Using Area Learning in Spatially-Aware Ubiquitous Environments

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ABSTRACT
We propose a framework using Google's Area Learning to create ubiquitous environments with cross-device proxemic interactions. We apply the framework to the domain of Emergency Response, and discuss the benefits and initial feedback of our framework.

Keywords
Sensors; Cross-device Interactions; Multi-surface; Area Learning; Ubiquitous Environments

1. INTRODUCTION
Ubiquitous environments have become increasingly common, as low-cost devices and sensors proliferate. Significant research has explored using these sensors to understand and interact with our surroundings. A recurring theme is to use proxemics, based on the relative positions of devices, to perform cross-device interactions. Existing frameworks for creating spatially-aware environments rely on strategically placed sensors, with many drawbacks. Camera sensors rely on line-of-sight, and run into the occlusion problem where moving users block each other from the sensors. If multiple sensors are used, they must be carefully calibrated to the same coordinate space. As the tracked space grows, the cost of expensive sensors also accumulates. We propose using the Area Learning tracking technology to enable spatially-aware ubiquitous environments, to overcome the aforementioned problems with existing frameworks and their sensors.

2. AREA LEARNING
Google's Area Learning (AL) is a spatial tracking methodology which maps an environment using mobile depth-sensing cameras [1]. The cameras are built into user devices, removing the need for external sensors. Each AL device is able to determine its own relative position accurately (± 0.1m) in 3D. By sharing the mapped environment, any number of devices can be integrated into a ubiquitous environment without any additional effort.

3. IMPLEMENTATION
SOD-Toolkit [3] is a flexible framework which can incorporate new sensors through its API. In addition to the existing Microsoft Kinect and Estimote iBeacon sensors, we used AL as a sensing technology. Mobile devices with AL capability are able to determine their own locations within the environment. Incompatible devices can still rely on other external sensors to provide spatial information. All spatial information is plotted in the same coordinate space.

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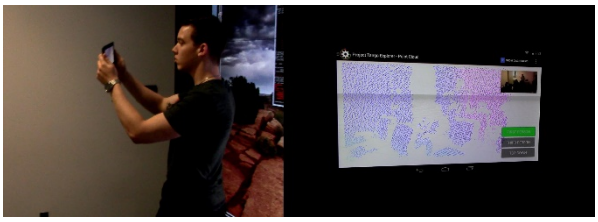

4. CASE STUDY
We used SOD-Toolkit with Area Learning within the Emergency Response domain, to design a spatially-aware Emergency Operations Centre [2]. Users were able to perform existing gestures from SOD-Toolkit, such as pouring data from a tablet onto a tabletop, with greater reliability using AL. In addition, users could interact in an augmented 3D space above the 2D tabletop, to interact with buildings on a map as well as their floorplans. The EOC prototype was demonstrated in several crowded environments, and required just minutes to setup at each location.

5. DISCUSSION & CONCLUSION
Previous versions of SOD-Toolkit required significant time and effort to setup, even by experienced users. The AL framework could be setup by anyone, and usually required under 10 minutes. For previous demos, we had to carefully consider the placement of devices while designating specific standing areas, as to not occlude sensors. In a recent demo, we had dozens of people standing side-by-side, and were able to reliably demonstrate cross-device proxemic interactions. We found AL to be highly robust, providing accurate spatial tracking at a relatively low cost. The ease of setup and flexibility to adapt spaces for different usages makes AL-enabled frameworks suitable for deploying spatially-aware ubiquitous environments in real-world scenarios.

6. REFERENCES
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