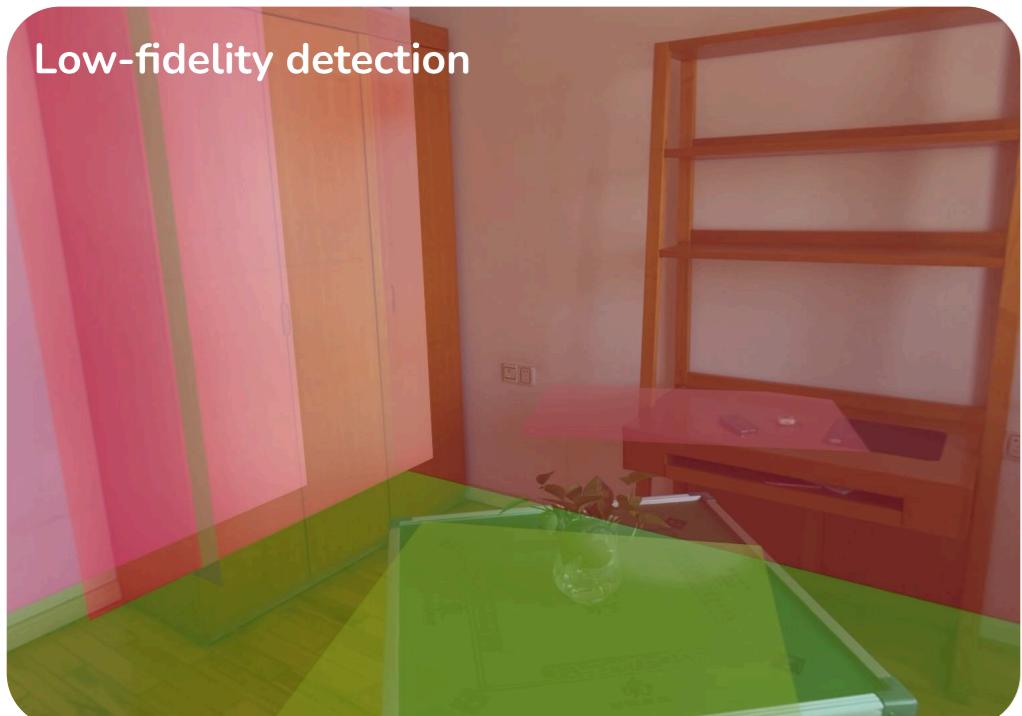


Abstract

Existing augmented reality (AR) measuring tools enforce a **monotonic measurement pattern** that is operation-heavy and unforgiving of motor imprecision, or they impose a requirement for close-range manual references during measuring workflows. As **spatial computing** enters everyday practice, we present **rulAR**, an innovative AR spatial-scene measurement experiential prototype, to surpass this stagnation. Developed on Apple Vision Pro, rulAR highlights **low-manual to zero-manual** task operation on an **intelligent, scene-aware** spatial interface: it intelligently labels measurement-critical points in the scene for selection, or automatically delivers comprehensive visualized dimensions immersively.

Scene Reconstruction

3D CV Resources



PlaneAnchor, provided by ARKit on VisionOS, serves as the core of this work for obtaining the initial raw scene data, which can detect horizontal, vertical, and slanted planes in space.

Two types of detection data is provided: Low-fidelity rectangles and High-fidelity geometric mesh. We choose to use the mesh data: it can (1) synthesize the main plane region even in the presence of occluding objects, and (2) give stable overall plane geometry pose.

Reconstruction from Mesh

The drawback of detection mesh geometry lies in its inability to effectively capture the perfect-complete geometry of a plane. With a reasonable assumption of “each individual mesh is a rectangle area”, we designed a **2-step optimization algorithm** in reconstructing useful digital back-end for rulAR’s interaction scenarios.

Algorithm 1 SceneReconPipeline

```

MinArea rectangle search
 $H \leftarrow \text{CONVEXHULL}(\{p_{i,2D}\})$ 
 $\Theta \leftarrow \{\text{edge directions of } H\}$ 
 $\min_{\theta \in \Theta} A(\theta) = (u_{\max} - u_{\min})(v_{\max} - v_{\min})$ 
 $\{u_i, v_i\}^* \leftarrow \arg \min_{\theta \in \Theta} A(\theta)$ 

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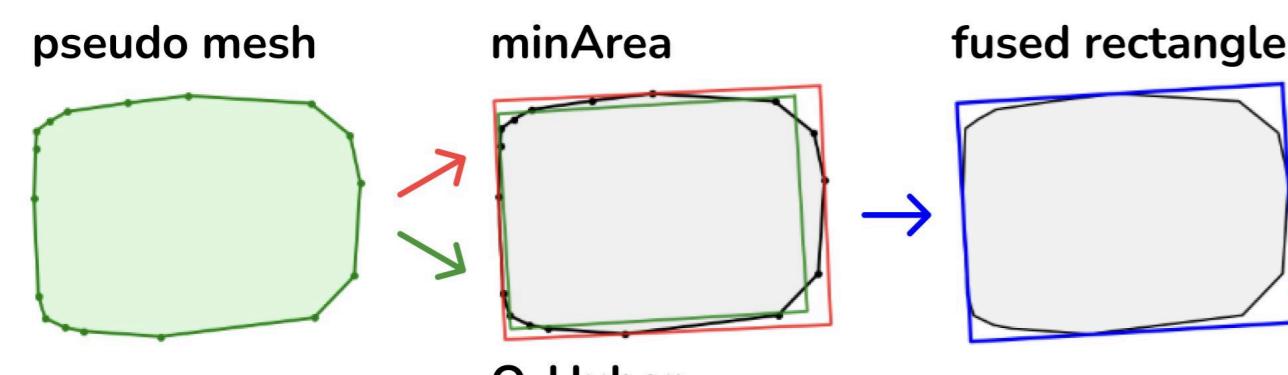
Q-Huber rectangle search
 $\theta_0 \leftarrow \text{INITTWO}(\{p_{i,2D}\})$ 
 $\Theta_{\text{coarse}} \leftarrow \text{LINSPACE}(\theta_0 - \frac{\Delta}{2}, \theta_0 + \frac{\Delta}{2}, n)$ 
 $(J^*, \theta^*) \leftarrow \arg \min_{\theta \in \Theta_{\text{coarse}}} \text{EVALUATEHUBERCOST}(\{p_{i,2D}\}, \theta; q, \lambda)$ 
 $\Theta_{\text{fine}} \leftarrow \{\theta^* + \varphi \mid \varphi \in [-\delta^\circ, \delta^\circ], \text{step} = \epsilon^\circ\}$ 
 $(J^*, \theta^*) \leftarrow \arg \min_{\theta \in \Theta_{\text{fine}}} \text{EVALUATEHUBERCOST}(\{p_{i,2D}\}, \theta; q, \lambda)$ 

```

```

 $(\text{center}, \text{width}, \text{height}) \leftarrow \{u_i, v_i\}^*$ 
 $\text{rect}_{2D} \leftarrow \text{CONSTRUCTRECT}(\text{center}, \text{width}, \text{height}, \theta^*)$ 

```



MinArea: rotating calipers minimum area search, gives the estimation of the plane position and size.

Q-Huber: minimizing Huber loss of quantile-trimmed rectangle in coarse & fine angles, gives the estimation of the plane orientation.

Fused-rectangle: obtain the final rectangle’s size & pose with the two above steps.

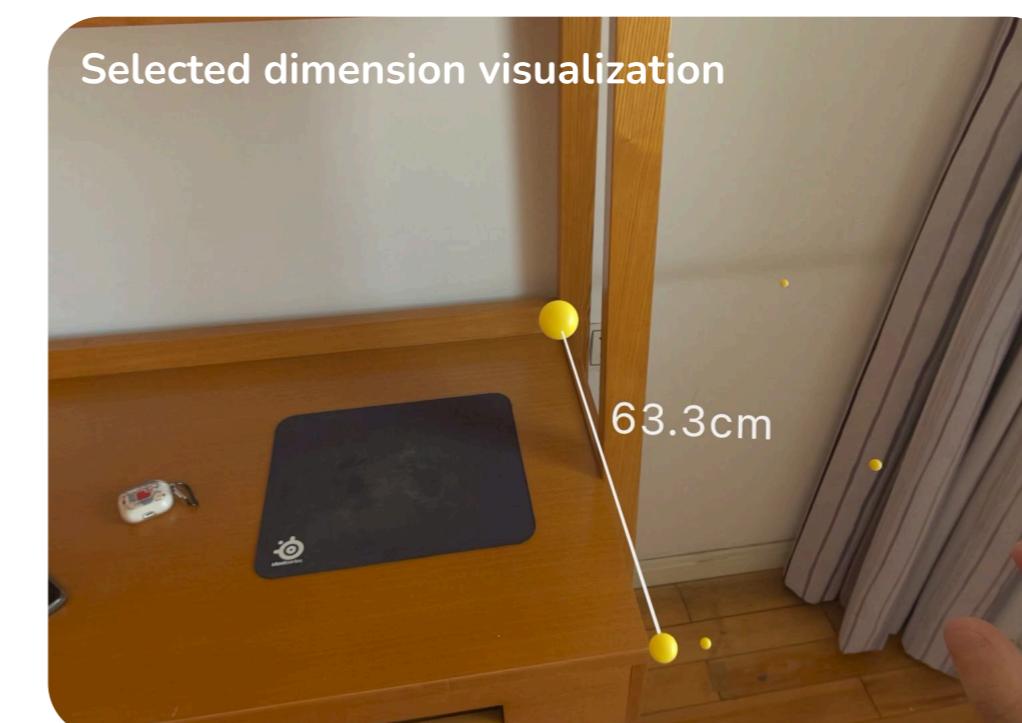
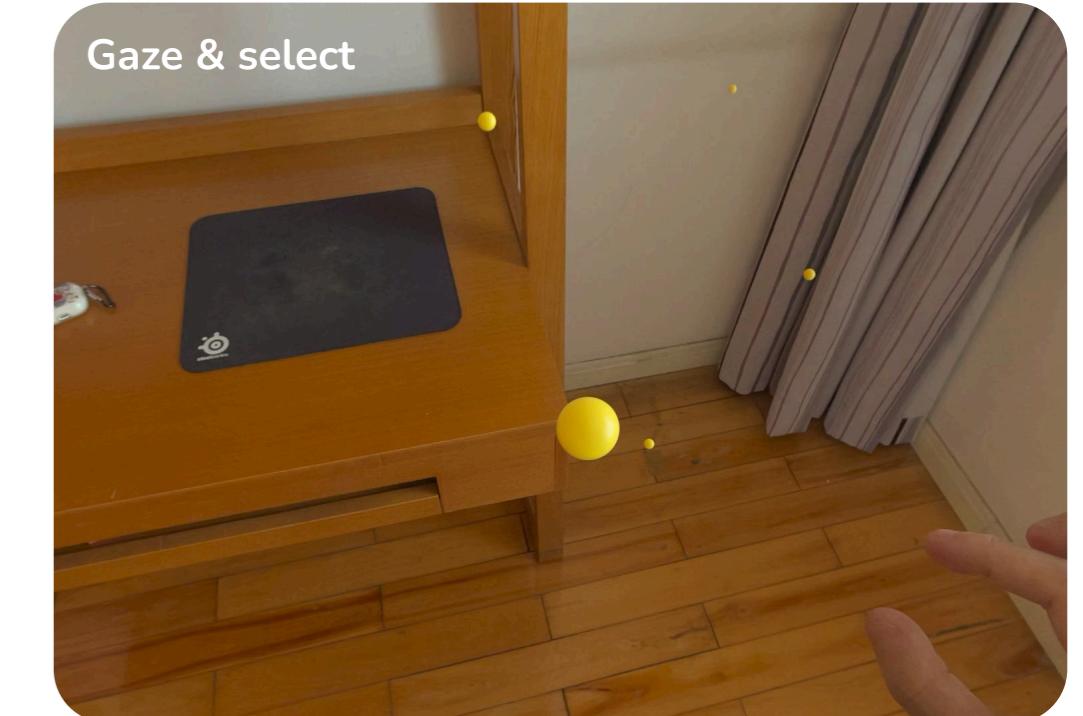


The fused rectangle result shows good qualities, as shown by the left figure.

The **plane-rectangle data** serves as the fundamental up-stream of the following rendering scenarios of two interactivity designs.

Scene Interactivity Design

Intelligent-Label Measurement



By providing critical points in the scene, user can use **lightweight gaze-tap** input to achieve **select-measure** process to query any interested dimension in the current environment.

Rendering: critical points of rectangle corners (averaged if multiple exist in-radius); gaze-on-entity animation; tapped animation; text labeled line segments (if prev_recorded == true).

Fully Immersive Display



Measurement interaction can be achieved **purely through visual communication** by directly rendering the plane-rectangle data.

Rendering: the boundary vectors of the reconstructed rectangles as line segments with labeling the length of one selected pair of adjacent edges.

Conclusion

rulAR demonstrates a practical path beyond monotonic AR measuring workflow interactivity. It is expected to provide an insightful experimental venue for addressing scenarios where precise device operations are inaccessible, and to serve as a concept for investigating innovative interactivity within spatial computing frameworks, and also a concept for investigating innovative interactivity within spatial computing frameworks.