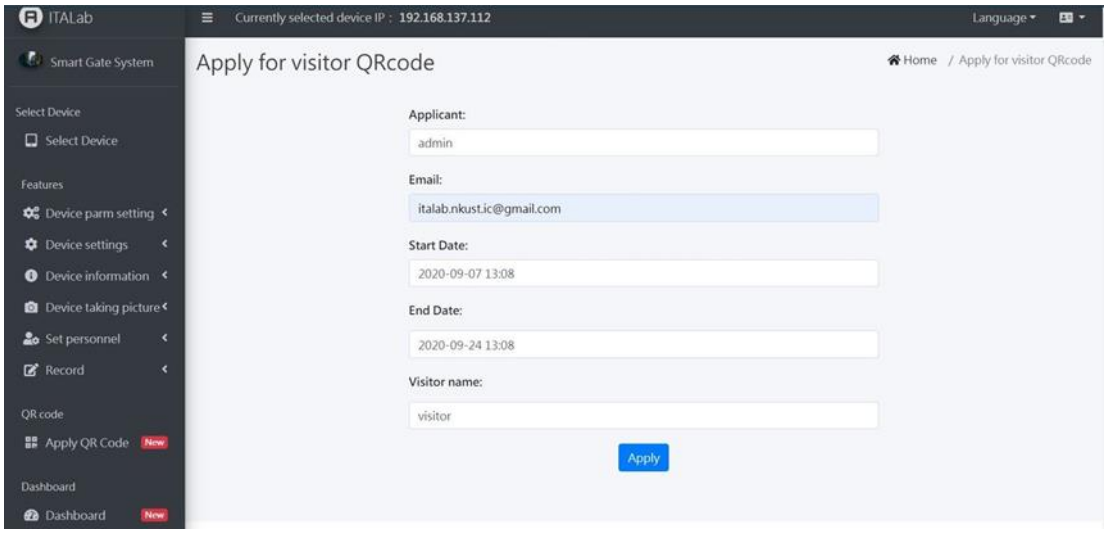

Figure 9. Apply QR code page

Regarding the establishment of face information, the setting interface provided in the web management platform can establish face information by the real-time photograph function and picture uploading, and age, name, gender, and personal information can be added through the personnel data management platform. In addition to face recognition, RFID card numbers, access period, and identity type (residents, guests, and blacklisted people) can be set, as shown in Figure 11. In addition, the content of the picture will be encoded into the Base64 format in the web management platform to facilitate transmission and access. As residents may be tenants only staying in the residential areas for a certain period of time, more flexible applications can be provided by this function. In addition to establishing the account, deletion and modification functions are provided, as shown in Figure 12 and Figure 13.

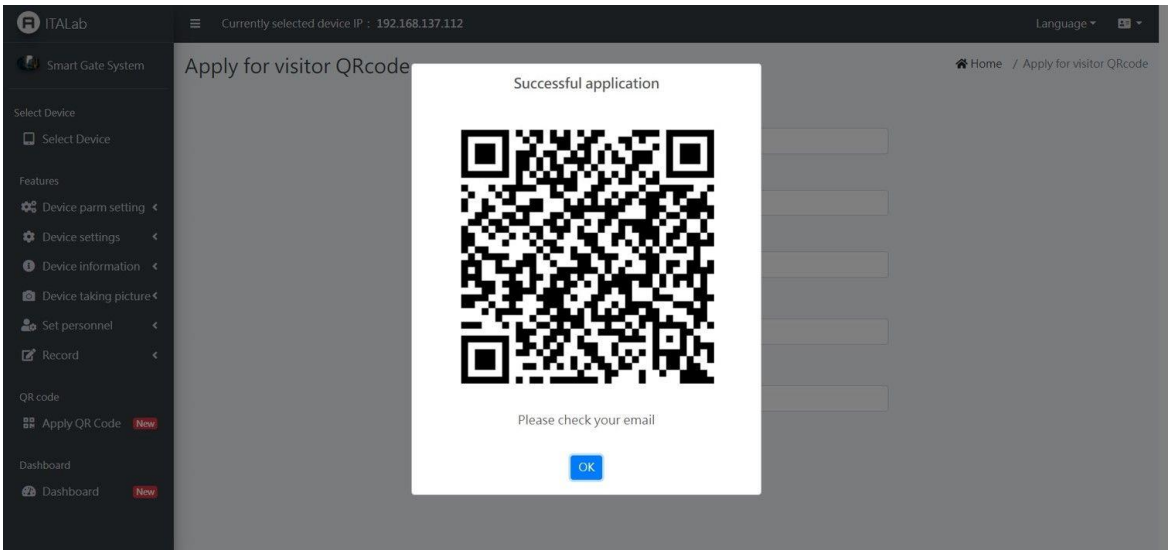

Figure 10. QR code generated by management system

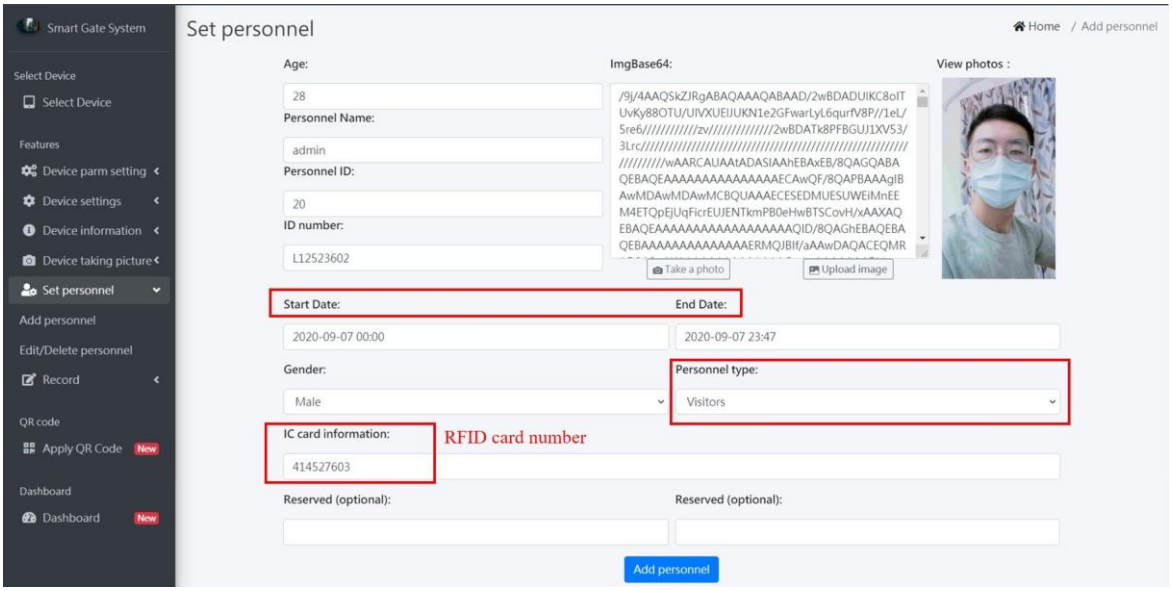

Figure 11. Setting page of personnel

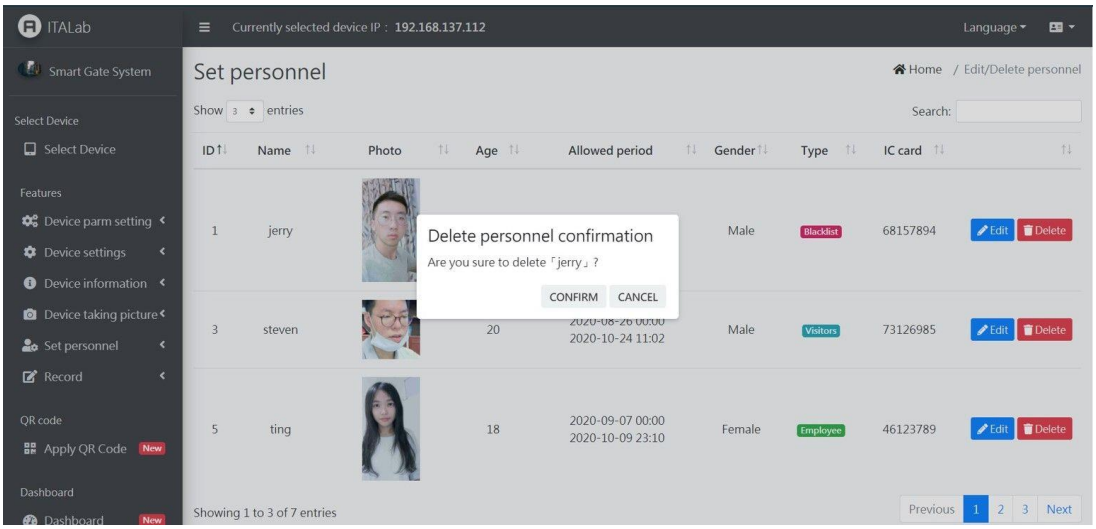

Figure 12. Delete personnel page

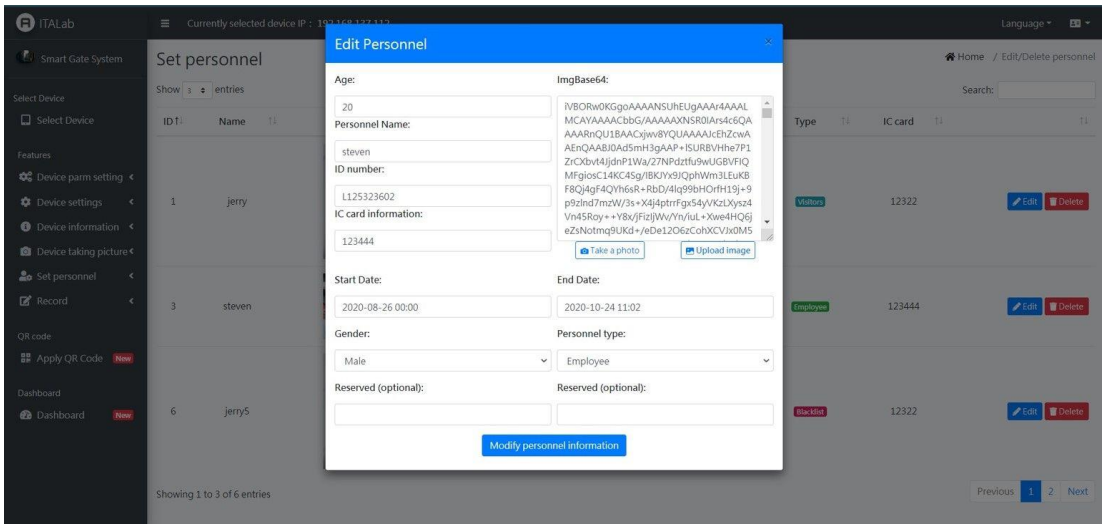

Figure 13. Edit personnel page

4.3 Device Establishment and Settings

There is often more than one entrance to enter a community, such as front door, back door, and driveway; hence, multi-device management is provided in the management platform. This paper managed multi-devices according to IP-based identification and password, and added the function of location to this device, as shown in Figure 14, which provides many functional settings, such as password setting, recognition distance (this device supports 0.5m to 1.5m), recognition time, and time delay of opening the door, as shown in Figure 15.

In order to match different application scenarios, the web management platform makes it easy to set device status, as shown in Figure 16. The status and settings of body temperature and masks are shown in Figure 17 and Figure 18, respectively. This device also provides many temperature settings, including a function for stranger records, which is suitable for the external activities of communities, and if a large number of strangers visit, it can be used to measure body temperature during epidemic prevention to save manpower and achieve effective access control.

4.4 Access Records and Environment Sensing

The most important information in an access system is the access records. The management platform provides access records according to the time setting, including the complete information of body temperature and mask status, as shown in Figure 19. Since the symptoms of COVID-19 are mainly fever and cough, it is very important for personnel to check their body temperature and whether wearing masks or not when they enter into the community. This system can support registered personnels and strangers. The real time access information can be pushed to management system to notify managers or guarders as shown in Figure 20 and Figure 21.

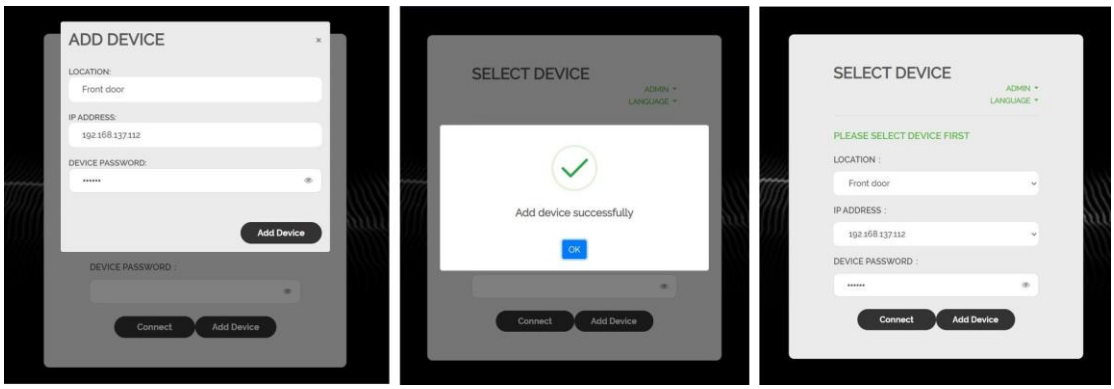

Figure 14. Device management page

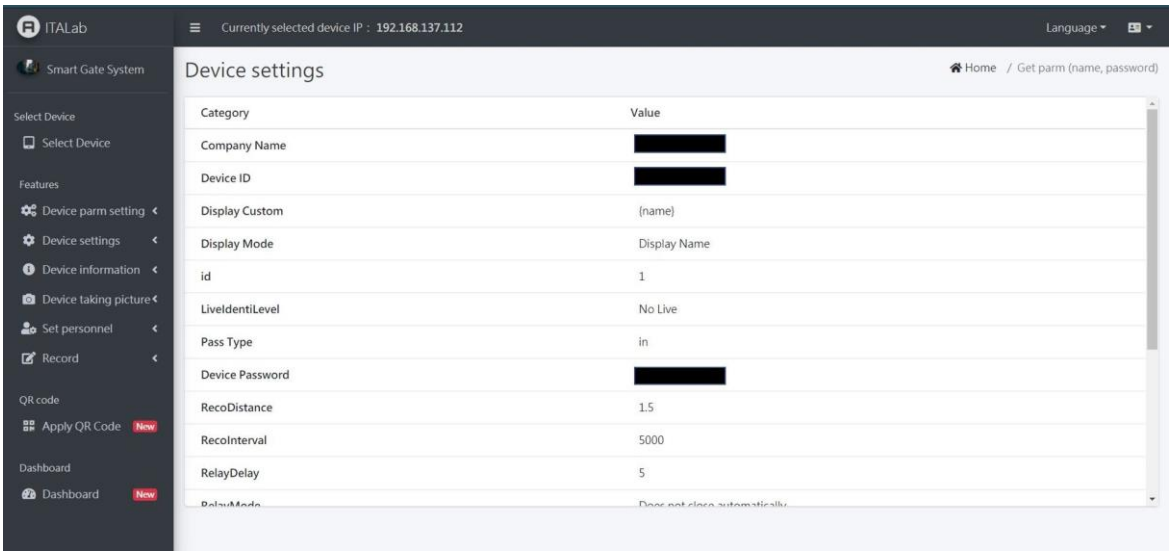

Figure 15. Device setting information page

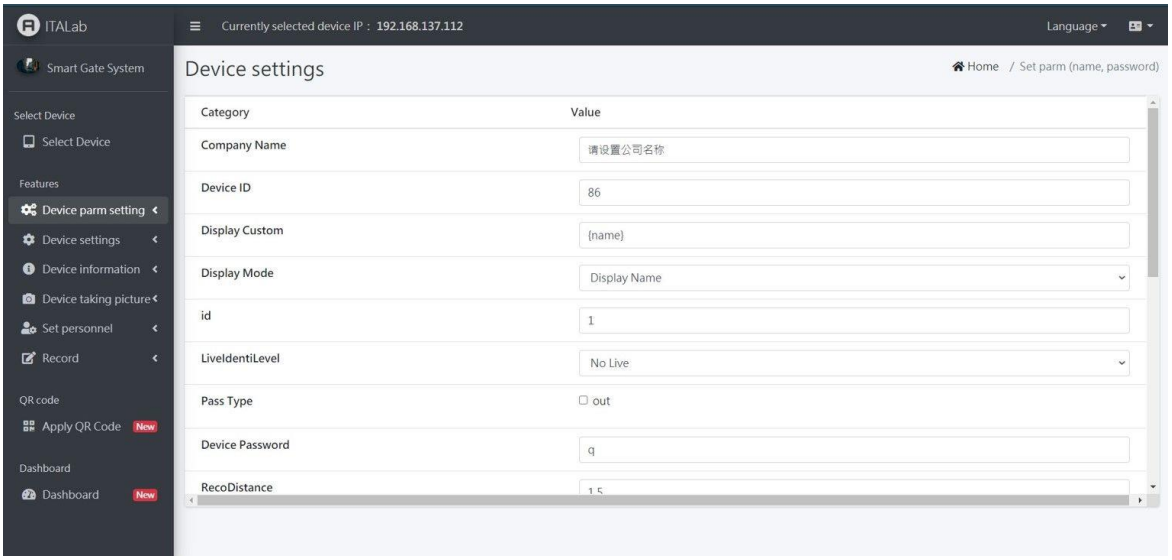

Figure 16. Edit device setting page

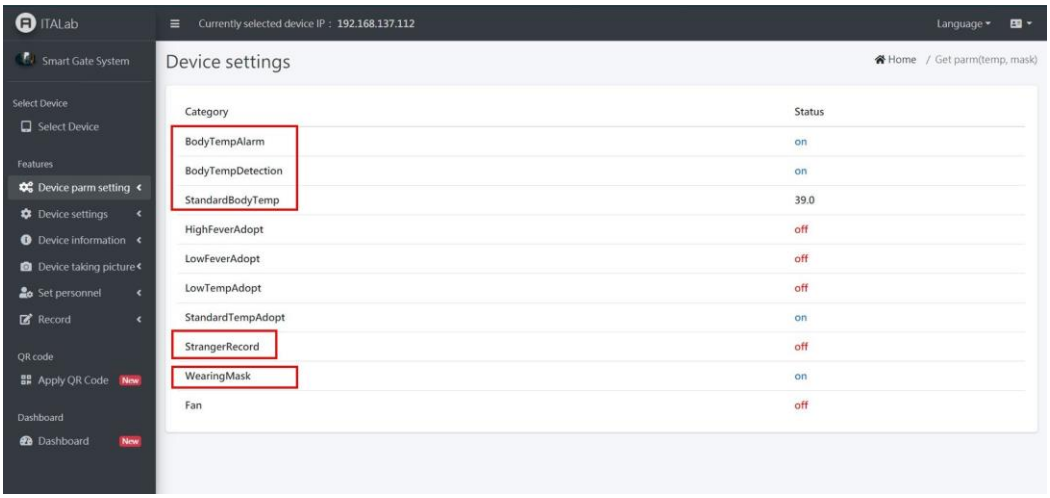

Figure 17. Status of device page

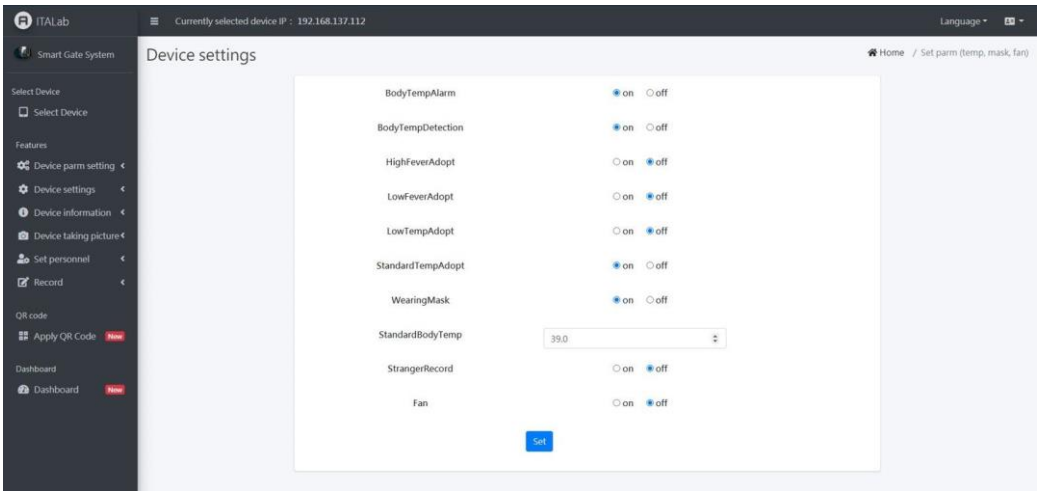

Figure 18. Edit status of device page

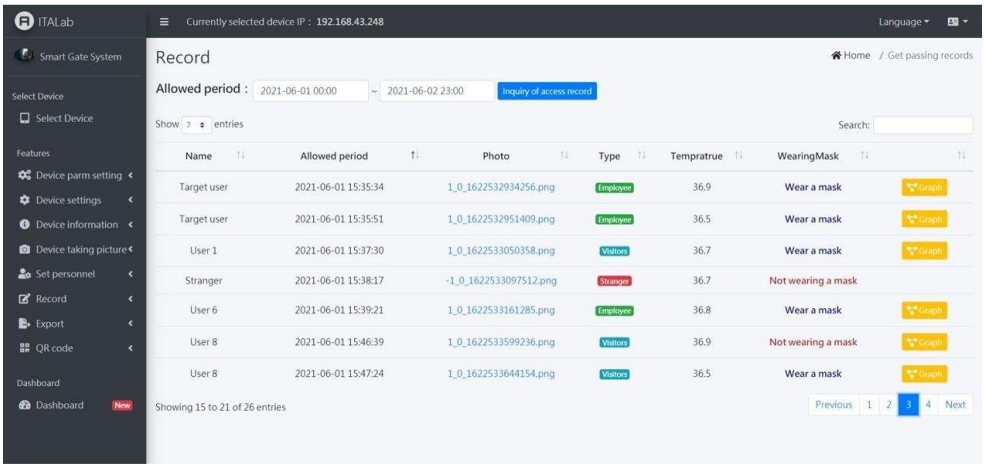

Figure 19. Access record page

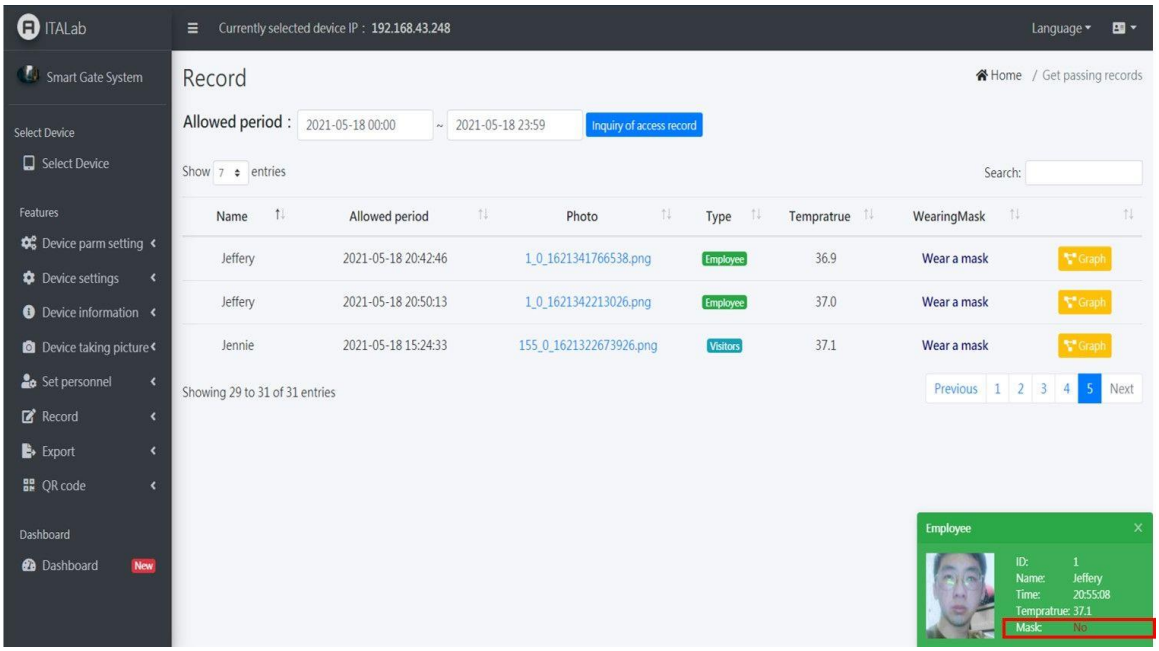

Figure 20. Real-time notification for registered personnel

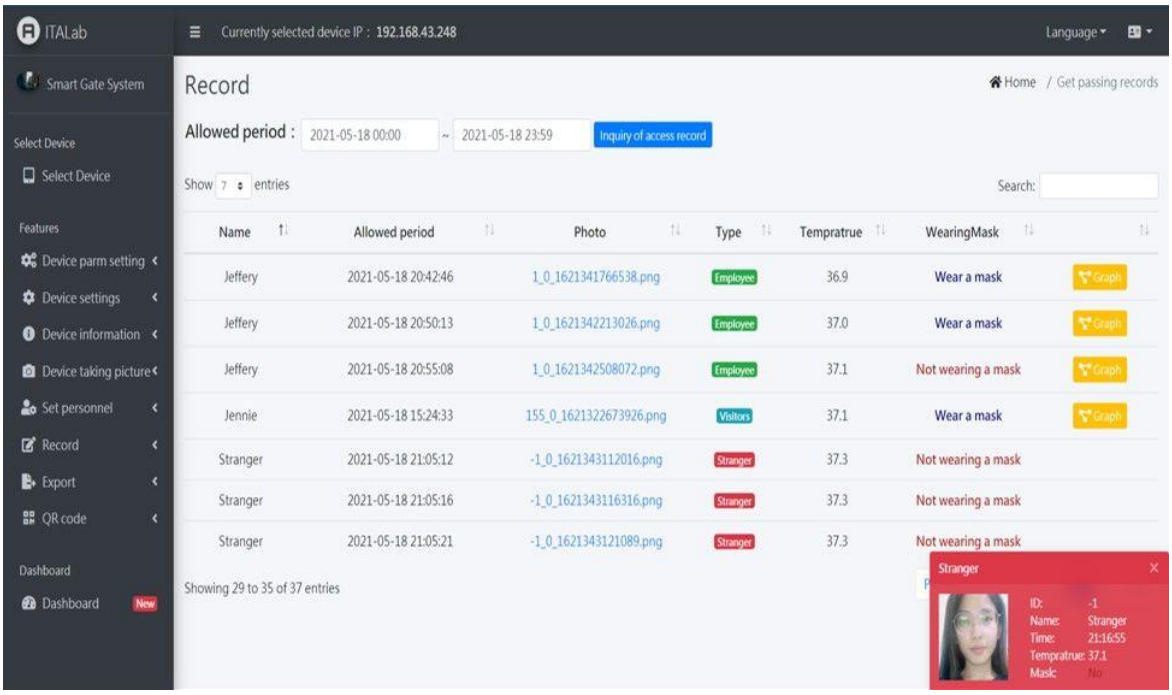

Figure 21. Real-time notification for stranger

In the environment sensing information, in order to clearly understand the living environment quality through time setting and device selection, the management platform records all the data measured by sensors, as shown in Figure 22. We will collect the sensor data that can be filtered according to time for data visualization. In data communication, not only using the defined HTTP RestFul API to transmit data, but also we can use Websocket to perform data transmission in order to dynamically present the real time data visualization effect.

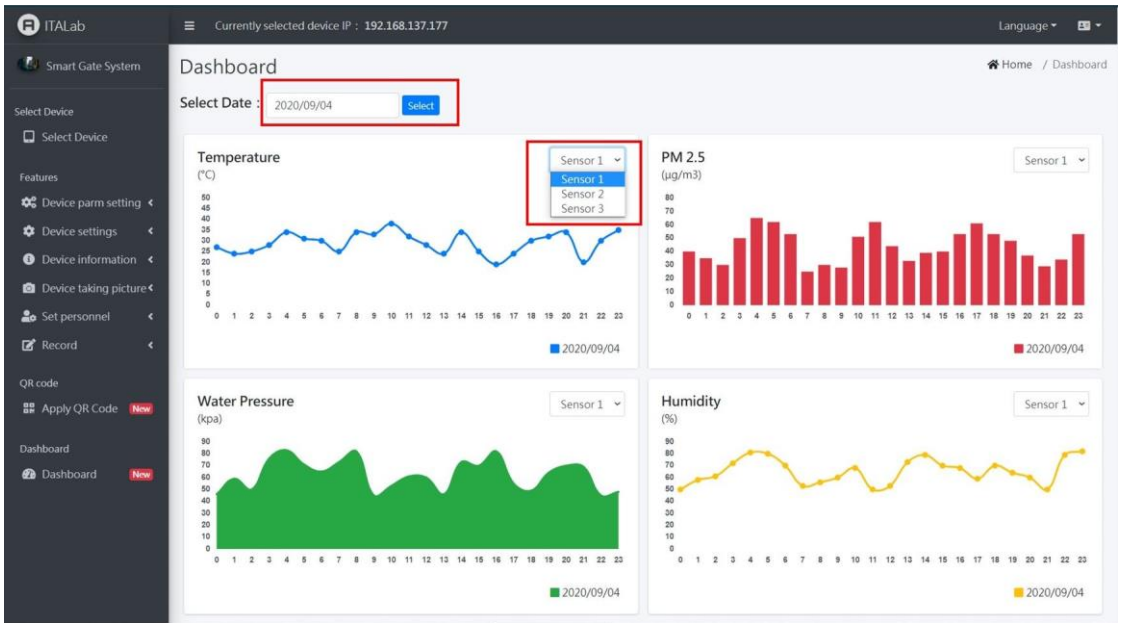

Figure 22. Sensing environment information dashboard

4.5 Simulation of Social Link Visualization

According to Chapter 3.4 and Eq. (1), this paper used simulated data to show the effect of social link. The system parameter settings are shown in Table 1.

Table 1. System parameter settings

Parameter	Explanation	Value
$\boldsymbol{Temperature}_{\mathbf{noraml}}$	Temperature	37.5 ^{0}C
$\boldsymbol{\alpha}$	Hyper parameter	10
$\boldsymbol{\omega}$	Weight	0.5

The simulated device positions are the front door, back door, lane and lane2 respectively. The simulated target user's position is the front door, and the distance information from other devices is shown in Table 2. In addition, the management system provides settings for the relative position between the device and the device as shown in Figure 23.

Table 2. Relative distance from target user's location

Location	Front door (target user)	Back door	Lane	Lane2
Distance	0	30m	50m	60m

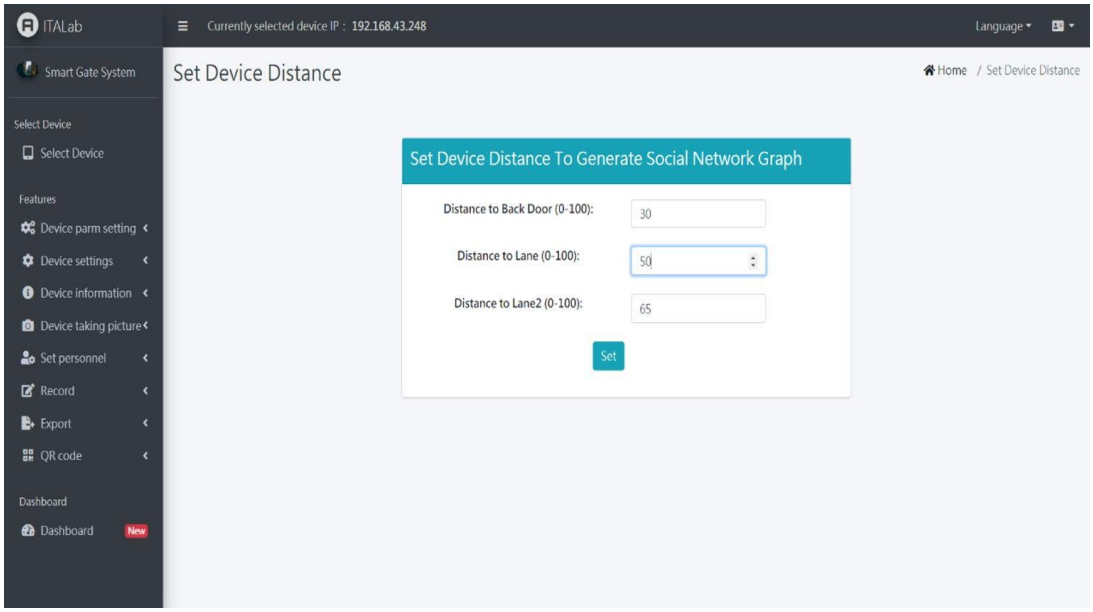

Figure 23. Relative distance setting page

When the manager clicks on one of the personnel's Graph button as shown in Figure 24. The system will filter the access records of all personnel who entered the community through the access control device within 12 hours according to the time. In this experiment, a total of 15 records were obtained. The information is shown in Table 3. The management platform proposed in this paper provides a social link graph, which can indicate the contact history of a person. The contact history can be presented in a visual manner as shown in Figure 25, which facilitates quick investigation during epidemic prevention.

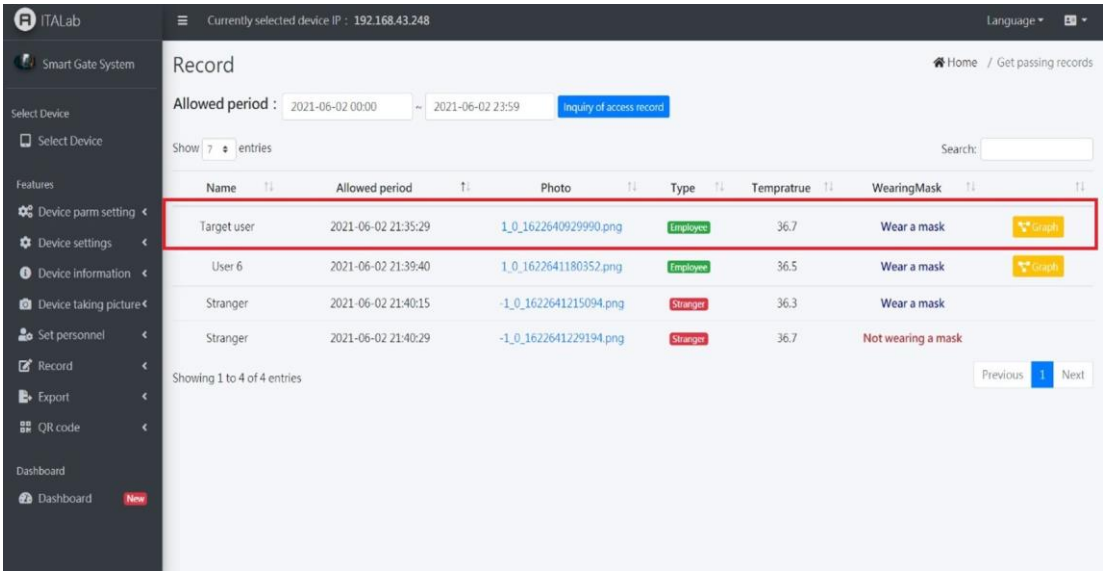

Figure 24. The information of target user

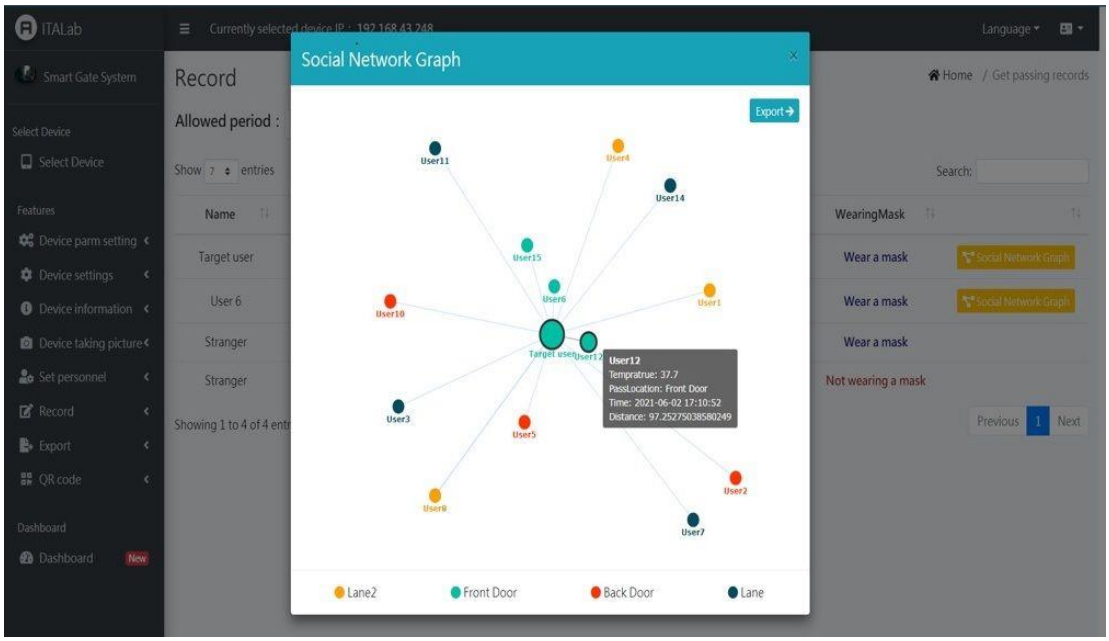

Figure 25. Visual social link graph page

Table 3. Simulated data

Name	Temp.	Time	Location	1st term in Eq. (1)	2nd term in Eq. (1)	3rd term in Eq. (1)	d_{ti}
Target	36.7 ^{0}C	2021-06-02 21:35	Front Door	0	0	0	0
User 1	37.1 ^{0}C	2021-06-02 17:20	Lane2	+1.6	+32.5	+8	42.1
User 2	36.9 ^{0}C	2021-06-02 13:16	Back Door	+3.6	+15	+32	50.6
User 3	37.0 ^{0}C	2021-06-03 02:53	Lane	+2.5	+25	+12.5	40.0
User 4	37.9 0C	2021-06-02 15:30	Lane2	+0	+32.5	+18	50.5
User 5	37.2 0C	2021-06-02 18:56	Back Door	+0.9	+15	+4.5	20.4
User 6	36.5 0C	2021-06-02 21:39	Front Door	+10	+0	+0	10.0
User 7	37.6 0C	2021-06-02 13:30	Lane	+0	+25	+32	57.0
User 8	37.0 0C	2021-06-02 12:27	Front Door	+2.5	+0	+40.5	42.5
User 9	37.2 0C	2021-06-03 01:20	Lane2	+0.9	+32.5	+4.5	37.9
User 10	36.2 0C	2021-06-02 16:32	Back Door	+16.9	+15	+12.5	44.4
User 11	36.0 0C	2021-06-02 20:20	Lane	+22.5	+25	+0.5	48.0
User 12	37.7 0C	2021-06-02 17:10	Front Door	+1.6	+0	+8	9.6
User 13	36.8 ^{0}C	2021-06-03 14:07	Back Door	+3.6	+15	+24.5	43.1
User 14	36.4 ^{0}C	2021-06-02 18:41	Lane	+12.1	+25	+2	39.1
User 15	36.2 ^{0}C	2021-06-02 19:20	Front Door	+16.9	+0	+2	18.9

5 Conclusion

This study proposed an improved gated system, which improves residential security and reduces human errors through intelligent technology and the techniques of the Internet of Things. We designed a facial recognition system that integrates the functions of body temperature measurement, RFID, and QR codes for access control. Regarding the function of QR codes for many flexible methods for community access control. In intelligent communities, sensors are installed on public facilities to improve residential security. This study designed an IoT gateway to transmit the collected sensor data, such as the water pressure of the community water towers, ambient temperature, humidity, and air quality, to the web management platform, in order to effectively monitor the data of the living environment. In order to prevent the COVID-19 epidemic, the social link graph function was proposed in this paper to help to effectively control the contact history and record body temperature of community residents for reducing the risk of spreading the COVID-19 virus. Through the Internet of Things technology and smart devices, this paper solves the problem of the traditional guard system in community, improves the overall efficiency of the process, facilitates innovative business models, and optimizes human operations. Fianlly, the system proposed in this paper is practical and integrated, and can be applied to community management, as well as to all public areas, such as schools, hospitals, government agencies, and private enterprises. The social link distance measurement proposed in this paper has a significant effect on people who are registered in database. For the stranger model, it is less meaningful. In addition, in order to calculate the social link distance more accurately, the manager needs to setup the physical distance between devices as accurately as possible. This is the limitation of the system architecture proposed in this paper.

In the future work, we will improve the evaluation method of community social link, according to more information about the personnel entry and exit in the community. Hence, the presentation of social link will more accurately describe the connectivity between people. In addition, we will integrate more sensor devices in the community, collect large amounts of data through the sensors, and analyze data, in order to improve the quality of community living. The protection of data privacy is a very important issue in modern society. This paper will study the authorization and protection of data in the future work. In terms of data access rights, a mechanism design of hierarchical authentication, anonymization and sharing based on token is adopted. In terms of data protection, this paper will focus on the security of data transmission, through an efficient encryption and decryption mechanism to achieve a reliable transmission framework between the IoT device and the management platform. How to integrate the Internet of Things technology through an improved gated system to improve the quality of community living will be our next research topic. Finally, this paper will discuss the issue of larger-scale gated system integration in the future work, deriving the management of a single community into a multi-community management system to form an intelligent community management system.

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