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A Study on the Artificial Intelligence Multiplex Smart Housing System

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Abstract

Recently, by applying the 4th industrial revolution technologies such as A.I., IoT, and big data to general residential infrastructure, various application services of residential-based are provided to residents through linkage and utilization between technologies. Accordingly, smart housing system is increasing as advanced living spaces that can improve the quality of life and convenience of residents. Such a smart housing is expected to be an item that can create new demands and markets in the construction industry since it provides a new paradigm that combines construction technology and IT by combining IT technology with existing construction industry. Based on this, it is expected that it will be possible to gradually develop large-scale markets such as smart buildings and smart cities. In this paper, therefore, we propose an artificial intelligence multiplex smart housing system as an intelligent platform that can autonomously manage and control the size of places and spaces, used for various purposes based on smart housing technology by using artificial intelligence systems.

Keywords: *A.I., IoT, Big Data, Smart Housing, Multiplex*

1. Introduction

Recently, by applying the 4th industrial revolution technologies such as A.I., IoT, and big data to general residential infrastructure, various application services of based on residence are provided to residents through linkage and utilization between technologies. Accordingly, the number of advanced spaces, improving the quality of life and convenience of residents, is increasing [1-3].

Accordingly, we want to build an artificial intelligence multiplex housing system as an intelligent platform in order for artificial intelligence systems based on smart housing technology to autonomously manage and control spaces of various sizes used for public purposes.

The artificial intelligence multiplex system used in various places should be operated by applying to various environments and aims to maximize the convenience of users.

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2. Concept and Configuration of Smart Housing

2.1 Smart Housing

Smart housing is to combine IT technology to collect real-time sensing data through various IoT sensors and devices to a server so that A.I.-based models can continuously learn and analyze data, meaning the intelligent housing that can handle the situation autonomously, where the key components for building this include sensors, controllers, networks, and user interfaces[4,5].

In addition, recently, an artificial intelligence controller has been developed that can analyze data by itself by applying A.I. and judge the situation and take action. As shown in Figure 1. domestic companies such as SKT, KT, and Kakao, as well as overseas companies such as Google and Amazon, are supplying artificial intelligence controllers [4-6].

Figure 1. (A.I.) controller

2.2 Smart Housing Communication Protocol

Data collected through various IoT sensors are transmitted to the controller and server through wired and wireless networks. It is necessary to utilize appropriate communication technology according to the characteristics of the device in order to enable the user to not only understand the state of their residence both indoors and outside, but also to enable system operation in the long term.

For example, for smart devices with large size and high power consumption, such as home appliances, we can transmit data within long-distance coverage at high speeds, using Wi-Fi or cellular systems that have completed network infrastructure construction. As illustrated in Figure 2. in the case of small sizes equipment, such as general IoT sensors, operating with a limited electric power from a battery, the low power-based communication technology, such as Beacon or Zigbee, is suitable[7-9].

Figure 2. Types of (IoT) communication protocols

2.3 Current Status of Smart Housing

Currently, various industrial fields, such as construction, home appliances, and telecommunications, are cooperating with each other in order to invest in smart housing projects. Telecommunication companies do not directly develop hardware or software, but they are establishing a cooperative system with various manufacturers in order to provide data communication networks [10-12].

In addition, home appliance companies provide a monitoring function that can be managed using smart devices both indoors and outdoors, by considering the smart housing service. Samsung Electronics and LG Electronics are providing user interfaces based on voice recognition, such as Bixby and LG Smart Hub [3-5].

2.4 The Limitations of the Existing Method and The Need for Research

Existing smart housing stays in the form of IT and communication networks, and changes are required in it. However, the current environment should not only change in the direction of convergence of various places and spaces, but also go beyond the stage of simply developing and supplementing existing methods.

Smart housing should create a service delivery system that can be applied anywhere based on IT convergence, and requires supplementation and scalability in operation.

Therefore, we ensure that the multiplex smart housing system can be operated according to various environments, and we want to build an artificial intelligence multiplex smart housing system with the purpose of maximizing user convenience.

3. Artificial Intelligence Multiplex Smart Housing

As shown in Figure 3. We present in this paper our research conducted based on the construction of an artificial intelligence multiplex smart housing system.

Figure 3. Artificial intelligence multiplex smart housing system

By using indoor IoT sensors (temperature/humidity, motion, and gas) and IP cameras, in the previously studied artificial intelligence multiplex smart housing system application service, we have provided user recognition functions, through the monitoring local field environment information and the image processing. Sensing data and images are expressed through Web-based GUI, by being transmitted to Edge computers installed at the site through wired and wireless networks.

Based on this, the user can monitor the indoor environment in real time using a web browser with a server IP address, and can identify the approaching objects by using a face recognition function using a camera.

3.1 Construction of Artificial Intelligence Multiplex Smart Housing

In this paper, we constructed a basic test block by using sensor and IP cameras in order to conduct smart housing-based experiments for the construction of artificial intelligence multiplex smart housing systems. As shown in Figure 4. we conducted a basic experiment on the site by installing a local computer as an Edge computer.

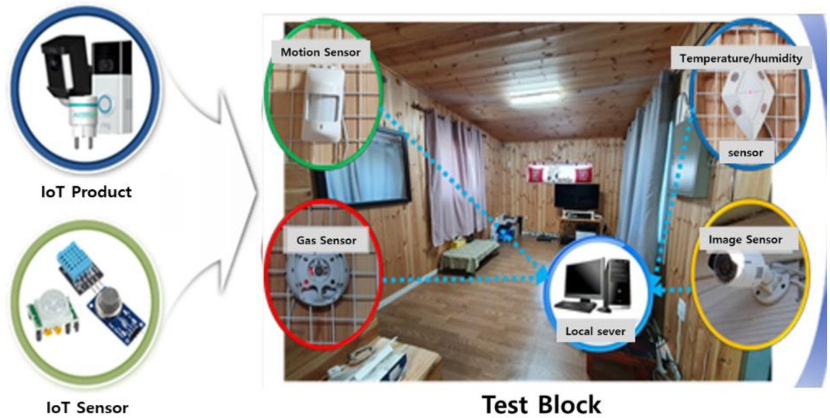

Figure 4. Test block for artificial intelligence multiplex smart housing

The researchers of the current project installed indoors temperature/humidity, motion, and gas sensors in order to build a basic test block for building an artificial intelligence multiplex smart housing system and installed outdoors an IP camera to identify external accessors.

By additionally installing existing IoT products such as IoT doorbells and smart plugs, we have established an environment in which users can monitor and control from the outside, using smart devices.

We have built a wired network indoors in order to collect sensor data. The camera installed at an outside spot can obtain video streaming data through a wireless network having an allocated IP address, where the obtained data is processed on the field PC in the test block through wired/wireless network, and the information is displayed through the data integration management UI we have developed.

As shown in the Figure, we installed a temperature/humidity sensor in the test block to measure the indoor temperature and humidity. The data collected in real time is delivered to the embedded board and finally to the Edge computer through serial communication.

3.2 Extracting Sensor Data Through Test Blocks

We conducted a study on sensor data extraction to deliver sensing data from the basic test block to the field server, and we have established a network to deliver sensed environmental data based on wire. The sensing data is delivered through the embedded board to the field PC.

In addition, data extracted using serial communication of the embedded board is transmitted to the field PC, and the field PC may check the received sensing data using a Python-based software program. Finally, data is delivered to the Web server through the MQTT protocol.

As shown in Figure 5. we installed an environmental sensor in the basic test block. To collect and process sensing data, the embedded board transfers the processed data to the on-site PC through a serial cable.

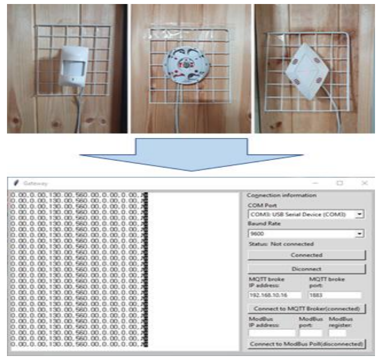

Figure 5. Test block for artificial intelligence multiplex smart housing

We developed a Python-based data gateway program for the PC to receive sensor data transmitted by the embedded board.

4. Artificial Intelligence Multiplex Smart Housing System

4.1 Integrated Data Management UI Software

As shown in Figure 6. we have constructed a basic test block using temperature/humidity sensors, motion sensors, gas sensors, and camera sensors, in order to conduct basic experiments on artificial intelligence multiplex smart housing systems. We have developed a data integrated management UI software that can collect and analyze environmental data and video streaming data, based on wired and wireless networks, in order to display information.

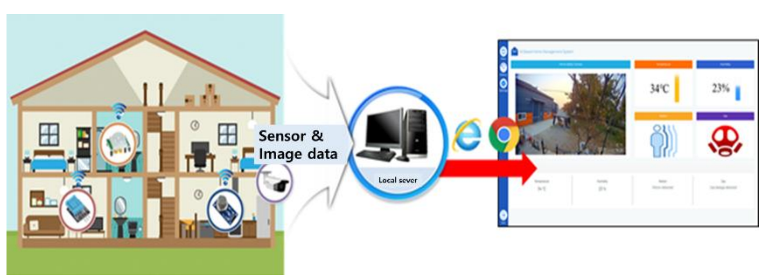

Figure 6. Data integrated management UI software

As shown in Figure 7. the integrated management UI of smart housing application service data developed based on Python can display face recognition functions based on sensor data and camera data used in the test block.

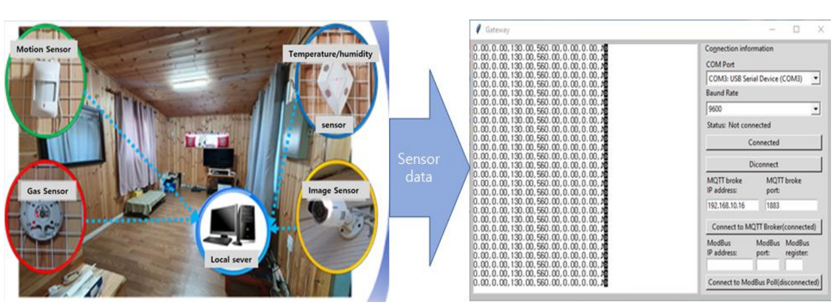

Figure 7. Extracting environmental data

As shown in Figure 8. sensor data installed in the test block is transferred to the embedded board on a wired basis, and the local PC receives sensor data from the embedded board through serial communication.

In addition, in order to finally display the collected sensing data to the user through the data integration management UI, the received sensor data is delivered to the Web server using the MQTT protocol.

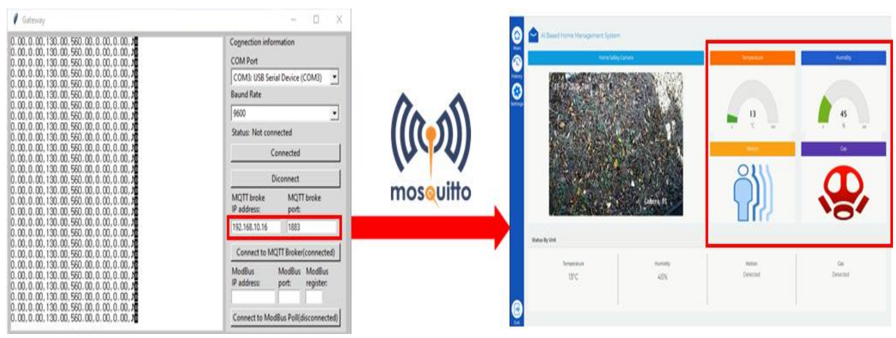

Figure 8. MQTT-based data transmission

As shown in Figure 9. IP cameras installed outside the test block are assigned unique IPs, so users can receive image data based on camera IPs regardless of time and place in an environment where the internet is available.

Figure 9. IP-based video data reception

We can distinguish between the person who is learned in the program from the inside of the frame and the person who is not registered, by using the Python-based face recognition program, developed for real-time video streaming data received based on IP.

Finally, the human face in the recognized frame is transmitted to the web server of the image frame, and the identity of the object currently approaching the camera in real time can be confirmed through the user UI.
As shown in Figure 10. when environmental data and image data are transmitted to the Web server using a wired/wireless network, the server displays information on each data through the corresponding UI item.

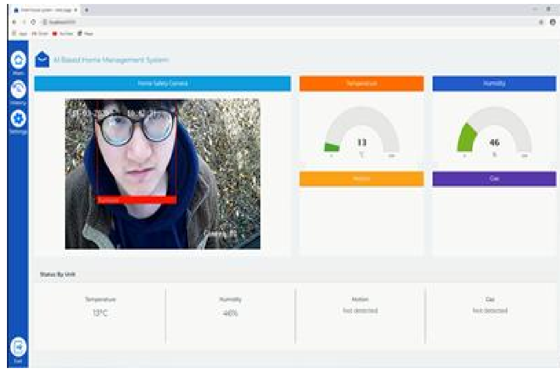

Figure 10. Extraction of environmental data

And in the case of analog data such as temperature/humidity data, the current indoor temperature and humidity are updated and shown at regular intervals, and
the digital sensors, such as gas and motion sensors, show a detection mark on the display item when an object is detected.

In addition, in the case of image data, the identity information of the approaching object is displayed in a square frame if the object is previously learned by detecting the accessor within the coverage, and in the case of unregistered objects, it is expressed as "Unknown" to tell that it is an unidentified one.

4.2 UI Configuration for Data Integration Management

Figure 11 shows the user UI of data integration management for test block, where user UI is largely classified as image and sensor data display.

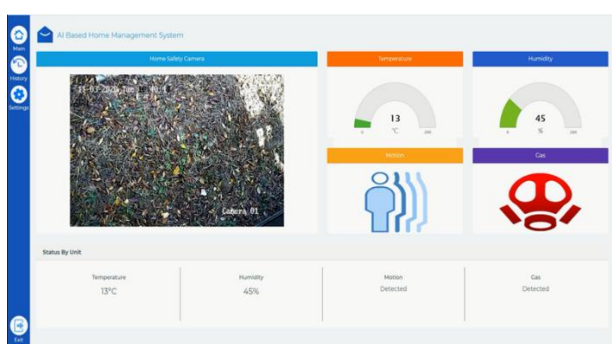

Figure 11. (UI) configuration for data integration management

In addition, the environmental sensor part is classified into icon type and text type.
As shown in Figure 12. the item on the left side of the user UI displays an IP camera image installed in the test block.

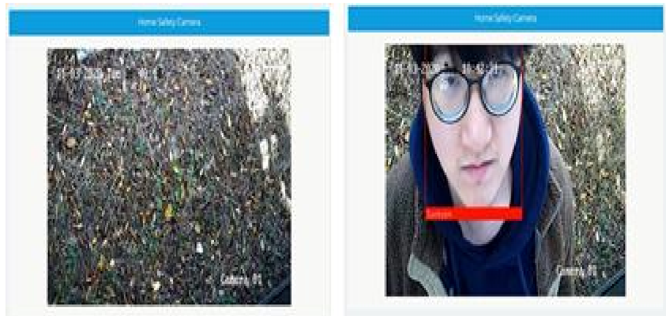

Figure 12. Image monitoring and face recognition

When a person approaches from outside, the identity of the person is displayed in a rectangular frame by using image processing according to whether the image is previously registered or not.

As shown in Figure 13. the environment sensor information installed in the test block is expressed in the right side of the user UI. In other words, data is indicated due to the sensor output method.

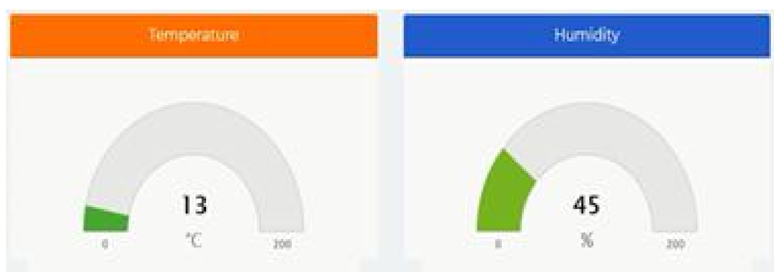

Figure 13. Temperature/humidity information

In the case of temperature and humidity sensors, the output can be expressed as a specific value by using an analog sensor. Therefore, we use the integrated data management UI we developed, in order to effectively express the current temperature and humidity values and numerical degrees by combining text and icons.

As shown in Figure 14. the motion and gas sensor represents a digital one that displays the output result to a digital value of 0 or 1. In the user UI, when the output result is 0, we do not display a specific icon.

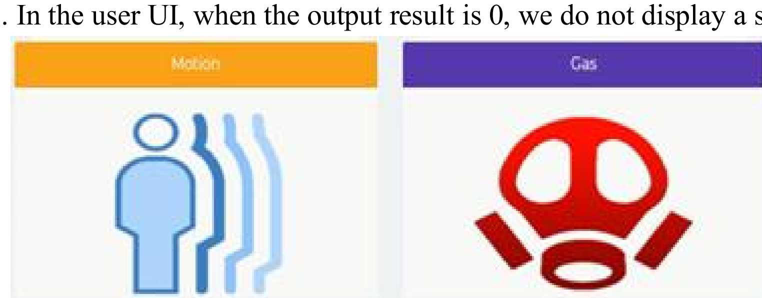

Figure 14. Motion and gas detection information

And when the output result is 1, we use one icon in order to express that an object has been detected.
These digital sensors are mainly used to detect accidents such as gas and fire. If it is linked with a device, such as a speaker, that can effectively notify the occurrence of an accident, the damage can be minimized because it can promptly notify when an accident occurs.

In addition, as shown in Figure 15. the integrated data management user UI software, developed by us, displays the entire data value from environment sensor in the form of text at the bottom of the UI, so in the case of digital sensors displayed only by icons, the results of current data status can be confirmed in the form of text.

Figure 15. Displaying the results of environmental data (text).

4.3 Experimental Results and Discussion

In this paper, we presented a basic test block, constructed by using various sensors regarding the user UI structure, in order to integrate and manage extracted data in connection with the test block for the artificial intelligence multiplex smart housing systems. In order to manage the extracted data, a Python-based user UI program was developed.

Figure 16. shows the temperature/humidity, motion, gas, and camera sensors used to construct test blocks for artificial intelligence multiplex systems. The environment and image data extracted according to the sensor are transmitted, wired or wireless, to the PC for Edge computer installed in the field

For environmental sensors, as shown in the Figure, if you use the gateway program, you can confirm the sensor data log transmitted through serial communication. When the address of the MQTT broker is set, serial data may be transmitted to the web server.

When the allocated IP address is identified, image data may be accessed to image streaming data. Therefore, when an outsider is captured inside the image frame recorded in real time, the identity of the approaching person can be determined by using the face recognition function by applying the image processing technique.

And through MQTT and IP addresses, the finally processed environment and image data are transmitted to the server and displayed to the user through a user UI for integrated web-based data management.

By transmitting data extracted from the installed sensor in connection with the installed test block to the web-based integrated management UI software, it shows the overall operation method that provides user monitoring functions.

In addition, by analyzing the environment and image data received from the server, the data integrated management UI software displays information in an appropriate form, based on the data, so that the user can clearly grasp the collected information.

In case of the camera sensor that can detect the appearance of video data based on IP, the function of grasping the identity of the approaching person can be provided by recognizing the face using the technologies of the image processing and real-time external monitoring.

And in the case of a digital sensor, since the display of the icon is changed according to the presence or absence of the detection target, the user may grasp the current situation.

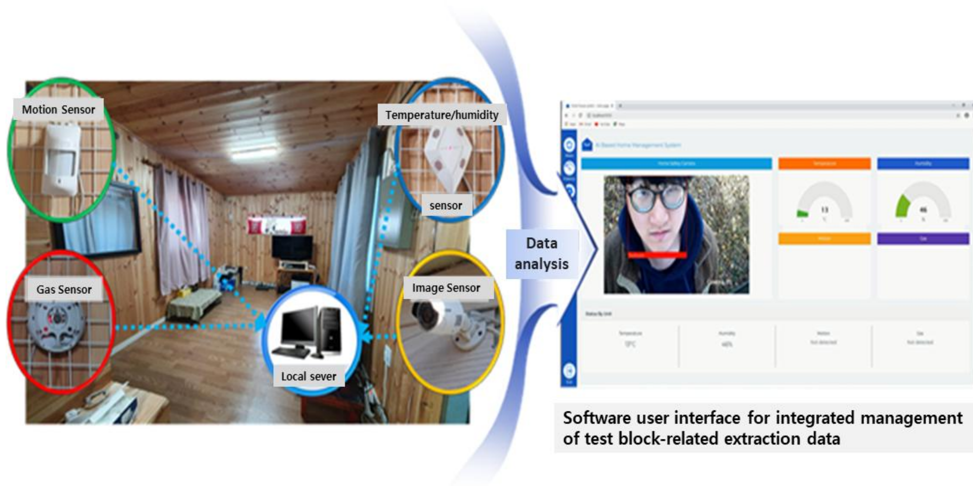

Figure 16. Integrated management of cast block-linked data.

5. Conclusion

In this paper, in order to develop an artificial intelligence multiplex systems, we have presented a performance study on the UI structure capable of integrated management by extracting lightweight data linked to a test block. We actually constructed a basic test block for cases of smart housing application by using various sensors and conducted experiments to confirm the basic performance.

We have constructed a network, based on the wired or wireless, so that on-site Edge computers can analyze environmental sensors and image data extracted from the installed test block, and have confirmed that environmental data was finally transmitted to the Web server through the MQTT protocol. By applying the Python-based face recognition function, we confirmed that the image data is displayed through the integrated management user UI of the web-based data by identifying the person approaching in the frame.

If the overall performance is upgraded based on the results of our research, it is possible to monitor and control the place and space, and it is thought that the user's convenience will be maximized, by applying our results to various environments.

In the future, if we upgrade the test block by using additional sensors and improve the function and design of UI software through integrated data management in connection with the test block, our research results will be able to be utilized for more diverse purposes.

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