Field Study of Thermal Infrared Sensing for Office Temperature Control

Akihisa Nomoto, PhD
Associate Member ASHRAE
Donghun Kim, PhD
Member ASHRAE
Hui Zhang, PhD
Yingdong He, PhD
Charlie Huizenga, MS
Edward Arens, PhD
Fellow ASHRAE
Robert Prickett, BFA
Sri Swaminathan, MS
Ronnen Levinson, PhD

ABSTRACT

The purpose of this paper is to evaluate the performance of a novel office temperature control system. To make occupants more comfortable with less energy, we have been developing a new system that uses an inexpensive infrared camera to evaluate occupants' thermal sensation and optimize room temperature. The system (1) detects the positions of a person's face, nose, and hands in a thermal image taken by an infrared camera and measures temperatures in those areas; (2) predicts thermal sensation using measured skin temperatures; and (3) adjusts an HVAC set-point temperature based on the predicted sensation to optimize occupant thermal comfort. We compared the comfort and energy performance of the new system to conventional control using a fixed setpoint of 72.0 °F (22.2 °C) in a small conference room. The results indicate that the conventional control often overcooled the occupants, whereas our system reduced cooling energy consumption and made the occupants more thermally neutral and comfortable than the conventional control.

1 INTRODUCTION

Delivering a thermally comfortable indoor environment is a primary goal of building HVAC (heating, ventilation, and air conditioning) systems. However, traditional HVAC control systems regulate air temperature, rather than thermal comfort, and operators select temperature setpoints based on thermal comfort standards such as ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 55 (ASHRAE, 2017b), or the operators' judgments. Many studies have documented high levels of discomfort and inefficient HVAC system operation in commercial buildings (Schiavon et al., 2017). Overcooling is a representative example: occupants in commercial buildings may feel cool during summer while HVAC systems are wasting considerable energy to overcool the space (Derrible & Reeder, 2015; Mendell & Mirer, 2009; Parkinson et al., 2021). To address this issue, we have been developing a new sensor/control system that combines an inexpensive infrared camera, comfort model, and control algorithm. It aims to directly estimate occupants' thermal sensation and determine the optimum room temperature set-point. This paper describes a multi-month field trial of our system conducted in an office near Houston, Texas.

Akihisa Nomoto is a postdoctoral researcher at Center for the Built Environment, University of California, Berkeley, California. **Donghun Kim** is a research scientist at Lawrence Berkeley National Lab, Berkeley, California. **Hui Zhang** is a professional researcher at Center for the Built Environment, University of California, Berkeley, California. **Charlie Huizenga** is a professional researcher at Center for the Built Environment, University of California, Berkeley, California. **Yingdong He** is an associate professor at College of Civil Engineering, Hunan University, Hunan, China. **Edward Arens** is a director at Center for the Built Environment, University of California, Berkeley, California. **Robert Prickett** is a senior manager at Daikin Open Innovation Lab Silicon Valley, Daikin U.S. Corporation, Santa Clara, California. **Sri Swaminathan** is a product manager at Daikin Texas Technology Park, Daikin Comfort Technologies LLC, Houston, Texas. **Ronnen Levinson** is a staff scientist at Lawrence Berkeley National Lab, Berkeley, California.