

Toward Building Seat Occupancy Detection System

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1. INTRODUCTION

Detection of seat occupancy is important for real-time seat monitoring and better facility management. In this ASSET paper, we present a real-world deployment of occupancy detection system, its techniques and performance metrics.

2. SYSTEM OVERVIEW

Capacitive sensing gets more attentions lately due to its wide range of applications [1]. Our system uses capacitive sensor mounted under table at the seat location to detect people and object occupant alike. Sensor's voltage is reduced when object approaches in detection field around the electrode. This reduction is proportional to object's size, distance to electrode, and material of object. Checking voltage, we know if there is object in close proximity to the sensor [2]

Aluminum foil is our material of choice for making electrode, and Raspberry Pi acts as micro-controller. Overall system control flow is illustrated in Figure 1. In our de-

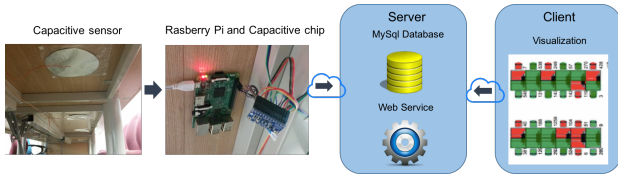


Figure 1: Flow chart of occupancy detection system.

ployment, hardware failures due to large amount of sensor and network issues arise from multi micro-controller connections are the norm. With different tweaks on hardware and detection algorithm, we reduce these problems to ensure system's availability and accuracy.

3. DETECTION ALGORITHM

We run a light weight algorithm bases on multi-stage thresholding. Each threshold accommodates for a single status of occupancy, e.g. unoccupied, object occupancy, laptop occupancy, and human occupancy. To be able to run continuous sensing for a long time, periodic auto calibration for sensor's signal and error checking is a must. We use *baseline* as a calibration point for our sensor, which updates its value periodically when signal is stable i.e. no people occupied. For error checking, we divide the process into two parts: hardware and network checking. Hardware failures can be checked by

Table 1: Detection performance of capacitive sensor

States	Precision	Recall
Unoccupied	91 %	84 %
Object Occupied	97 %	63 %
Laptop Occupied	81 %	75 %
People Occupied	89 %	98 %

monitoring sensor's signal. Signal that has magnitude too high, too low, or is not updated in a long time provides a hint for a failure. For network, we use polling to check for client network status from sever side, and auto reset connection in in place for protection of Wifi lost on client side.

4. EVALUATION AND CONCLUSION

We deploy our experiment system on 36 seats. Precision and recall of each occupancy state is presented in Table ?? . We identified scenarios where system can not capture the correct occupancy state. For example, people stationary for a long time can be flagged as object, thin papers on table and small objects at the side of table can not be detected, laptops that periodically change their working state sometimes being flagged as people. Hardware failures such as foils got tinkered by students, loose wires.

Overall detection result is presented in Table 1, our system achieves reasonable high performance at 91.2% accuracy. We also provide an easy to interpret real-time seat occupancy map that can help students save time searching for available seats. Hogging detection for object occupied get a reasonable high precision of 97%, which can be reliable tool for staff when they need to monitor seat hogging behavior.

5. REFERENCES

- [1] Tobias Grosse-Puppendahl, Christian Holz, Gabe Cohn, Raphael Wimmer, Oskar Bechtold, Steve Hodges, Matthew S Reynolds, and Joshua R Smith. Finding common ground: A survey of capacitive sensing in human-computer interaction. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 3293–3315. ACM, 2017.
- [2] Larry K Baxter. Capacitive sensors. *Ann Arbor*, 1001:48109.