Activity-based services in smart buildings
Itai Katz, Prof. Hamid Aghajan
Wireless Sensor Networks Laboratory
Dept. of Electrical Engineering

Objective
As of 2007, energy consumption in the United States approached 22 quadrillion BTUs in the residential sector and 18 quadrillion BTUs in the commercial sector.\(^1\) In these human-occupied spaces approximately 7% goes towards lighting and 20% towards HVAC. Given this scale even a modest reduction in energy consumption could translate into a significant economic impact. As the cost of energy continues to rise, energy efficient designs are taking on increasing importance. Recent advances in sensor technology have enabled the development of smart environments, where rooms modify their energy usage policies based on the activities and needs of the occupants in it. A smart environment can observe behavior over time and learn the optimally energy efficient configuration while still operating transparently to the occupant.

Approach
A smart environment typically has three components:

i) A sensor to observe the environment, typically a camera
ii) A means to identify occupants’ configurations (e.g. position in the room, pose, associated objects)
iii) A method to aggregate occupant data to identify particular behaviors

Based on learned behavior patterns, lighting and HVAC can be modified in real-time to react to changing needs. Our approach uses the Y2E2 iRoom as a testbed. Eight cameras are installed in a track along the ceiling to observe the environment (Figure 1). These cameras operate in a collaborative fashion known as a calibrated camera network. By combining observations from multiple viewpoints the 2D position of an occupant can be reconstructed. Pose is acquired by matching silhouettes to a database of previously acquired silhouettes labeled with poses through a technique known as chamfer matching. Positions and poses are considered together over time to identify particular behaviors. Behaviors are indicative of particular scenarios: small groups suggest localized lighting, while a forward-facing audience suggests presentation-style lighting.

Status
After installing the camera network, we demonstrated the chamfer matching-based pedestrian localization and pose determination at the 2\(^{nd}\) International Conference on Distributed Smart Cameras\(^2\). Subsequent steps are to build a database of commonly seen poses, and to develop a hypothesis testing system to aggregate poses into behaviors.

---
\(^2\) I. Katz, H. Aghajan: Multiple Camera Based Chamfer Matching for Pedestrian Detection. In: 2\(^{nd}\) International Conference on Distributed Smart Cameras, Stanford, California (2008)