
Personalized Comfort Modeling for Occupant-centric Environmental Control

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Indoor Environmental Quality survey

How satisfied are you with your ability to adjust your furniture to meet your needs?

Very Satisfied ▶️ ◀️ ◀️ ◀️ ◀️ Very Dissatisfied

Overall building

Lighting

Overall workplace

Office furnishing

Acoustic quality

Office layout

Air quality

Thermal comfort

Cleanliness & maintenance

Leader: Lindsay Graham
How satisfied are you with the temperature of your workspace?

Karmann, Schiavon, Arens 2018 Percentage of commercial buildings showing at least 80% occupant satisfied with their thermal comfort
Building occupant satisfaction

CBE survey on 351 bldg. and 52,980 occupants

Frontczak, Schiavon et al. 2011 Occupant satisfaction and IEQ Indoor Air
Building occupant satisfaction

CBE survey on 351 bldg. and 52,980 occupants

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Radiant and all-air spaces have equal indoor environmental quality with a tendency towards improved temperature satisfaction in radiant buildings.
Climatic chamber thermal comfort study in Denmark
How accurate is the PMV-PPD model?

PMV predicted thermal sensation correctly only one out of three times.

PMV had a mean absolute error of one unit on the thermal sensation scale.
Desk fan, foot warmer, heated and cooled chair
Energy savings

500 - 1500 W

2-100 W
Energy savings

Wider dead band reduces HVAC energy 7-15% per degree C

Schiavon and Melikov 2008 Energy saving and air movement Energy and Buildings
Hoyt et al. 2015 Extending air temperature setpoints Building and Environment
Personal comfort systems and models

Sensor inputs
- Environmental sensors
- Mobile & wearable devices
- Weather data

Personal comfort models

Space conditioning
- HVAC systems
- Personal comfort systems

Applications
- Commercial
- Residential
- Automotive

Modified from Kim, Schiavon, Brager 2018 Personal comfort models - a new paradigm in thermal comfort Building and Environment
Personal comfort model is a new approach to thermal comfort modeling that predicts individuals' thermal comfort responses, instead of the average response of a large population.

PCM could be based on:
- Environmental sensors
- Occupant feedback & behavior
- Physiological parameters
Environmental sensors

Gall, Cheung, Luhung, Schiavon, Nazaroff 2016 Real-time monitoring of personal exposures to carbon dioxide Building and Environment

Cheung et al 2017 Longitudinal assessment of thermal and perceived air quality acceptability Building and Environment
Occupant behavior with chair

Kim et al 2018 Personal comfort models: predicting individuals' thermal preference using occupant heating and cooling behavior and machine learning B&E
Occupant behavior with chair

Personal comfort models

Conventional comfort models

Median prediction accuracy improved from 0.51 to 0.73

Prediction accuracy (mean AUC)

Kim et al 2018 Personal comfort models: predicting individuals’ thermal preference using occupant heating and cooling behavior and machine learning B&E
Physiological parameters

Liu, Ming, Das, Schiavon, Spanos (2018) Personal thermal comfort models based on physiological parameters measured by wearable sensors.
Physiological parameters

Liu, Ming, Das, Spanos, Schiavon (2019) Developing personal thermal comfort models with wearable sensors
Modeling process

Data collection
Data preparation
Model selection
Model evaluation
Continuous learning

![Graph showing the modeling process with a ROC curve and a comparison of different models' performance metrics: Median Cohen's kappa, Median accuracy, and Median AUC.](Image)
Modeling process

Data collection → Data preparation → Model selection → Model evaluation → Continuous learning

Bar chart showing prediction accuracy (mean AUC) for different variable groups.

Variables included:
- Group 1: PCS control behavior
- Group 2: date/time
- Group 3: HVAC system
- Group 4: outdoor env.
- Group 5: indoor env.

Line graph showing AUC over the number of training data.
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Conclusions

• Personal comfort models produce individual-specific and context-relevant predictions.

• They improve predictive power compared to PMV, Adaptive.

• The proposed framework provide a unified approach to develop and evaluate personal comfort models.

• Personal comfort models can be integrated into real-world systems (buildings, vehicles, aircraft, etc.) to enable intelligent comfort management.
Bibliography


Questions

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