An in silicon human model for fluid-initiated environmental design in an enclosed space

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Keynote Speaker

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Short Biography

Kazuhide Ito is Professor of Interdisciplinary Graduate School of Engineering Sciences at Kyushu University. He was born in Gifu in 1972. He earned his B. Eng. in 1995 from Nagoya University, and M. Eng. (1997) and Dr. Eng. (2000) from The University of Tokyo. Before he joined the faculty at Kyushu University, he was a faculty member at Tokyo Polytechnic University. His current research topics include indoor environment, public health, and energy-efficient, sustainable building design and analysis. He has published over 100 journal and conference papers.

He has received several awards from the Japanese government, the Architectural Institute of Japan (AIJ), and the Society of Heating, Air-conditioning and Sanitary Engineers of Japan (SHASE). He is a recipient of the Commendation for Japan Society for the Promotion of Science (JSPS Prize) in 2015, and Science and Technology by the Minister of Education, Culture, Sports, Science and Technology (The Young Scientists' Prize) in 2011. He has also received SHASE Award of Technical Paper (in 2007, 2008, 2011, 2013, 2014, 2015, and 2016), The Encouragement Prize of AIJ in 2007, The Prize of AIJ in 2012, The Maeda Engineering Foundation Award in 2001. He also received the SAGE Best Paper Award of Indoor and Built Environment in 2013.

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Abstract

In modern society, people spend more than 90% of their time in enclosed spaces like car and commuter train interiors, aircraft cabins, and buildings, wherein the indoor air quality (IAQ) greatly influences their quality of life. Today, people remain in enclosed spaces, i.e. indoors, more than they did in the past, making IAQ issues increasingly important as far as controlling health risks to residents are concerned.

In recent years, indoor air pollution has become a serious social problem. Indoor air pollution is caused by chemical substances called volatile organic compounds (VOCs) that are emitted from vehicles/building materials. They are exacerbated by the introduction of new materials and new construction methods, and by the growing prevalence of airtight environments, high thermal insulation, and insufficient ventilation. Ventilation systems have also been recognized as

dominant transport pathways for the transport of contaminants from outdoor to indoor environments. Contaminants originating from an outdoor environment may diminish indoor air quality. Recent epidemiological studies indicate that exposure to gas-phase and particulate-phase contaminants in air is associated with increased risks of lung cancer, asthma, and chronic diseases, as well as increased risks of induced mortality and morbidity in humans. Individuals in enclosed spaces are at risk of being exposed to gas-phase and particulate-phase contaminants that originate outdoors and later penetrate indoor environments. Health conditions related to enclosed spaces have also led to considerable attention being given to the effect of indoor air on the quality of life.

Numerical simulations of airflow, temperature, and the contaminant distribution field have been used in the designing of room air conditioning and the analysis of environmental quality in enclosed spaces. Numerical simulation is useful in the analysis of contaminant distribution field structures and can be used to design a precise control method for environmental quality.

Interest in using an *in silico* human model, i.e. computer-simulated person (CSP) integrated with computational fluid dynamics (CFD) simulation for this purpose in research and design has been growing steadily.

Recent developments of computer and visualization technology in the medical field have been remarkable. The use of *in silico* models as a substitute for biological bodies for in vivo study/experimental studies, and tissue and cells for in vitro studies has been increasing as animal and biological tests are always needed for inhalation toxicology studies and the development of respiratory drug delivery systems. Recently, *in vivo* studies involving human subjects and mammal surrogate models for toxicology studies have been facing ethical restrictions. *In silico* models, with detailed geometry and physiology reproductions of these animals, as substitutes for real humans/animals, are therefore in great demand.

Recently, an *in silico* human model that integrates thermoregulation and the respiratory tract with physiologically-based pharmacokinetics (PBPK) models for indoor environmental quality assessment has been developed. This *in silico* human model, integrating detail human body surface geometries with a virtual respiratory tract model by generating a continuous grid design in order to analyze the effect of the indoor environment around the human body and on the inside of the respiratory tract via the nostrils and oral cavity, can be used for the inhalation exposure analysis without ethical concerns. By using this *in silico* human model for fluid-initiated indoor environmental design, we have reported the prediction results of tissue dosimetry in respiratory tract in addition to the non-uniform contaminant concentration around human body and in room. In this study, they emphasize that room-averaged contaminant concentration and the concentration in breathing zone were predicted different values and inhalation exposure concentration in respiratory tract was also greatly different. For further application, we also reported first- and second-hand smoke exposure assessment from e-cigarettes using integrated analysis of CFD and *in silico* human model.

In this keynote lecture, I will introduce past, current, and future trends of developing *in silico* human model for fluid-initiated environmental design in an enclosed space.