Poster: Bringing AR/VR to Everyday Life- A Wireless Localization perspective

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ABSTRACT

Augmented reality (AR) and virtual reality (VR) have the potential to revolutionize the way we interact with the environment around us. These technologies allow us to experience and collaborate with people in an immersive and intuitive way. Today, AR/VR is no longer limited to gaming and entertainment, rather it's blending into our everyday lives with applications in medical fields, education, grocery shopping, virtual try-ons etc. While a lot of progress has been made in visual rendering and scene understanding, little work is done on multi-user localization. To fully realize the potential of collaboration and multi-user applications, it is important to have an accurate and real-time 3D localization. Current 3D localization frameworks use cameras to create a relative coordinate system but these visual technologies struggle in low light conditions, and also require all devices to share an overlap of visual features which limit the applications to line-of-sight and room-level.

We propose a new peer-to-peer localization framework that utilizes Ultra-Wideband (UWB) radio to create a wireless network of nodes and measure the range and angle-of-arrival (AoA) between them. A common approach to this problem is Multidimensional Scaling (MDS) [1], which involves formulating a least squares problem and minimizing the difference between measured distances and euclidean distances from estimated coordinates. However, this approach becomes challenging when the network topology is highly dynamic and reconfigurable, especially in real-time applications like AR/VR. To address this challenge, we developed a new algorithm that selects key edges to measure and incorporates angle information along with distance measurements.

Edge-selection to minimize latency: UWB uses two-way ranging to estimate the distance between nodes which is a time-consuming process. In a network of many nodes, the time taken to measure the distance between all edges increases exponentially. To create a real-time system, it's important to minimize the number of measurements required. We discovered that adding angular information to the measurements doesn't take extra time. By using an antenna array, the same signal exchanged between nodes during two-way ranging can be used to estimate the angles between nodes. This adds an additional layer of constraint to the topology without needing extra measurements. We carefully select key edges to measure which maximizes the constraints in the topology and minimizes the latency.

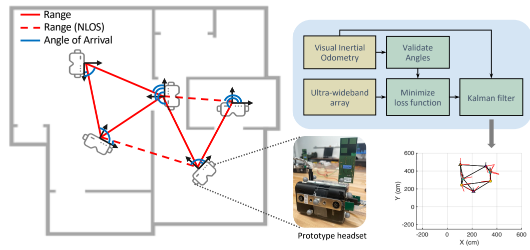

Figure 1: Overview of our 3D localization system for AR/VR.

Incorporating angles: The classical MDS technique [1] doesn't take angles into account. Including angles is non-trivial because the loss function becomes highly non-convex. To address this challenge, we propose a new loss function that jointly minimizes errors in both range and angle measurements. Consider a topology of N nodes, with unknown locations $X = [x_1, \cdots x_N]$ and measured distances $\hat{d_{ij}}$ and angles $\hat{\theta_{ij}}$ where (i, j) is the pair nodes in the topology. Our goal is to solve for X while minimizing the following loss function:

$$\min_X \sum_i \sum_j w_{ij}(\hat{d_{ij}} - d_{ij}(X))^2 + w'_{ij}(1 - cos(\hat{\theta_{ij}} - \theta_{ij}(X)))$$

where w and w' are the weights of edges. Note that the measured AoA is not same as the angle between nodes. The AoA is also affected by the orientation of the nodes. Therefore, we jointly solve for 3D orientations and location of the nodes.

CCS CONCEPTS

• **Computer systems organization** → **Sensor networks**.

KEYWORDS

Ultra-wideband; peer-to-peer localization; infrastructure-free

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