Smart Desk to Promote Health and Productivity

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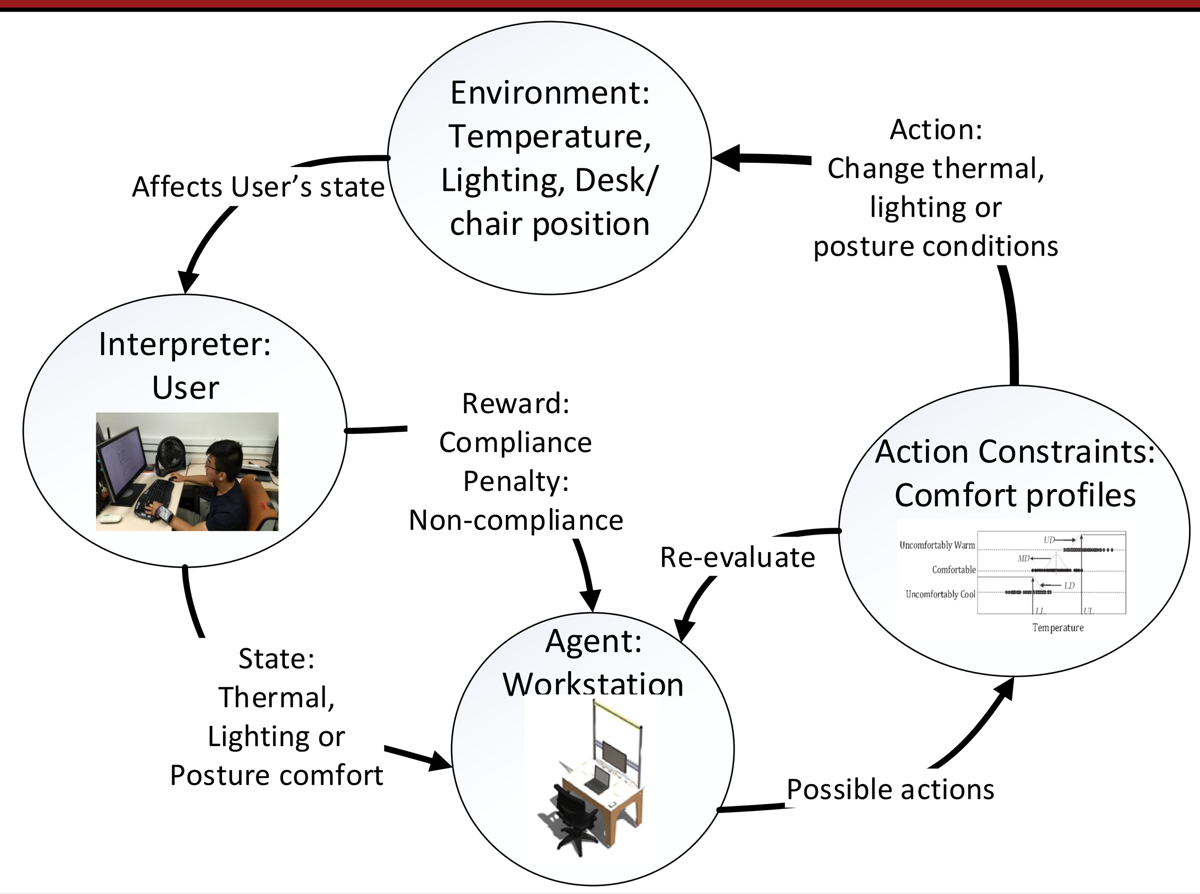
Motivation and Background

- 40% of U.S. jobs are sedentary or light[1], contributing to increased obesity, and risk of cardiovascular diseases. Sit-stand desks could reduce sedentary time and aid aforementioned issues [2].
- Exposure to constant temperatures over long periods is linked to obesity and increased risk of cardiovascular diseases. Regular exposure to variable temperatures could improve metabolic health [3]. Personalized comfort systems can improve comfort, productivity and reduce energy consumption [4].
- Poor lighting leads to lower alertness, eyestrain and reduced performance, which could be improved by proper task lighting. Negative impacts of blue light exposure on circadian rhythm could be resolved by lighting that follows daylight cycle [5].
- The motivation is to create spaces that adapt to occupants, instead of occupants having to adapt to inflexible buildings, by creating a sustained feedback loop between user and the desk where the desk adapts to the user's needs.

Overall Framework

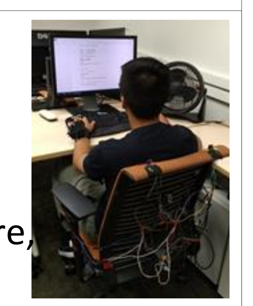


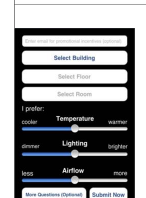
Methodology

Each aspect: thermal comfort, visual comfort and sit-stand regimen is comprised of sensing, learning and control. We use multiple sensing methods to acquire appropriate information and leverage different machine learning algorithms to learn user preferences. We interact with the user using reinforcement learning framework to motivate users towards healthier goals, and detect changes in preference profiles over time to monitor the shift towards healthier choices.

Thermal Comfort

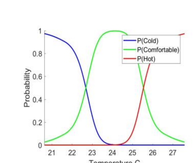
Sensing:
Physiological: Skin Temperature, GSR, thermal imaging.
Environmental: Temperature, humidity, air speed





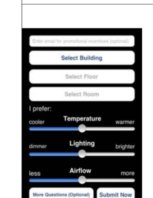
Learning:
Logistic Regression, Bayesian classifier,

Control:
Local fan, heater, change HVAC setpoint

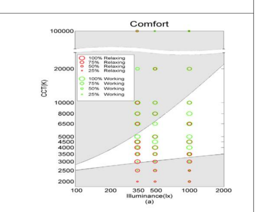


Visual Comfort

Sensing:
Environmental: Light intensity, color temperature
User related: Occupancy, energy consumption (for activity recognition)

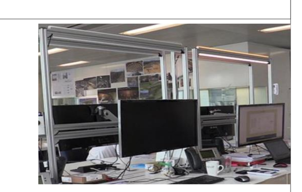


Learning:
Decision trees, Support Vector Machines



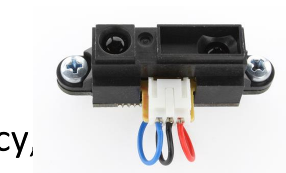
Wang et. al, 2017, Optik

Control:
Task Light using comfort profiles,
Ambient light following sun cycle

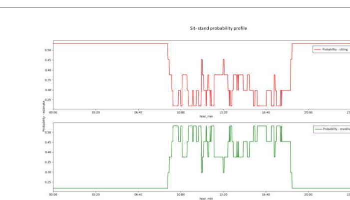


Sit-stand

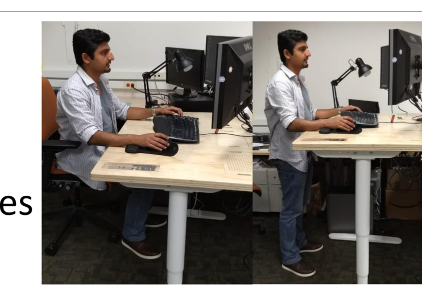
Sensing:
Physical: Desk height
User related: Occupancy, energy consumption (for activity recognition)



Learning:
Sit stand ratio,
Schedule profiling



Control:
Desk height based on learned profiles



Objectives

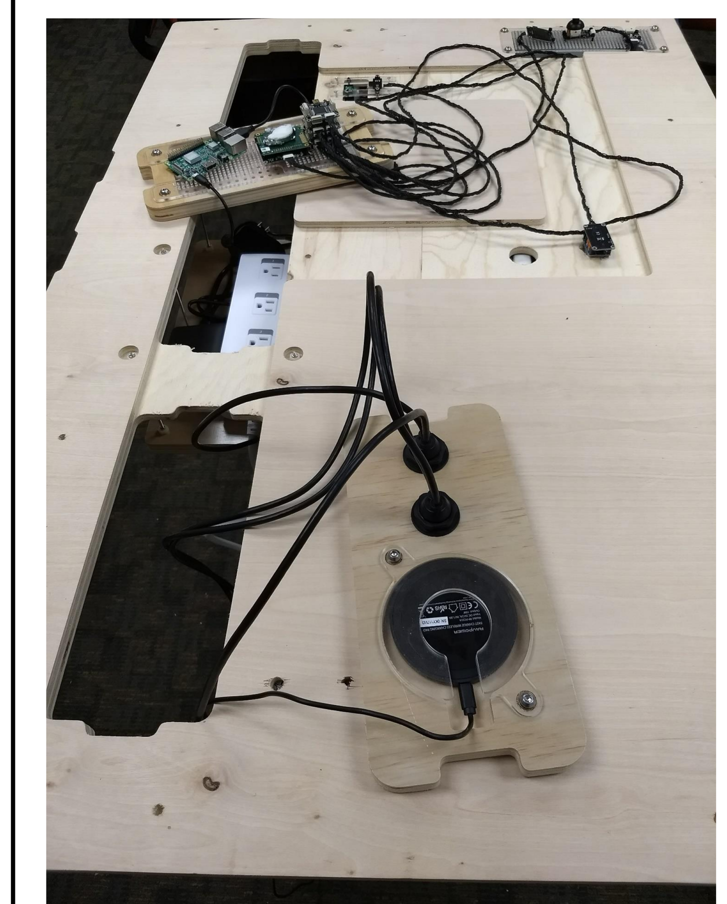
Objective: Create an autonomous system to improve office workers' sit-stand regimen, thermal and lighting conditions. The system learns user's preferences, and over time tries to shift the user towards healthier goals by engaging users in a bi-directional interaction. Current focus is to:

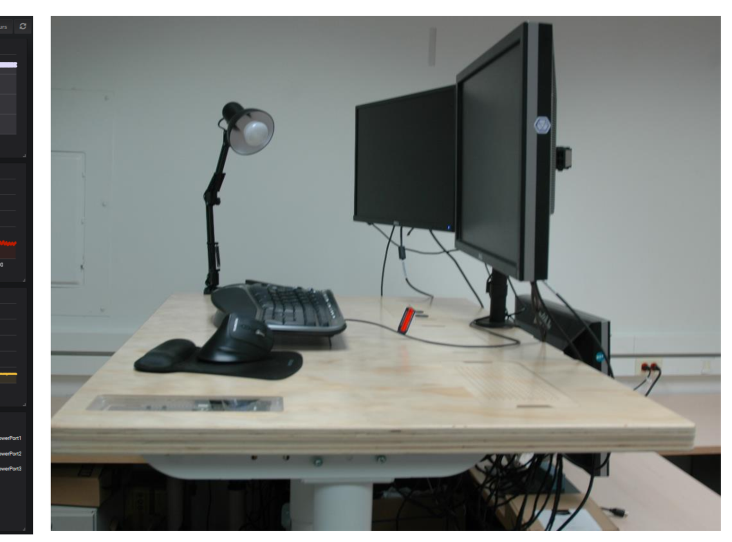
- Reduce continuous sitting time to reduce musculoskeletal discomfort
- Increase thermal comfort range to promote metabolic health
- Provide dynamic lighting that reduces discomfort and supports circadian rhythm.

Research Questions:

- What sensing and learning methods are best suited for monitoring changes in thermal, lighting and sit-stand preferences?
- How often and what type of feedback promotes sustained interaction with the user? What individual factors (e.g. gender, personality) influences the interactions?
- How successful is the desk at promoting behavior changes?

Initial Implementation





References

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4. Zhang, H. *et al.* Comfort, perceived air quality, and work performance in a low-power task–ambient conditioning system. *Build. Environ.* **45,** 29–39 (2010).
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ARUP USC University of Southern California