

## Reliability testing of the occupancy sensor systems in residential and commercial buildings

PIs: Dr. Kristen Cetin, Paul Kremer

Yiyi Chu, Stefanie Nussbaum

### Project Objective

#### Overall Goal:

Evaluate the robustness of occupancy sensor systems (all types) under range of ‘typical’ and ‘challenging’ scenarios; identify areas of improvement for improving occupancy sensor system reliability.

### Testing Method

#### Define testing scenarios:

- **Normal testing:** “Typical” conditions that are expected to occur on an every-day basis in the residential or commercial settings being considered (*e.g., using ATUS data to define “normal”*)
- **Failure testing:** “Challenging” conditions that may be less common and/or more extreme than what might occur under a “typical” scenario (*e.g. someone running quickly, very dark/bright lighting conditions, etc.*) to determine if systems fail at such levels.

#### Testing Methods: 2-stage failure testing:

- **Stage 1:** Testing of the impact of single variables and combinations of variables to determine if a variable or combinations of variables are influential or not

*If it is determined a sensor system is sensitive to a variable or combination of variables*

- **Stage 2:** Several levels of testing will be conducted to better determine the level of a particular variable that elicits a failure

### Challenging conditions

#### Preliminary influential variables:

- **Building:** *size and dimensions of test area, number of doors*
- **Environmental:** *lighting level, sunlight (direct/diffuse) or other light sources, various forms of electromagnetic interference*
- **Occupants:** *number of occupants, spatial location of occupants, noise level of occupants, clustering of occupants, number of occupants entering/existing in a room at the same time*
- **Other:** *presence, size, and movement of pets*

#### Define “most important” variables:

- Survey sent to all ARPA-E SENSOR teams and workshop attendees
- Responses were collected from 54 responses of expert stakeholders from a variety of backgrounds.
- Two methods were used to evaluate the data:
  - **Method 1:** A count of the number of times that participants selected each variable, regardless of how it was ranked: the higher the count, the “more important” the variables were.
  - **Method 2:** Using a weighing factor, of which the first 6 responses from each participant were considered: the variable ranked first received a weightage factor of 6, the second received a 5, etc...
- Divide the variables into **tiers of importance:** From Method 1, if the resulting count for each variable was larger than half of the total responses from the “most/least important variables” data for that category, then the variables were categorized as Tier 1. Similar results were obtained following Method 2.

### Most important variables

#### The most important variables in residential and commercial buildings:

Residential Buildings	
Most important (Tier 1)	A2. Size (length/width) and shape of test area
	C5. Level of motion of occupant(s)
	D1. Presence of pets
	B1. Lighting level (regardless of source of light) (lux)
	C4. Spatial location of occupant(s)
	C1. Number of occupants (including 0)
	A9. Presence of large objects (especially metal objects) within or near a space
	B3. Presence of interior lighting sources (non-overhead)
	A4. Number of doors (entrances/exits)
D4. Use of robots	
Commercial Buildings	
Most important (Tier 1)	A2. Size (length/width) and shape of test area
	C1. Number of occupants (including 0)
	D9. Repeatability of performance of system (i.e. does it provide the same results consistently)
	D7. Initial performance/performance over time (e.g. does it take a while for the system to work well)
	B1. Lighting level (regardless of source of light) (lux)
	C4. Spatial location of occupant(s)
	A9. Presence of large objects (especially metal objects) within or near a space
	C5. Level of motion of occupant(s)
B7. Presence of sunlight - direct	
C7. Clustering of occupants (distance between occupants)	

#### Survey results conclusion:

- Size and shape of test area is important
- The presence of pets, instead of size and movement, is more important
- D9 and D7 will be used for evaluating ease of commissioning
- C7 is added from the results of the last question for commercial building

### Future work

Implement lab experiments to test the “Most important variables” for different occupancy sensor systems.