IoT, AI, and the disaster management of houses and buildings

SANKAI Toshihiro (Ph.D), Director, Housing Department

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1. Introduction

The use of innovative systems that use IoT and AI is increasing in houses and buildings. Many new technologies are being released, especially in the field of technologies, to sophisticate and streamline building operations.[1] While the use of IoT has been increasing in the field to improve convenience and service, the use of these new technologies, however, is happening too slowly in the field of assisting people during fire evacuations and of improving the safety of the elderly and disabled on a daily basis. Progress is also slow in the field of responding to the cutoff of utilities. Therefore, this article discusses the utilization of IoT and AI in fire evacuations, daily-level disasters, and utility disruptions.

2. Application of IoT and AI to assist in fire evacuations

Fire evacuation technologies (e.g. emergency lamps, fire extraction system, fire alarm system, backup power, and emergency power) that are now in use are regulated under technical standards based on the Building Standards Act that was established in 1970 after the fatal fire in the Sennichi Department Store building.

Therefore, they seem outdated compared to current technical standards. The use of new technologies, such as IoT, is thus greatly advantageous and should actively be adopted. The following are fields where the use of new technologies is expected.

1) Technologies to detect fire more quickly and accurately

⇒ Early and accurate detection of fire with the sensors of IoT devices that are used in daily scenes and the early detection of fire through AI-based image recognition technology

2) Technologies to enable proper evacuation during a fire

⇒ Technologies to assist evacuation-vulnerable people using signs, navigation (use of AR and mobile devices), and robots that enable rational evacuation (e.g. parade-like autonomous evacuation by power wheelchairs or autonomous evacuation using wearable robots)

3) Technologies to properly extinguish fires

⇒ Realization of early fire extinguishing using AI-based image recognition technology and fire-extinguishing technology using robots

In reality, however, private companies have rarely proposed or developed new technologies in this field for the following reasons. First, current industries that have the best knowledge in this field have evolved with the presumption that they must remain in compliance with current regulations, and they are not very motivated to work on new technologies. Also, knowledge of the current industries is limited within some of the technical standards that are based on regulations, and application beyond the standards is difficult to achieve.

To respond to this current situation, the Building Research Institute (BRI) is leading the research and development of IoT-based evacuation assistance technologies and technologies to assist the elderly and disabled in evacuations using robots.[2]

For evacuation assistance technology, the BRI is examining evacuation assistance within a building using AR (augmented reality) technology. This technology is expected to enable proper evacuation from building spaces where it is relatively difficult to find evacuation routes.

For the technology to assist the elderly and the disabled, the BRI is examining technologies to realize autonomous horizontal evacuation using power wheelchairs and verifying evacuation performance when mobile support technologies, such as a robot suit, are used.

3. Application of IoT for elderly and disabled support and prevention of disasters on a daily basis

The construction of barrier-free buildings has been realized by establishing regulations on the sizes of buildings (i.e. heights and widths) and the installation of handrails and elevators among other regulations. Yet, the number of people who lose their lives within houses is now more than double the number of people who die in traffic accidents. The most frequent cause of death is drowning in the bathtub, which accounts for nearly 70% of all fatalities that occur inside houses. Some speculate that heat shock is the greatest factor that leads to drowning. Nonetheless, no effective

technology is now available to prevent such deaths. Meanwhile, the use of a watchful-eye service is rapidly increasing in the field of care and nursing. Assistance technologies are rapidly being installed in the housing of people living alone. Yet, there remains a serious conflict between ensuring safety and protecting the privacy of users. AI and IoT-based technologies are attracting attention as a possible solution to such conflicts.

AI has been going through an explosive evolution since it had reached the stage where the classification of photos of cats and dogs became possible through deep learning in 2012. Meanwhile, as IoT devices have become more multifunctional with higher processing speed, a local system became able to perform AI-based image recognition. This indicates the possibility that information in the domain of privacy can be fully localized (so-called edge computing). For example, some argue that it is possible to create a system in which AI locally processes image information that a person is about to drown in a bathtub and only sends a signal to call for rescue to the outside. In the case of drowning, a rescuer who is dispatched after receiving the warning may not be able to arrive at the scene in time to save a life. Yet, a possible rescue idea is to have an airbag attached to the bottom of the bathtub, which is inflated when a drowning is detected to prevent an accident. The real question may be how far the system should go to intervene rather than what the system can do.

4. Responding to utility disruptions

The use of IoT and AI in houses and buildings may be able to generate great social benefits. Still, they are basically vulnerable to power disruptions. Energy harvesting is one of such technologies attracting attention to overcome such a vulnerability. Energy harvesting means “environmental power generation.” Various technologies are now in actual use, such as semiconductor devices that can generate power from faint vibrations, temperature changes, lights, ambient electromagnetic waves, and other phenomena, and the use of the power for operation and communication, as well as lighting systems that emit light as people step on a power-generating unit.

Cable-less IoT can be realized by using these technologies, which can overcome the vulnerability that comes from dependency on an external power supply. In addition, as discussed below, there is the possibility of compensating for the inherent nature of an emergency power supply in buildings where it is not suitable for a long-term power failure in buildings (activated simultaneously upon a power failure regardless of load condition and shuts off quickly) because the control and surveillance system and power generation system can become isolated. Details are discussed below.

(i) The system is able to maintain the necessary control and surveillance functions even when the power supply is stopped. The combination with mobile devices will also be an effective option.

(ii) Securing building functions by running an emergency power supply only when a large amount of power is needed (intermittent operation of an emergency power supply) becomes technically possible. The length of operation allowed by a certain amount of fuel has become drastically longer compared to the commonly used emergency power generator. The expectation for applicability to respond to a power failure is thus increasing.

5. Summary

The National Institute for Land and Infrastructure Management is falling behind in the field of using IoT and AI in the field of housing. Yet, the half-committed involvement of the public sector in this field where the private sector is leading technological development might distort the technologies. Careful involvement should thus be required. By observing the active development and advancement of technologies in the private sector, the public sector can find how technologies will relate to current regulations and the possible challenges because bystanders can have a bird’s eye view of the situation and the progress. Thus, being able to objectively observe the direction of the technologies was an advantage of falling behind in the game.

☞For more information:

1) *Society 5.0 Housing and Building*. Toshihiro Sankai. NILIM Report 2019. p.38, p. 39, July 2019.

2) Possibility of using sensor and robot technologies to ensure evacuation safety in a more advanced form. Koji Kagiya, Toshihiro Sankai. Compilation of Academic Lectures at the Architectural Institute of Japan Conference (Hokuriku). Fire Control pp. 369-370, September 2019.