Network Construction × Wearable Heat Countermeasures

Kazuhiko Takagahara, Hiroyoshi Togo, and Naomi Nagai

Abstract

One of NTT's key roles in the 2021 international sporting event held in Japan was the construction of a large-scale network during the hot and humid Tokyo summer to provide a stable and secure communication environment. We built and installed a health-management system that involves wearable biological/environmental sensors to prevent heat-related health issues and enable construction work to be carried out more safely.

Keywords: heat countermeasures, wearable sensors, health management

1. Background and objectives

The numbers of deaths and emergency room visits caused by heat stroke have been increasing due to climate change and other factors, and this has become a major issue for society in general. According to a survey by the Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications of Japan, 46,299 people required emergency hospital treatment for heat stroke between June 1 and October 3, 2021, and according to the Ministry of Health, Labour and Welfare of Japan, there were 829 cases of heat stroke at the workplace in 2020 resulting in an absence of four days or more, of which 22 cases resulted in fatalities. The Ministry of Health, Labour and Welfare and other organizations published guidelines and manuals on how to prevent heat stroke in the workplace.

At NTT, we developed a method for implementing heat-related health issue prevention measures for individual workers by estimating health risks on the basis of vital-sign data and issuing alerts when necessary. To verify the effectiveness of this method, we conducted a demonstration experiment with the cooperation of NTT EAST. We monitored 49 construction workers in the Tokyo, Kanagawa, and Hokkaido areas for a total of 834 person-days in August and September 2020. We asked the construction workers to fill out questionnaires about how hot or cool they felt while working, and we were able to confirm the relationship between their estimated internal-body-temperature fluctuations and whether they felt hot or cool.

2. Method for estimating health risks and issuing alerts

Our method estimates the risk of heat-related health issues by means of logic for estimating changes in internal body temperature,[*1] which was created in a new joint research project with Nagoya Institute of Technology (NIT). This logic is based on an original program developed by NIT that combines electromagnetic field analysis and thermal analysis by taking into account factors such as a person's internal-body-temperature regulation, clothing, and level of activity. In a joint experiment among NTT, Yokohama National University, Shigakkan University, and NIT, we conducted clinical experiments in the artificial weather room at Shigakkan University that confirmed the applicability of the logic for estimating internal-body-temperature fluctuations.[*2] On the basis of the theory of thermal and exercise physiology, we also

*1 Since the method described here is not a medical procedure, the expression "internal body temperature" is used instead of "core temperature."

*2 Shigakkan University Research Ethics Review Committee: Accession number 124.

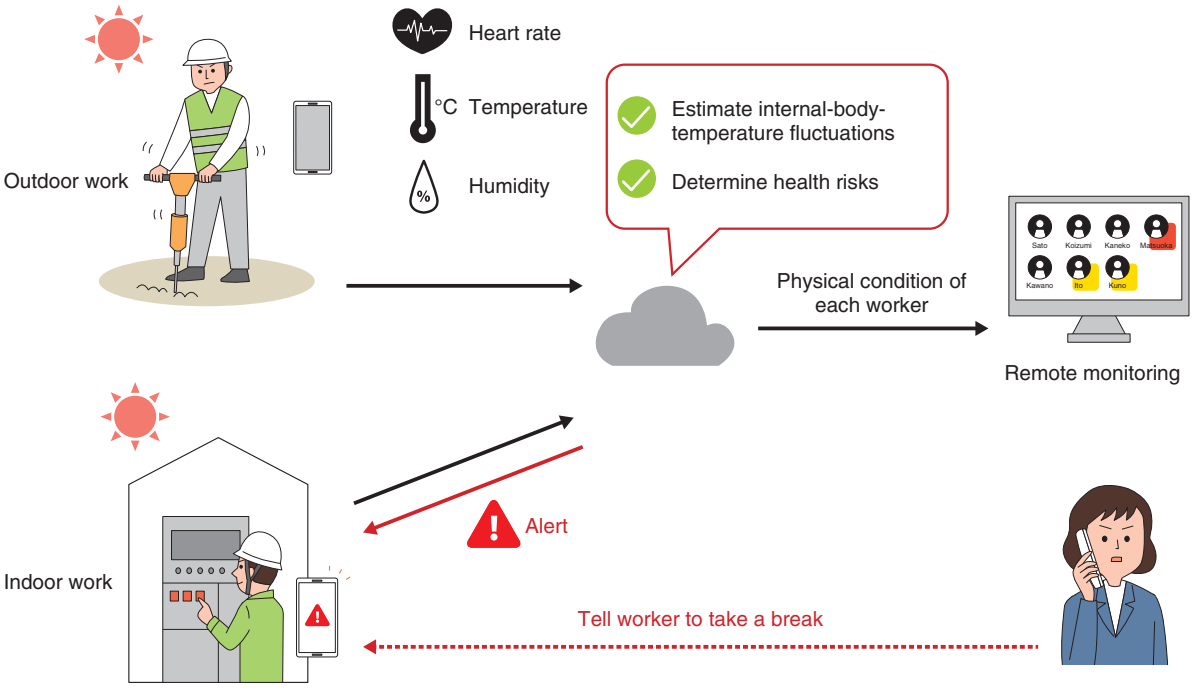

Fig. 1. Flow of our health-risk estimation method.

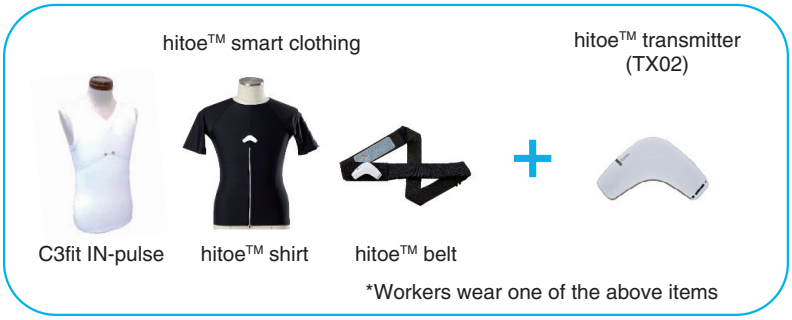

Fig. 2. Wearable biological/environmental sensors.

created criteria for using internal-body-temperature fluctuations and other factors to trigger alerts (**Fig. 1**). Together, the estimation logic and alert criteria constitute our method for estimating health risks.

3. Wearable biological/environmental sensors

Wearable biological/environmental sensors[*3] are used to acquire an individual's heart rate, temperature inside clothing, and humidity. In addition to a TX02 transmitter marketed by NTT TechnoCross based on wearable biological/environmental sensors developed by NTT Device Innovation Center, we use either a piece of C3fit IN-pulse clothing made by GOLDWIN Inc. or a hitoe™ shirt or belt developed by Toray Industries, Inc. [1] (**Fig. 2**) to monitor various parameters including the wearer's heart rate, R-R interval, step count, and upper-body tilt.

*3 This sensor is not a medical device. hitoe™ is a functional fabric developed by Toray Industries, Inc. and NTT to collect biomedical signals, which are weak electrical signals emitted from the body, with little burden on the wearer. The functional fabric hitoe™ is a trademark of both companies.

4. Operation support for the 2021 international sporting event

By applying this method to construction work at venues used for the international sporting event in 2021, we were able to prevent heat-related health issues among construction workers, enabling the event to be held safely and securely. From May 24 to September 30, 2021, the health-management system applying this method was used by a total of twelve construction workers at two sites [2]. In addition to remotely monitoring health risks, the system also issued appropriate alerts to the construction workers and their site managers based on the above-mentioned alert criteria. A total of ten alerts were issued during this period. In each case, the site manager was able to check the physical condition of the affected construction worker and take measures such as encouraging them to take a break if necessary. As a result, we were able to prevent the occurrence of health issues, such as heat stroke, among the construction workers.

5. Summary

At NTT, we will continue to deepen our knowledge by introducing this method to more sites with the aim of ensuring that large-scale events around the world can be held safely and securely.

References

[1] K. Takagahara, Y. Hashimoto, K. Matsunaga, Y. Higuchi, N. Matsuura, K. Kuwabara, H. Togo, T. Kawahara, A. Hirata, H. Tanaka, and T. Miyazawa, "Physical-condition Management Technology for Creating More Comfortable Work Sites," NTT Technical Review, Vol. 19, No. 6, pp. 48–54, 2021.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr202106fa7.html

[2] Press release issued by NTT TechnoCross, June 15, 2021 (in Japanese).
https://www.ntt-tx.co.jp/whatsnew/2021/210615.html

Kazuhiko Takagahara
Senior Research Engineer, NTT Device Innovation Center.

He received a B.S. in mechanical engineering and M.S. in information science and technology from the University of Tokyo in 2006 and 2008. He joined NTT Microsystem Integration Laboratories in 2008, where he was engaged in research and development (R&D) of optical and wireless telecommunication devices and vital sensing devices. He is a member of the Japan Society of Applied Physics.

Hiroyoshi Togo
Senior Research Engineer, Supervisor, NTT Device Innovation Center.

He received an M.Sc. and Ph.D. in applied physics and electronic engineering from the University of Tsukuba, Ibaraki, in 1996 and 2010. He joined NTT Musashino Opto-electronics Laboratories in 1996. Until 2001, he was involved in the development of the thermo-capillary waveguide-based optical switch and from 2001 to 2002 endeavored to commercialize it for NTT Electronics. From 2003 to 2015, he developed ultrawideband impulse radio systems using photonic techniques and millimeter-wave tomography with electro-optic probing at NTT Device Technology Laboratories. Since 2016, he has been leading a wearable-device development project to contribute to smart healthcare at NTT Device Innovation Center. He is a senior member of the Institute of Electrical and Electronics Engineers (IEEE) Photonics, Antenna and Propagation, and Microwave Theory and Techniques Society, and the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan. He was a finance director of the Council of Technical Committee Representatives and director of the Technical Committee on Photonics-applied Electromagnetic Measurement in the IEICE Communications Society. He is also an expert member of the Technical Committee on Microwave Photonics in the IEICE Electronics Society and expert member of the Japan Electronics and Information Technology Industries Association wearable electronics standardization. He received the 2006 Asia Pacific Microwave Photonics Conference AP-MWP Award, the 2010 European Conference on Antenna and Propagation Award, and the Japan Wood Research Society Best Paper Award 2013.

Naomi Nagai
Senior Manager, Produce Group, Research and Development Planning Department, NTT.