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Internet of Things Technology and Open Data: Application of Indoor Air Control

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Home is a place for people to relax and to feel secure. However, there are some external factors, such as temperature and humidity, making living conditions uncomfortable. With the development of Internet of Things (IoT) technology, the research issue of smart home becomes more important. The purpose of this study is to explore the application of IoT technology in indoor air monitoring and control, combined with the analysis of outdoor air quality data. This study develops a prototype system and tests and evaluates the performance of the system through user trial reports. The results show that (1) Air comparison of indoor and outdoor are practical for users, (2) Through the transmission of Bluetooth, restrictions on the practicality should be achieved through the WiFi remote monitoring effect, (3) It can receive multiple sensors at the same time, to achieve multiple indoor space monitoring effects, (4) It can be combined with other home appliances, if the integration of home appliances control will be more practical, (5) The current database is only a record, has not developed other applications, and in the future can develop predictive applications. We hope that through this study, we will provide some suggestions for the application of innovative technology in smart home.

Keywords: Internet of Things, open data, smart home, mobile applications, sensor

Introduction

Internet of Things (IoT) is not an extension of a single network, but a system that coexists with the Internet and mobile communication networks. The International Telecommunication Union (ITU), in its report of 2005, pointed out that the “Era of Internet of Things is coming”, which attracted countries attention to the development of IoT. Stojkoska and Trivodaliev (2017) think that IoT represents a worldwide network of uniquely addressable interconnected objects. According to Gubbi, Buyya, Marusic, and Palaniswami (2013), IoT is an,

> Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics and information representation with Cloud computing as the unifying framework.

Atzori, Iera, and Morabito (2010) point out the main strength of the IoT idea is the high impact; it will

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have on several aspects of everyday-life and behavior of potential users. From the point of view of a private user, the most obvious effects of the IoT introduction will be visible in both working and domestic fields. In this context, domestics, assisted living, e-health, enhanced learning are only a few examples of possible application scenarios in which the new paradigm will play a leading role in the near future.

Nowadays, many papers have focus on the feasibility of smart home based on the progress of IoT technology. Soliman, Abiodun, Hamouda, Zhou, and Lung (2013) think that smart home minimizes user's intervention in monitoring home settings and controlling home appliances. Li and Yu (2011) present the design of a smart home system based on IoT and service component technologies. Stojkoska and Trivodaliev (2017) emphasize although IoT brings significant advantages over traditional communication technologies for smart grid and smart home applications, these implementations are still very rare. They hope to maintain a safe and stable indoor air environment and reduce the occurrence of disasters, such as, carbon monoxide poisoning, fire, gas explosion, damp allergy, and so on. That can be effective preventive steps, so that human beings can live in a safe environment, and create a peaceful society. In this study, the technology of networked environmental monitoring system is used to combine with the open platform of public data, so that indoor air monitoring can be compared with the external environment. This allows the user to make a more accurate judgment, making appropriate response.

The purpose of this study is to explore the application of IoT technology in indoor air monitoring and control, combined with the analysis of outdoor air quality data. There are two key points in this study. First, it is the real-time monitoring. By means of IoT technology, coupled with intelligent mobile devices, and initial testing of all sensors detected by the data, it can real-time display in the mobile device, and make corresponding recommendations. Second, it is the open data. In addition to receiving general sensor information, it is possible to combine open data. We hope to make a more accurate suggestion and expand its application through the combination of IoT technology with the surrounding environment.

Literature Review

Internet of Things (IoT)

In the Internet of Things (IoT) paradigm, many of the objects that surround us will be on the network in one form or another. Radio Frequency IDentification (RFID) and sensor network technologies will rise to meet this new challenge, in which information and communication systems are invisibly embedded in the environment around us (Gubbi et al., 2013). It enables the physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network. D. X. Li, He, and S. Li (2014) point out IoT has provided a promising opportunity to build powerful industrial systems and applications by leveraging the growing ubiquity of RFID, and wireless, mobile, and sensor devices. On the IoT, everyone can apply electronic labels, connect real objects, and find their actual location through the IoT. Through the IoT, you can use servers and devices for centralized management. It can also be used for home appliances, cars remote control, as well as search locations to prevent the theft of goods and so on. At the same time, the data can be collected, integrated into big data, including the redesign of roads to reduce accidents, urban renewal, disaster prediction and crime prevention, epidemic control, and other social changes.

Smart Home

Home security is a very important part of human life. Houses that reside in a potentially dangerous

physical structure may cause personal injury or death. In urban life, there are some risks that threaten the safety of families and lives. It includes gas leakage, fire, air pollution, theft, and so on. In order to prevent home security threats and potential risks, people need to know the quality of life in real-time information in order to understand the status of home security. Smart Home promises the potentials for the user to measure home conditions (e.g., humidity, temperature, luminosity, etc.), manipulate home HVAC (heating, ventilation, and air conditioning) appliances, and control their status with minimum user's intervention (Soliman et al., 2013). Sivaraman, Gharakheili, Vishwanath, Boreli, and Mehani (2015) present the increasing uptake of smart home appliances, such as lights, smoke-alarms, power switches, baby monitors, and weighing scales, raises privacy, and security concerns at unprecedented scale, allowing legitimate and illegitimate entities to snoop and intrude into the family's activities.

Embedded System

Embedded systems are widely used in daily life. From MP3 Walkman and personal digital assistant (PDA) to now, everyone has mobile phones or smart phones, which are embedded system products applications. Embedded system is portable, hardware specifications and personal desktop computer slightly different. The most common use is ARM (Advanced RISC Machine) CPU. There are many issues in the research of embedded system, including development platform to build real-time operating system execution environment, developing applications in the operating system, writing and developing the underlying driver, research on different bus hardware architectures, and research on HW/SW co-design, or an ARM CPU plus DSP for operational acceleration.

Open Data

The availability of open data has grown significantly, with pressure being placed on all kinds of public organizations to release their raw data. Some main motivations are that open access to publicly funded data provides greater returns from the public investment, which can generate wealth through the downstream use of outputs, provide policy-makers with data needed to address complex problems and can help to involve the citizenry in analyzing large quantities of data sets (Janssen, Charalabidis, & Zuiderwijk, 2012). Bertot, Gorham, Jaeger, Sarin, and Choi (2014) think the transformative promises and potential of Big and Open Data are substantial for e-government services, openness and transparency, governments, and the interaction between governments, citizens, and the business sector.

Research Methods

As the market does not provide the relevant products that combine indoor air quality with open data, in order to fully understand the status of open data combined with indoor air quality monitoring, this study has developed a prototype system for evaluation. In information management field, Nunamaker (1991) proposes five steps to focus on system development; this study follows these steps, to build our prototype system, so please refer to Figure 1.

The research about smart home has a common point, mostly taking the Anti-Theft series as the spindle (such as: reed switch, face identification); a few studies add air quality sensing, and display on the mobile device and cloud monitoring. However, these studies often overlook the assessment of the external environment; in fact, we have to pay attention to the pollution of the environment, the impact on human health. The purpose of this paper is to explore how to compare the internal and external environment data in real-time by means of

hardware sensing devices and intelligent devices and the open environment data provided by government agencies, so that users can make correct judgments based on the results.

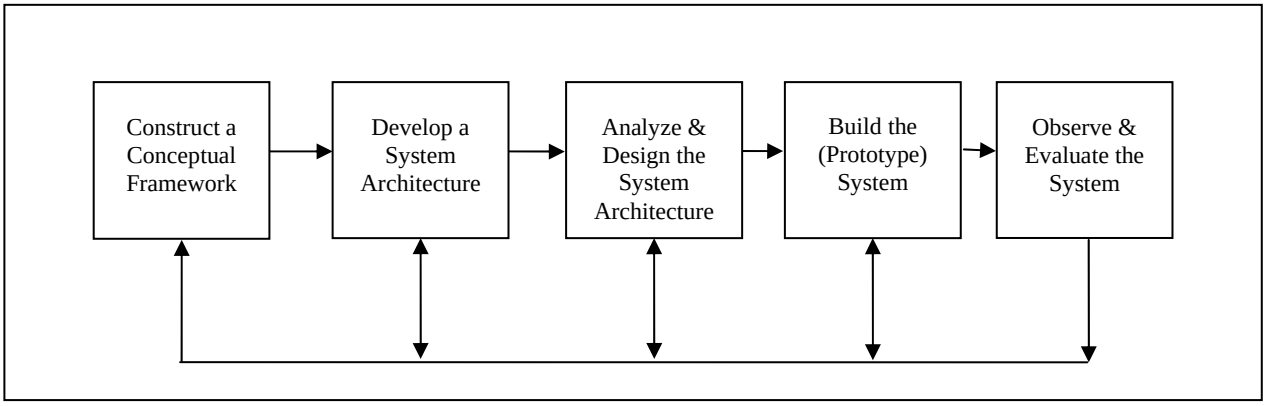

Figure 1. Systems development research process.

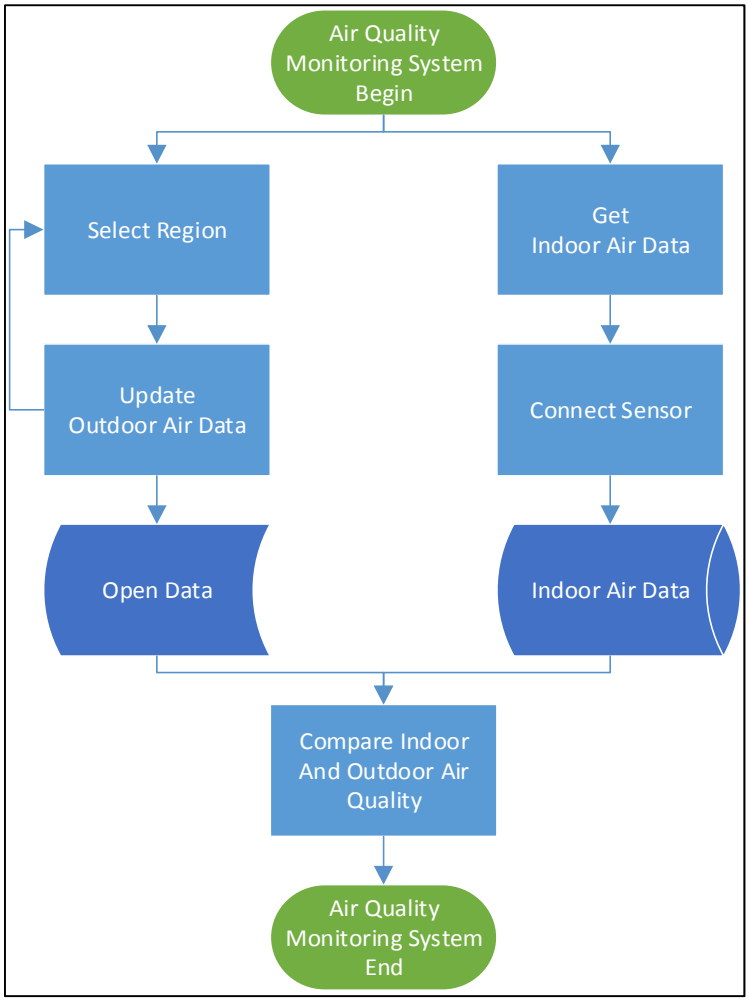

Figure 2. Flow chart of the prototype system.

In the related products, the current air monitoring system in the market is mainly based on indoor air data. In the selection of air detection system, consumers are more focused on the function; less can have considered

the outdoor air condition system simultaneously. Users often can only switch between two functions to interpret the data. This does not make any difference to switching between two of mobile applications, and the data that have not been processed is of little value to the user. Therefore, in the design of air monitoring system, this study from the sensor to obtain indoor air quality data, and outdoor air quality open data to compare, will be compared to the situation, to provide users as a decision reference. In this paper, we present the related system operation process, so please refer to Figure 2.

The data on indoor air quality are the use of Sharp GP2Y1051A fine suspended particulate sensor to collect data, through the Arduino UNO Development Board to process into useful information, and transfer data through the HC-05 Bluetooth module to the mobile device. For the part of the mobile device is to use App Inventor 2 to make an Android application, in addition to receiving data from the Arduino UNO Development Board, and also from the Internet to update air quality data from the EPA's Air quality monitoring network. Further we can compare two kinds of data, and put these data into the database in case of subsequent use. The system design and operation Architecture environment is shown in Figure 3.

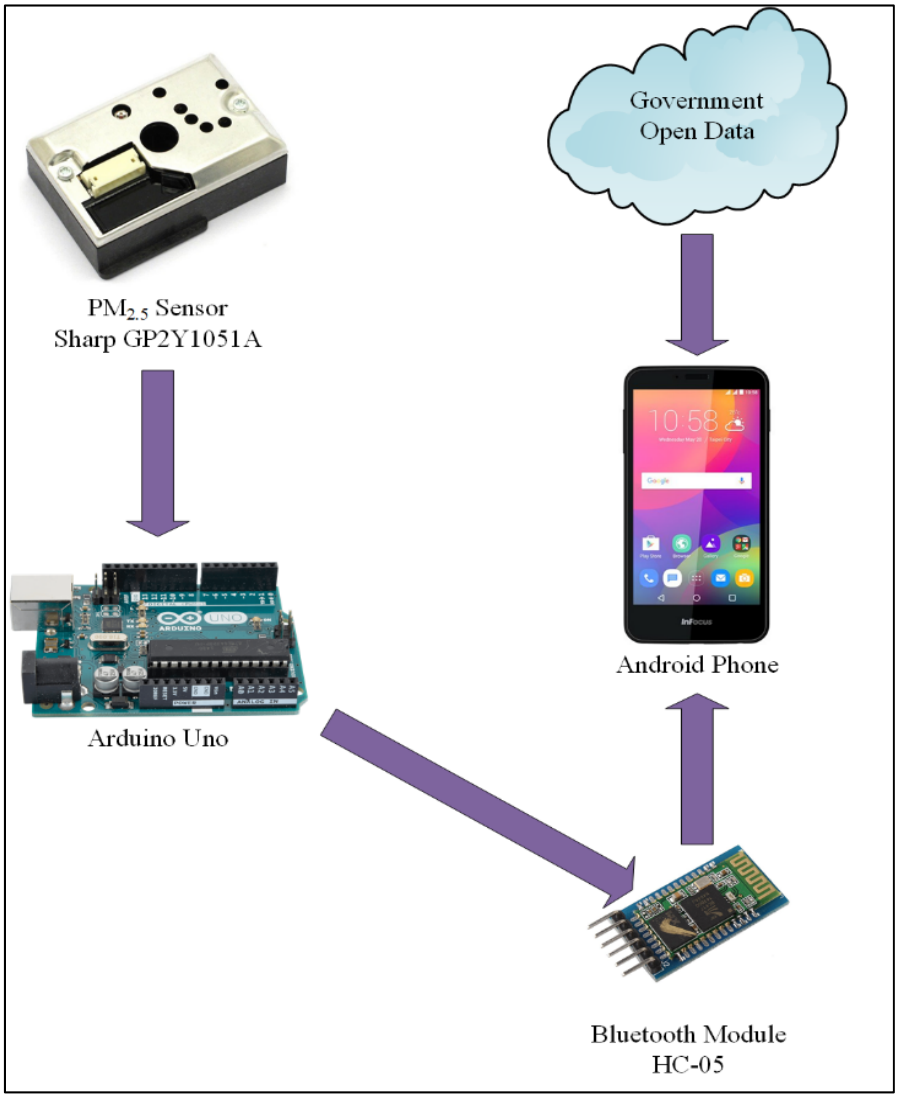

Figure 3. System environment.

Systems Implementation and User Assessment

In this study, we used the embedded system Development Board to enable the sensor to operate, hardware from the Arduino UNO Development Board combined with fine suspended particulate sensor and Bluetooth communication module, data transfer to the mobile device. In this study, a mobile device was used to receive data from a fine suspended particulate sensor through a blue bud and to receive government open data through the Internet. The script's arrangement uses the Bluetooth module built in App Inventor 2 to display the Bluetooth device that is found in a list column, allowing the user to choose. The indoor Air quality sensing system composed of Arduino Uno development version, Sharp GP2Y1051A fine suspended particulate sensor, and HC-05 Bluetooth communication module, can be used in any place after the development of Arduino program is completed.

We've got some voluntary users to try out and interview, the process as follows:

(1) The user operates the "Indoor air Monitoring System" for 5-10 minutes.

(2) The user to the prototype system to propose personal participation process or use of experience.

(3) Comments and recommendations on the use of the "Indoor air Monitoring System".

Finally, according to these users, the suggestions and comments are listed below:

(1) Air comparison of indoor and outdoor is practical for users.

(2) Through the transmission of Bluetooth, restrictions on the practicality should be achieved through the WiFi remote monitoring effect.

(3) It can receive multiple sensors at the same time, to achieve multiple indoor space monitoring effects.

(4) It can be combined with other home appliances, if the integration of home appliances control will be more practical.

(5) The current database is only a record, and has not developed other applications; the future can develop predictive applications.

Conclusion

Users can achieve real-time monitoring through the prototype system, in addition to displaying real-time indoor air quality data, and directly inform the data located in which type of severity, to help users intuitively understand the current indoor air quality status. This prototype system can receive open data and compare with real-time data of indoor air quality, which can help users intuitively compare indoor and outdoor air quality, without switching between different mobile devices and applications.

Due to time constraints, the Arduino Development Board is only used in the part of the Blue Bud module and the mobile device to do data transmission, thus restricting the mobile device can only operate in the Bluetooth module wireless signal range, in the future may consider using wireless network modules to transmit data. The establishment of a server to the indoor air quality data back to the server, through the password security mechanism, can let different users see in any place in the home of air quality, in addition, through the Electromechanical control module to connect the home appliances, but also in the outdoor control home appliances operation. In this study, the function of querying historical data is only used to construct TinyDB as storage indoor air quality data for the purpose of the time limit. In the future, if the service is built on the server, the data can exist in the server, in addition to reducing the space occupied by the mobile device program, data analysis, and predict the possible future changes in indoor air.

This is an experimental indoor air monitoring system, which can only show the data of indoor air quality and the outdoor air quality data of Open data through the mobile device program; it can provide the user practical information, and also help the user to make the decision. The following difficulties may arise in applying the structure proposed by the Institute in the actual operation of the relevant products: (1) Functional design considerations are not comprehensive. In the initial selection of the relevant experimental plates and components, considering the system development and the hardware cost, so only through the Bluetooth transmission data to the mobile device, the sensor part also uses only the sharp GP2Y1051A fine suspended particulate sensor as the pointer data, so the embryonic system is limited to the function. (2) The evaluation of the experimental system is limited. As the voluntary users in this study do not necessarily have the actual demand for air quality when using the system, it is necessary to further explore whether the advice provided is in line with their needs.

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