

Smart Home and Thermal Imaging Technology for COVID 19 Detection Using the Internet of Things (IoT)

Ahmed Jameel Ismael¹, Herlina Abdul Rahim^{1*}, Rashidah Ghazali¹ and Khalid Naji Mezher²

¹School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

²Mechanical Engineering, Technology University, Baghdad, Iraq.

*Corresponding author: herlina@utm.my, Tel: 607-5537804

Abstract: The Internet of Things (IoT) is a technological advancement that is rendering the world progressively intelligent. Without IoT technology, the concept of a connected world would be inconceivable. The number of people infected with the coronavirus is on the rise. Most of them are ignorant about the virus's most common symptoms: fever or high body temperature. Owing to the rapid spread of the disease, infrared thermometers are being used everywhere to measure body temperature in places with a large population. This action is extremely effective in stopping the disease from spreading. This study identifies and outlines the features of current infrared imaging technology for thermal imaging in smart home doorbell technologies, as well as their benefit in detecting the covid-19. This technology makes use of infrared rays that are naturally emitted from the skin's surface. When a high-temperature body is detected, the thermal camera generates infrared spectra with high-intensity levels. Virtual Reality (VR) was also used to monitor and manipulate the cameras, and it was connected to the IoT. This smart doorbell system uses an infrared temperature sensor to detect visitors' body temperatures as they approach. If the doorbell detects a temperature, it will trigger a sound and illuminate corresponding LED lights to warn the visitor. The screening procedure, which involves the detected face and the detected body temperature, will be shown on the monitor. A visitor will be given an alert if their body temperature is too high.

Keywords: Coronavirus, Doorbell, Infrared Imaging Technology, Thermal Camera, IoT.

© 2021 Penerbit UTM Press. All rights reserved

Article History: received 25 May 2021; accepted 12 June 2021; published 15 September 2021.

1. INTRODUCTION

Smart homes, is an integral consideration of the Internet of Things (IoT), provide excellent service to consumers by connecting with a range of IoT-enabled digital devices. Both smart home systems, in the perfect version of a wired future, interact with one another seamlessly. IoT-based smart home technologies have revolutionized human life by introducing connectivity to everyone, regardless of time or place. For open access doors, home access systems are widely used.

A database with the identification features of designated individuals is utilized in a usual structure. When an individual method the access control, his/her identity qualities are immediately gathered as well as compared to the database. If the data source information matches, access is granted; otherwise, it is denied. When it comes to an extensively distributed institute, the integration of innovation and services by house networking for a much better lifestyle is referred to as wise home.

Smart homes use various technologies to equip home components for more intelligent monitoring and remote control, as well as to enable them to interact harmonically, allowing everyday housework and tasks to be automated without user intervention or with the user's remote control in an easier, more convenient, more efficient, safer, and

less expensive manner. Wireless and wired home intercom systems make it easier for families to answer the door and remain connected in the house.

The Internet of Things (IoT) [1] plays an important role in the design of a smart house. Almost every item in our everyday lives in our homes can be linked to the internet through IoT. IoT enables all these related objects to be monitored and controlled at any time and from any place [2]. Now that COVID-19 is in effect, we are all being a lot more cautious about who we associate with, particularly at home. However, determining whether someone who comes to the front door, whether family or a delivery person, has COVID-19 symptoms is not always easy.

Early detection of coronavirus symptoms will be one of the most effective methods of preventing the virus's spread. High body temperatures are one of the most common symptoms, so a real-time screening system that displays a thermal image of their temperature is needed. As a result, the screening process diagnosis will take less time, and there will be fewer human encounters that may hasten the spread of the coronavirus. It is possible to conclude that remote sensing and detection technology, which offers a variety of methods for detecting, screening, and monitoring coronavirus, offers a high degree of assurance and potential.

2. LITERATURE REVIEW

2.1 Smart Home Functions

Applications designed on top of IoT infrastructure make up a smart home framework. The following are some of the key features that smart home apps can provide [3], [6-19].

2.1.1 Alert

The smart home system will detect it and send notifications to the user via their registered computer or account. The information in the warning is linked to environmental data. This data may include the concentrations of various gases in the atmosphere, as well as temperature, humidity, and light intensity. The consumer may receive a warning regularly at a predetermined time. Alerts may be sent via email, text message, tweets, or any other form of social media [4].

2.1.2 Security

Security is one of the most vital elements of a smart house. With the help of numerous sensors and camera feeds, an intelligent house will track its environments. Surveillance is an important feature considering that it keeps an eye on all behavior in a clever house, which is the main requirement whereupon any subsequent activity or choice can be made. As an example, tracking area temperature level and alerting the consumer to turn on the air condition unit if the temperature level rises above a specific degree.

2.1.3 Control

This smart home feature allows the user to monitor a range of activities. Switching on/off lights, air conditioners, and appliances, locking/unlocking doors, opening/closing windows and doors, and many other things are possible [5]. Things can be controlled by the user from the same location or at a remote location. This feature also helps users to automate activities such as turning on/off the air conditioner when the room temperature rises or falls. Consumers benefit from smart homes because they can integrate energy-saving features such as lighting, air conditioning, and home appliances.

2.1.4 Intelligence

The most important feature of a smart home is intelligence, or home intelligence (HI), which refers to the intelligent behavior of the smart-home environment [4]. This role is concerned with making decisions based on the occurrence of different events. The Artificial Intelligence (AI) mechanism built into the smart home ecosystem is essential to HI. HI not only serves as the brain of the smart house, but it is also critical for home security [4]. HI provides an integrated smart home ecosystem in which the AI mechanism can recognize and react appropriately to changing conditions and events. HI will alert the user and provide an immediate automated response if irregular or unusual events are observed. For example, when a user arrives, automatically prepare coffee, send an alert to the user if suspicious behavior is detected at the door or inside the building, automatically order supplies if there is a

shortage in the refrigerator, and send a notification to the electrician/plumber if maintenance is needed [4]. Smart homes will take energy efficiency a step further by monitoring the energy consumption of each appliance in the building. The service of high-power-consuming appliances could be scheduled by smart house controllers.

2.2 Advantages of Smart Home

Home networking can additionally give you complacency. The smart house can keep you informed of what is taking place whether you go to job or on holiday, and safety and security systems can be set up to give a good deal of assistance in an emergency. Not only will a resident lookout for an emergency alarm, but the clever residence would certainly additionally open doors, call the fire department, and light up the course to safety and security.

Smart houses will certainly likewise aid you to conserve cash on energies. Considering that systems like Z-Wave and ZigBee limit the flexibility of certain gadgets, they will certainly "rest" as well as get up when commands are released. Electric costs are reduced when lights are turned off immediately after a person exits the room, and areas can be heated or cooled depending on the conditions at any given time. Some devices can control how much power each household appliance uses and even instruct it to use less.

Smart house innovation provides a lot of assurance to a senior citizen who lives alone. For instance, smart home could notify residents when it was time to take medicine, send an emergency warning to the hospital if they suffer an emergency, and keep track of their meal's routines. It also motivates adult youngsters who might live elsewhere to be associated with their elderly parent's treatment. People with disabilities or a limited variety of movement will certainly take advantage of automated systems that are easy to run.

2.3 Intercom System of a Smart Home

A home intercom system adds a layer of protection to your smart home, giving you peace of mind. Smart intercoms with doorbell video units enable you to see and communicate with visitors at your front door, in addition to providing seamless communication inside the house. The intercom's smart integration with your home security system allows you to make the most of technology.

Installing a home intercom device allows you to communicate and interact with others in your house. There is no need to scream at the top of your lungs when you can communicate with family members in any room of the house with the click of a button (or a seamless voice command!). You can connect with your family from anywhere in the house or even across town with web-based IP-enabled intercom units!

For families with young children, the elderly, and people with special needs, home intercoms are a godsend. From every part of the building, one can easily keep an eye on babies or check in on elderly people. Elders will enter the family talk from the comfort of their beds using internet-enabled video intercoms. They are also useful as a medical warning system, particularly if you have elderly

or differently abled family members.

There is no doubt that home intercom systems are extremely useful. The doorbell can be answered without looking through the peephole or getting up. With smart door release systems, you can check on visitors remotely and even open the front door! Apart from eliminating the need to shout to reach family members, two-way intercom systems are often simple to use for those who are less tech-savvy.

You can play music in any room of the house with Bluetooth networking or wired connections to your music system with the new home intercom systems. On-demand music is right at your fingertips! The latest generation of home intercom systems undoubtedly adds a powerful punch to your smart home. The humble intercom has developed into a cutting-edge digital system that can communicate with water meters, switches, and other smart devices. The intercom is a must-have in your smart home for convenience, added security, and productivity!

2.4 Various Types of Intercom Systems

The single-line, single-button door buzzer panel has long been replaced by intercom solutions. Intercom is emerging as the potential central hub system for audio and video connectivity in communication and building management environments. Intercoms are available in a range of designs. Others are incredibly simple to use, while others can be extremely difficult. Audio intercoms, video intercoms, integral intercoms, and multi-tenant intercoms are all available.

Intercom systems come in a range of types and designs. Some of the designs are straightforward, while others are more complex. There are intercom devices that are explicitly built for purposes, in addition to the various interface features. For example:

2.4.1 Wired Intercom Systems

The wired one's significant advantage is that it provides extra personal privacy and safety and security in the direction of intrusion assaults from other systems.

2.4.2 Wireless Intercoms

In situations where wires cannot be run, a wireless solution is used.

2.4.3 Security intercom systems

Safety and security intercom systems are utilized to provide voice communications around two or even more places for security purposes. Intercom systems are widely used to communicate between a locked building entrance and a regularly managed area inside the building.

2.4.4 Apartment Intercoms

A visitor presses the appropriate button for the apartment they want to speak with, and the occupant responds by speaking and then pressing a button to unlock the door.

2.4.5 Video Intercom

An entrance unit with a display, audio speaker, and push-

button, in addition to an internal control device that can communicate with the entrance unit, are typical components.

2.4.6 Two-Way Radios

Two-way radios are used to communicate with base station intercoms. Therefore, can use a handheld radio for long-distance interaction while still having the functionality of a fixed intercom.

3. METHODOLOGY

3.1 Thermal Imaging and Temperature Measurement

Thermal imaging is a clear term. Infrared radiation is given off by all artefacts above absolute zero (0 Kelvin). Although infrared radiation is undetectable to the nude eye, unique video cameras referred to as thermal imagers can spot and view it. These cameras pick up a things' infrared radiation and change it to a black and white or various colored picture on a display screen, with the various tones or shades representing the thermal patterns around the things' surface (Figure 1). While thermal imaging video cameras have a variety of benefits for this form of application, several aspects can affect the accuracy of the information gathered. Both false favorable, as well as incorrect adverse analyses can be produced by these variables.

Many readily available infrared tools that can gauge surface temperature are presently offered as shown in Figure 2. Imaging radiometers, non-contact radiometers, and call infrared thermostats, such as those made use of to check the temperature inside a client's ear canal, are all examples of these. Several variables can adversely influence observed temperature levels by using any kind of devices that gauges temperature levels around the surface area of the body. Understanding just how radiometers operate as well as the elements that influence the accuracy of observed temperature levels is critical to identifying the feasible resources of a mistake related to non-contact infrared temperature level measurement. Error Sources for non-contact infrared temperature measurement human body, environment, test equipment.

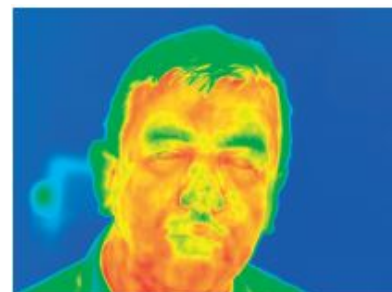


Figure 1. IR thermal images

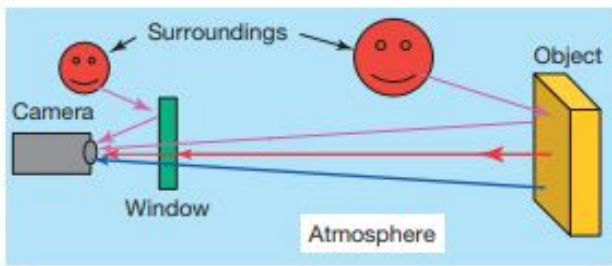


Figure 2. Various signal contributions entering an IR camera due to external influences.

3.2 Smart Home System

To enable all the above-described activities and data management, the system is composed of the following components, as described in Figure 3.

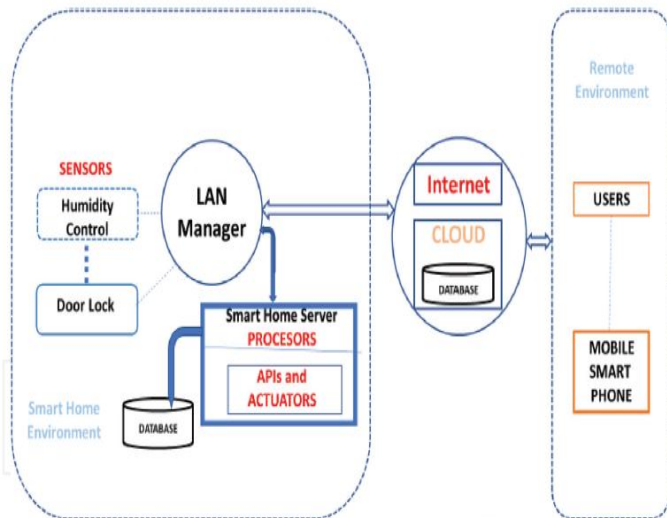


Figure 3. Smart home paradigm

- (i) Sensors gather and measure data from inside and outside the house. These sensors are related to both the home and the devices that are connected to it. These are not the internet of things sensors that are connected to household appliances. The data from the sensors is collected and sent to the smart home server regularly through the local network.
- (ii) Processors that conduct both local and global acts. It may also be linked to applications that need more capital. The data from the sensors is then processed by the local server.
- (iii) External applications may execute a set of software components wrapped as APIs if they follow the pre-defined parameter format. An API like this can process sensor data or handle needed behavior.
- (iv) Actuators are used in the server or other control devices to provision and execute commands. It converts the necessary action into command syntax, which the system can then execute. The role checks whether any rules have become valid when processing the data from the sensors. The machine may then send a command to the appropriate computer processor.

- (v) The generated data obtained from the sensors and cloud services will be stored in a database. It will be used for data interpretation, data visualization, and data presentation. For future usage, the stored data is saved in the attached database.

3.3 System Description

The intercom is fitted with a thermal camera, which enables exact temperature as well as face information to be gathered. A thermal video camera was used to identify the temperature level at which the various concentrates of passion were uncovered. This component is about an approach of picture segmentation based on the tape-recorded temperature level and colored pictures accumulated by the thermal video camera.

The thermal camera is used for hot body detection and recognition by taking on the high-temperature irregularity contrasted to other things within the checked location [6]. If the high-temperature body is envisioned by the thermal camera, it produces high strength levels of the infrared ranges. Additionally, the video cameras will be run and regulated by Virtual Reality or Virtual Reality. The presence of Virtual Reality will certainly be combining with the IoT. This clever buzzer system can take the body temperature of site visitors when they come close to making use of an infrared temperature level-sensing unit. If it spots a fever, the doorbell will certainly make use of audio and coming with LED lights to advise the visitor.

Virtual reality is made use of together with online video tracking to direct the electronic camera to scan individuals since the drone is operated by the pilot to the specified stage.

After obtaining details concerning an individual's body temperature, the microcontroller that had these observations transferred to it over the Internet could provide self-service online access to this data.

When the thermal camera senses a body with heat, the tool informs the worried person of the risk. Besides, the device can take a photo and send it to the individual who is concerned.

Utilizing an infrared temperature sensor, this smart buzzer device will find site visitors' body temperatures as they come close to. The doorbell would utilize audio and equivalent LED lights to signal the guest if it senses a high temperature.

4. RESULTS AND DISCUSSION

Thermography is the best technique for scanning individuals and large numbers of people in a non-intrusive and contactless manner from a distance [6]. To do so, the temperature is measured, and an alarm is activated if it exceeds the normal threshold.

This helps people with elevated body temperatures to be easily and accurately detected and separated for further examination. As shown in Figure 4, this smart device detects high temperatures automatically through screening images, allows faster diagnoses, and reduces the risk of human error.

The screening procedure, which involves the detected face and the recorded body temperature, will be shown on the screen. The database also stores the recorded face and temperature. After the data is exchanged from the mobile, the Householder and administrator will access the

screening result. The visitor will be alerted via a warning as soon as a high body temperature is detected.



Figure 4: the captured body temperature by a doorbell camera

5. CONCLUSION

Today's residences have effective computation and networking capacities thanks to the fast growth of the Net and interaction technologies. An IoT-based wise house is getting momentum as an essential element of the smart and smart cities that are being intended as well as built all over the world. A clever home's goal is to enhance living criteria, security, and safety and security while additionally saving power and resources. The clever house is crucial to the improvement of society.

Doorbell innovation with a sensor and a thermal video camera to detect the temperature of a site visitor COVID-19 would be much less usual as a result. COVID 19 would certainly be less common as a result. A fever or raised body temperature, on the other hand, is just one perspective sign of a COVID-19 infection. When made use of properly, thermal imaging systems can dependably detect a high body temperature. They do not seek any other indications of infection, as well as many people with COVID-19, which can be transmittable even if they do not have a high temperature. Besides, a high body temperature level does not constantly indicate that a person is infected with COVID-19. Given that remote thermal imaging does not require a person to look at the patient, it is an affordable technique. Consequently, this procedure is extremely effective in stopping the spread of the coronavirus from infected individuals to the individual carrying out the testing.

ACKNOWLEDGMENT

The authors wish to thank the University Teknologi Malaysia (UTM) for financing this research.

REFERENCES

- [1] Nevon Projects "IoT Patient Health Monitoring Project." Retrieved from: <http://nevonprojects.com/iot-patient-health-monitoring-project/>
- [2] G. Kortuem, F. Kawsar, D. Fitton, and V. Sundramoorthy, "Smartobjects as building blocks for the Internet of Things," *IEEE Internet Comput.*, vol. 14, no. 1, pp. 44–51, Jan./Feb. 2010.
- [3] L. Columbus, "2016 Internet of Things (IoT), Big Data & Business Intelligence Update", *Forbes Magazine*, Oct.2, 2016. Retrieved from: <https://www.forbes.com/sites/louiscolombus/2016/10/02/2016-internet-of-things-iot-big-data-business-intelligence-update/#144b6b614923>
- [4] T. Malche, P. Maheshwary. "Internet of Things (IoT) for building smart home system", 2017 *International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (ISMAC)*, 2017
- [5] M. A. Jabraeil Jamali, B. Bahrami, A. Heidari, P. Allahverdzadeh, F. Norouzi. "Chapter 4 Some Cases of Smart Use of the IoT", *Springer Science and Business Media LLC*, 2020
- [6] S. B. Udgata, N. G. Kumar Suryadevara. "Internet of Things and Sensor Network for COVID-19", *Springer Science and Business Media LLC*, 2021
- [7] L. Mainetti, L. Patrono, and A. Vilei, "Evolution of wireless sensor networks towards the Internet of Things: A survey," in *Proc. 19th Int. Conf. Softw., Telecommun. Comput. Netw. (SoftCOM)*, Sep. 2011, pp. 1–6
- [8] A. DelVecchio, A. DelVecchio, "IoMT (Internet of Medical Things) or healthcare IoT".
- [9] Y. Ma, Y. Wang, J. Yang, Y. Miao, W. Li, "Big Health Application System based on Health Internet of Things and Big Data", *IEEE Access*, Year: 2016, Volume: PP, Issue: 99, Pages: 1 - 1, DOI: 10.1109/ACCESS.2016.2638449
- [10] Z. A. Hussien, H. Jin, Z. A. Abduljabbar, Mohammed Abdulridha Hussain; Ali A. Yassin; Salah H. Abbdal; Mustafa A. Al Sibahee; Deqing Zou, "Secure and efficient e-health scheme based on the Internet of Things", 2016 *IEEE International Conference on Signal Processing, Communications and Computing (ICSPCC)*, Year: 2016, Pages: 1 - 6, DOI: 10.1109/ICSPCC.2016.7753621, IEEE Conference Publications
- [11] I. Chiuchisan, I. Chiuchisan, M. Dimian, "Internet of Things for e-Health: An approach to medical applications", 2015 *International Workshop on Computational Intelligence for Multimedia Understanding (IWCIM)*, Year: 2015, Pages: 1 - 5, DOI: 10.1109/IWCIM.2015.7347091, IEEE Conference Publications
- [12] H. Khemissa, D. Tandjaoui, "A Lightweight Authentication Scheme for E-Health Applications in the Context of Internet of Things", 2015 *9th International Conference on Next Generation Mobile Applications, Services and Technologies*, Year: 2015, Pages: 90 - 95, DOI: 10.1109/NGMAST.2015.31, IEEE Conference Publications
- [13] B. Harpham, "How the Internet of Things is changing healthcare and transportation", Retrieved from: <http://www.cio.com/author/Bruce-Harpham/>
- [14] K. Ullah, M. A. Shah; S. Zhang, "Effective ways to use Internet of Things in the field of medical and smart health care", 2016 *International Conference on*

- Intelligent Systems Engineering (ICISE)*, Year: 2016, Pages: 372-379, DOI: 10.1109/INTELSE.2016.7475151.
- [15] M. Alloghani, A. Hussain, D. Al-Jumeily, P. Fergus, O. Abuelma'atti, H. Hamden, "A mobile health monitoring application for obesity management and control using the internet-of-things", *2016 Sixth International Conference on Digital Information Processing and Communications (ICDIPC)*, Year: 2016, Pages: 19 - 24, DOI: 10.1109/ICDIPC.2016.7470785
- [16] M. Thangaraj, P. P. S. Anuradha, "Internet Of Things (IOT) enabled smart autonomous hospital management system - A real world health care use case with the technology drivers", *2015 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC)*, Year: 2015, Pages: 1 - 8, DOI: 10.1109/ICCIC.2015.7435678
- [17] H. Anumala, S. M. Busetty, "Distributed Device Health Platform Using Internet of Things devices", *2015 IEEE International Conference on Data Science and Data Intensive Systems*, Year: 2015, Pages: 525 - 531, DOI: 10.1109/DSDIS.2015.110
- [18] B. P. L. Lo, H. Ip, G-Z Yang, "Transforming Health Care: Body Sensor Networks, Wearables, and the Internet of Things", *IEEE Pulse*, Year: 2016, Volume: 7, Issue: 1, Pages: 4 - 8, DOI: 10.1109/MPUL.2015.2498474, IEEE Journals & Magazines
- [19] M. A. Al-Tae, W. Al-Nuaimy, A. Al-Ataby, Z. J. Muhsin, Suhail N. Abood, "Mobile health platform for diabetes management based on the Internet-of-Things" *2015 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT)*, Year: 2015, Pages: 1 - 5, DOI: 10.1109/AEECT.2015.7360551