

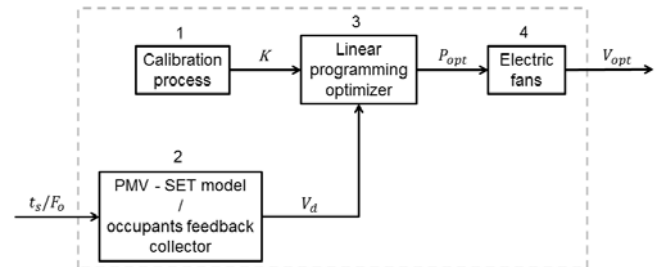
# OPTIMIZED AIR MOVEMENT FOR THERMAL COMFORT CONTROL

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## MOTIVATION AND CONTRIBUTION

- Increased air movement can lead to energy savings and thermal comfort improvements
- Fans commonly generate a strongly non-uniform air speed field and they are not coordinately controlled
- For the first time, multiple fans are controlled collectively and cooperatively. A provisional patent was granted

## SYSTEM OVERVIEW



## PROBLEM FORMULATION

Minimax-error problem:

$$\text{Minimize } \|K \cdot P - V_d\|_{\infty}$$

subject to  $P_{min} < P < P_{max}$

Equivalent linear programming problem:

$$\text{Minimize } [0 \ \dots \ 0 \ 1] \begin{bmatrix} P \\ \varepsilon \end{bmatrix}$$

subject to  $\begin{bmatrix} K & -1_I \\ -K & 1_I \end{bmatrix} \begin{bmatrix} P \\ \varepsilon \end{bmatrix} \leq \begin{bmatrix} V_d \\ -V_d \end{bmatrix}, P_{min} < P < P_{max}$

## NUMERICAL OPTIMIZATION

Minimax-error problem:

$$\text{Minimize } \|K \cdot \Delta P - \Delta V_d\|_{\infty}$$

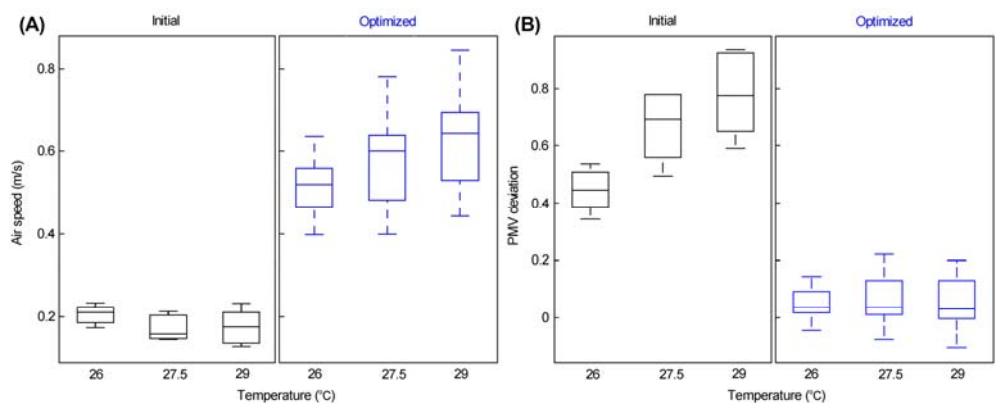
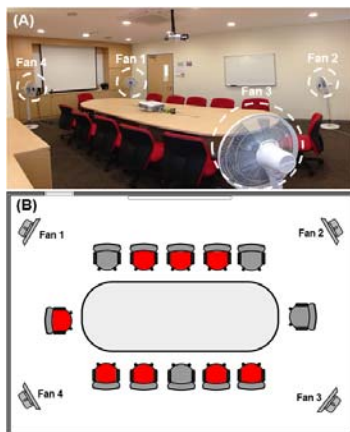
subject to  $-\hat{P} < \Delta P < P_{max} - \hat{P}$

Equivalent linear programming problem:

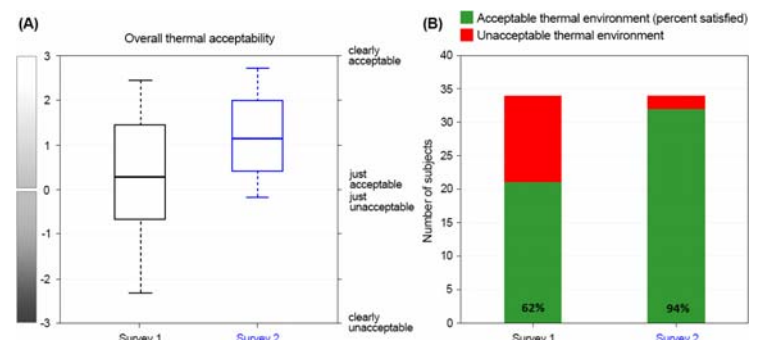
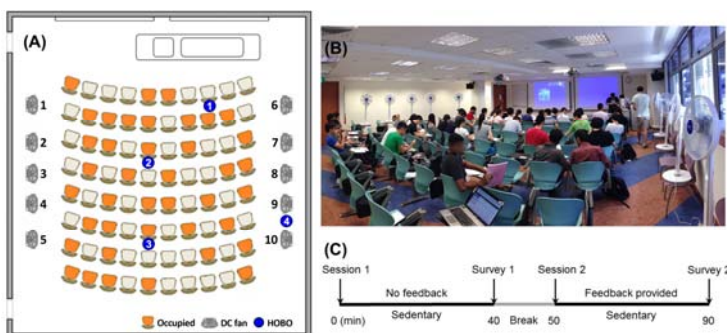
$$\text{Minimize } [0 \ \dots \ 0 \ 1] \begin{bmatrix} \Delta P \\ \varepsilon \end{bmatrix}$$

subject to  $\begin{bmatrix} K & -1_I \\ -K & 1_I \end{bmatrix} \begin{bmatrix} \Delta P \\ \varepsilon \end{bmatrix} \leq \begin{bmatrix} \Delta V_d \\ -\Delta V_d \end{bmatrix}, -\hat{P} < \Delta P < P_{max} - \hat{P}$

## EXPERIMENT 1: CONFERENCE ROOM WITHOUT HUMAN SUBJECTS



## EXPERIMENT 2: CLASSROOM WITH HUMAN SUBJECTS



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