Heating and cooling that anticipates your needs

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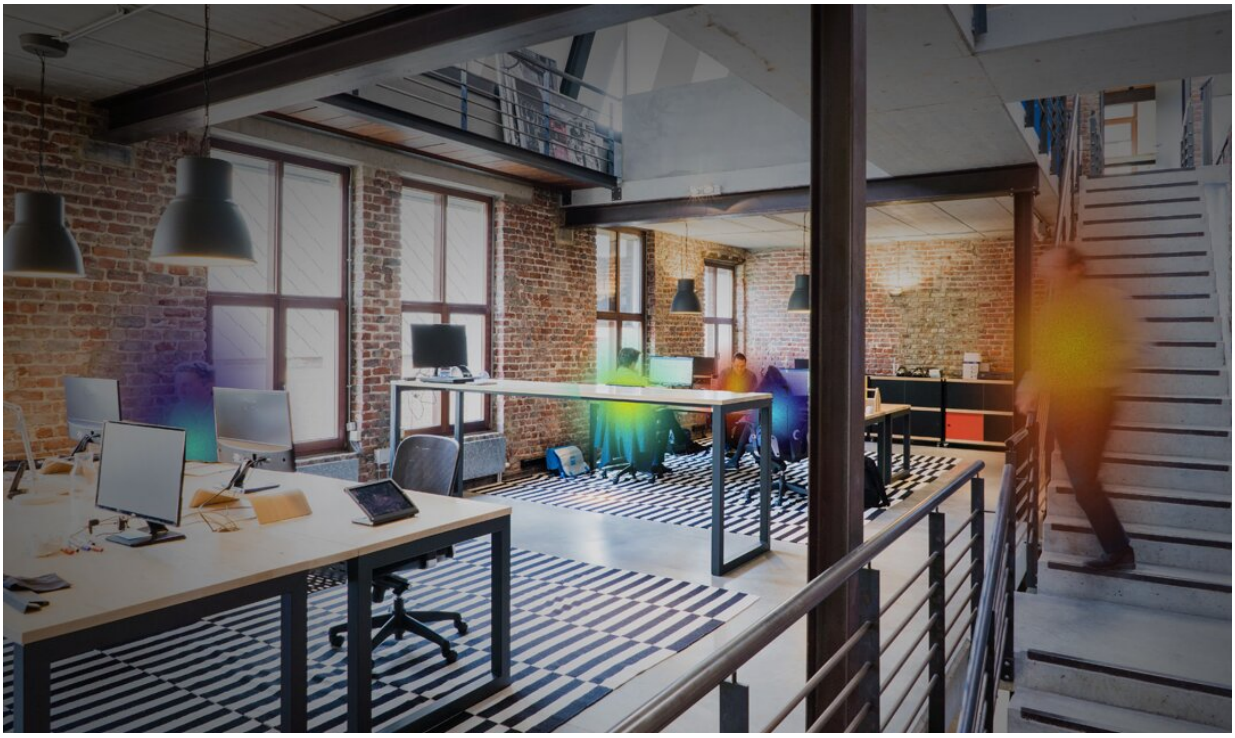

Credit: Carnegie Mellon University, Department of Civil and Environmental Engineering

According to a recent survey, about half of Americans feel their office is either too hot or too cold. A number of factors play into this issue of thermal comfort, but the hardest factor to control for is the one we're most interested in: humans themselves. Clothing choice and body shape

are intrinsically tied to what temperature an individual will be most comfortable at.

Carnegie Mellon University's Mario Bergés believes that our environments should be more adaptive and consider not just our presence, but also our physical characteristics, clothing, and thermal comfort preferences when deciding how to condition the spaces we are in.

Bergés, a professor of civil and environmental engineering, and his collaborators have created the first model that combines environmental information with data on an individual's body shape to determine at what temperatures that person will feel most comfortable. That information is then aggregated to find the temperature that most occupants possible will find comfortable, in a system his team has dubbed OccuTherm. Crucially, the system can estimate body shape information from depth-imaging sensors mounted on doorways, which is less privacy-invasive than other sensing approaches such as traditional cameras.

As Bergés and fellow researchers note in a recent paper, thermal comfort has a significant effect on the physiological and psychological well-being of an individual and affects occupants' health, satisfaction, and performance. Studies have shown that optimal thermal comfort conditions can lead to an increase in concentration and productivity, while poor thermal comfort conditions can lead to lethargy and distraction.

OccuTherm works by estimating the circumference of an individual's shoulders from above, then combining it with height and weight estimates to infer the optimal temperature for that individual's comfort. Just as society has come a long way in embracing differences that were once brushed over or ignored, this system demonstrates the need to acknowledge that each person has a different body shape, with different

needs that must be met on their own terms. It incorporates a much deeper level of human understanding than traditional heating and cooling methods, which use generic set-temperature models that have been in place for decades. OccuTherm is a dynamic system that personally factors each individual entering or leaving a room into the system's temperature setting.

OccuTherm is six percent more effective than leading state-of-the-art approaches, which may also employ restrictive wearables or require constant user interaction. The system, the authors note, "works without the need for frequent user comfort feedback reports and leverages data from depth-imaging sensors, which are quickly becoming commonplace in indoor environments."

A smarter temperature control system like OccuTherm could also help reduce energy costs and, by extension, carbon emissions. About 50 percent of energy used in human-occupied spaces is expended on heating, cooling, and ventilation. Thermostats are usually turned to a set temperature for the whole building, even if most of the area is unoccupied. Eliminating wasteful, outdated methods and putting the individual needs of the occupants first could not only equal a more content and productive workplace, but also major savings for both managers and the environment.

Bergés and his colleagues plan to integrate more advanced features as the system continues to improve that can also take into account an individual's clothing choices. Allowing users to provide direct feedback could also further refine OccuTherm's ability to help people reach optimal thermal comfort. Ultimately, the system will help close the gap between human needs and the spaces built to satisfy them, providing a more comfortable and livable environment for all.

"Buildings can do a better job in keeping us comfortable while using less

energy, and we have a lot to learn still, including replicating this study on a larger population, says Bergés. "These results are promising and show that there's potential for non-intrusive technologies to obtain comfort -predictive attributes for occupants."

The OccuTherm research team includes doctoral candidates Jonathan Francis of Carnegie Mellon's School of Computer Science, Matias Quintana of The National University of Singapore, and Nadine von Frankenberg of the Technical University of Munich, as well as Senior Research Scientist Sirajum Munir from the Bosch Research & Technology Center.

More information: Jonathan Francis et al. OccuTherm, *Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation* (2019). DOI: 10.1145/3360322.3360858

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