Indoor Ultra Wideband Ranging Samples from the DecaWave DW1000 Including Frequency and Polarization Diversity

Pat Pannuto
University of California, Berkeley
Berkeley, California

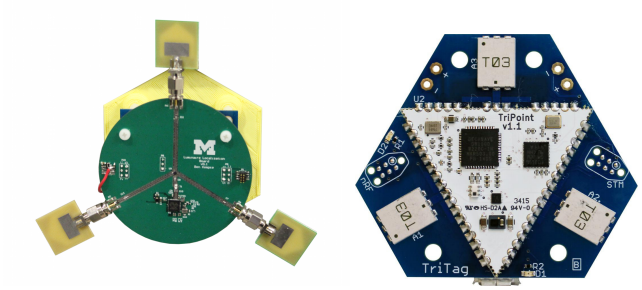
Benjamin Kempke
University of Michigan
Ann Arbor, Michigan

Bradford Campbell
University of Virginia
Charlottesville, Virginia

Prabal Dutta
University of California, Berkeley
Berkeley, California

ABSTRACT

When performing RF ranging in a complex indoor environment, the error of a single channel estimate can vary widely. A key insight of the PolyPoint and SurePoint ranging protocols is that individual nodes can efficiently capture multiple independent samples of the RF channel. For each point in space, nodes capture twenty seven independent samples by varying the spectrum sampled and the polarization of antennas. This dataset includes all of the measurements reported in the PolyPoint and SurePoint papers, which comprises several thousand points in a complex indoor environment. Precise 3D coordinates of nodes were captured using an optical motion capture system calibrated to millimeter accuracy. Several tracking studies are included, with continuous samples over time as a node moves through the environment.



(a) PolyPoint **(b) TriTag (SurePoint)**

Figure 1: Ranging Hardware. This dataset contains samples from two generations of ranging hardware. The first, (a) was used during the PolyPoint study at HotWireless'15 [5]. The second, (b) was used during the SurePoint study at SenSys'16 [4].

1 INTRODUCTION

Indoor localization is one of the best-researched areas in sensor networks. Over the course of four years of the Microsoft Indoor Localization Competition, ultra wideband (UWB) has proven to be a consistently high-performing technology, serving as the underpinning technology for roughly half of the top ten teams each year [6–9].

Interest in UWB was reinvigorated shortly after the turn of the century when the FCC released new guidelines permitting access to several gigahertz of spectrum [3]. Five years ago, DecaWave released the first broadly commercially available UWB transceiver, the DW1000 [1].

In our initial forays into UWB research, we discovered that while the median range estimate afforded by UWB is much improved over narrowband ranging, range errors of more than a meter are still possible. The innovation of the PolyPoint system was to capture multiple independent samples of the channel, permitting an estimate of this distribution, from which the system can extract more accurate ranges [5]. The SurePoint project expanded PolyPoint to a complete system demonstrating how to efficiently capture the diversity that PolyPoint motivated and scale ranging to multiple nodes in space [4]. As a consequence of these projects, we have amassed a dataset of thousands of range estimates in a complex indoor environment, which is shared here.

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In our experimentation, we focused our efforts on improving the fidelity of a single range estimate. However there is great potential for additional insights from considering multiple estimates over time. Indeed, this dataset served as the foundation for the initial experimentation of a new system to automatically identify non-line-of-sight paths in indoor environments [2]. We are excited to see what other innovations lie yet undiscovered in the data.

2 THE DATA

The dataset consists of a timestamp, ground truth X, Y, and Z coordinates, and range estimates between nodes in a complex indoor environment. Figure 1 shows the hardware systems used to collect range estimates. For each location, there are (up to) twenty seven range estimates, from the selection of one of three RF channels, one of three transmitting antennas, and one of three receiving antennas ($3 \times 3 \times 3 = 27$).

The majority of samples were collected in Tishman Hall, the atrium of the Bob and Betty Beyster Building at the University of Michigan, a large 20×20 m open-air space [10]. Anchors were placed on support pillars that surround the atrium and on walls. Over the course of experiments, some anchors were placed at floor height to afford Z-axis variation, however the majority of anchors were placed at approximately head height. Some experiments were performed when the atrium was largely empty and static, while others were run with a high degree of activity and movement throughout the space. Datasets are labeled with the approximate conditions they were run under to the best of the authors' ability.

3 ACKNOWLEDGMENTS

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