Multi-User Augmented Reality with Communication Efficient and Spatially Consistent Virtual Objects

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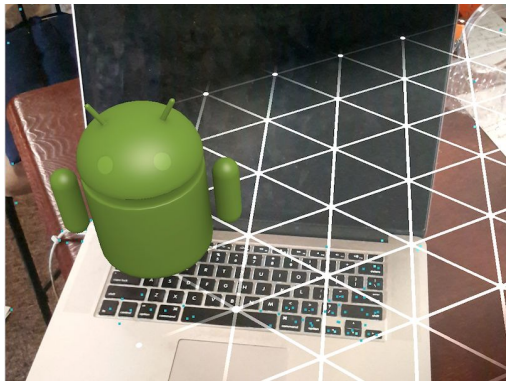
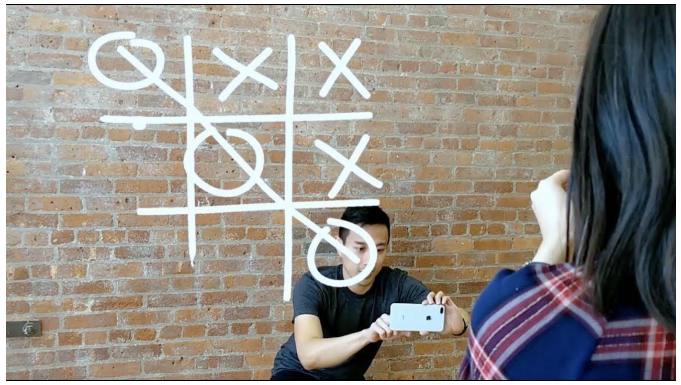
Multi-user Augmented Reality

Pokemon Go Buddy Adventure

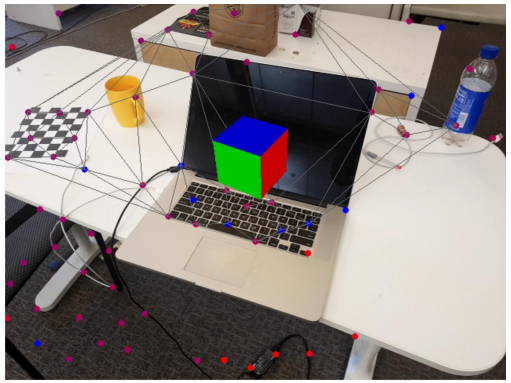
Minecraft



CloudAnchor



Just a Line

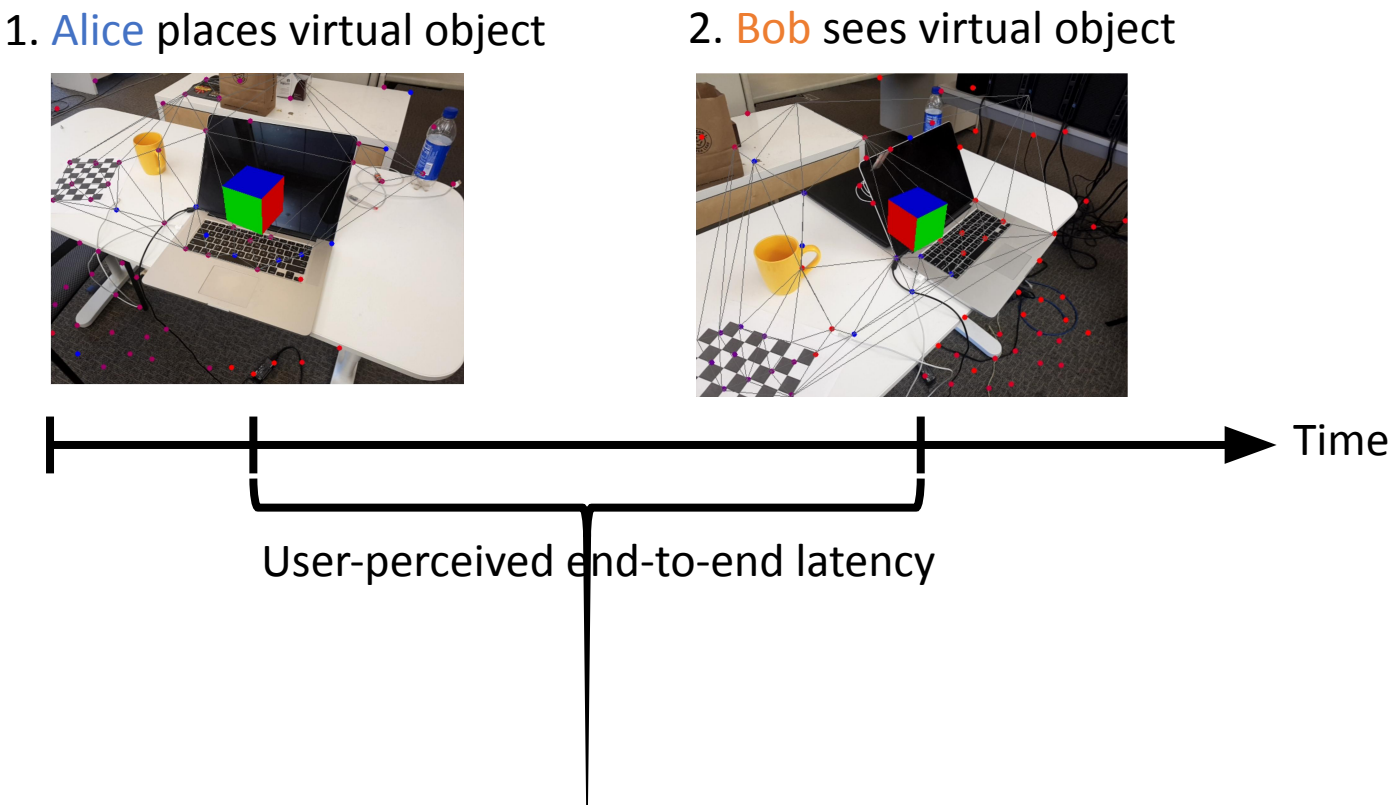


VINS-AR*

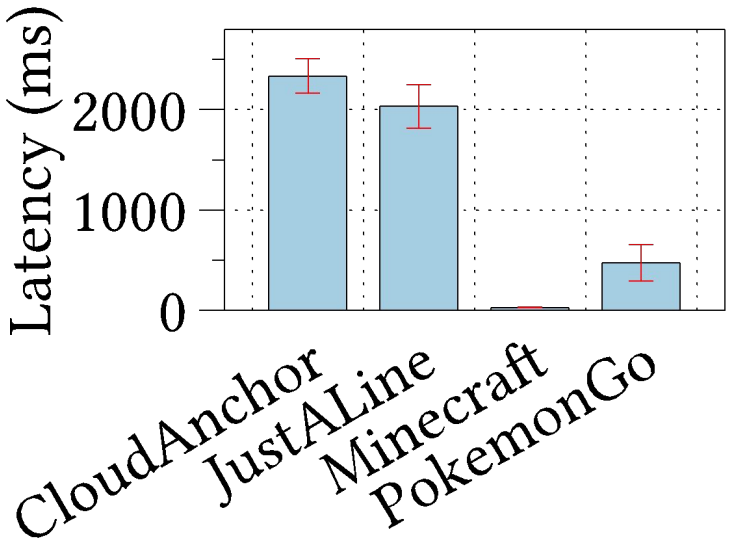
*Li, P., Qin, T., Hu, B., Zhu, F., and Shen, S. Monocular visual-inertial state estimation for mobile augmented reality. ISMAR 2017

Initialization Latency

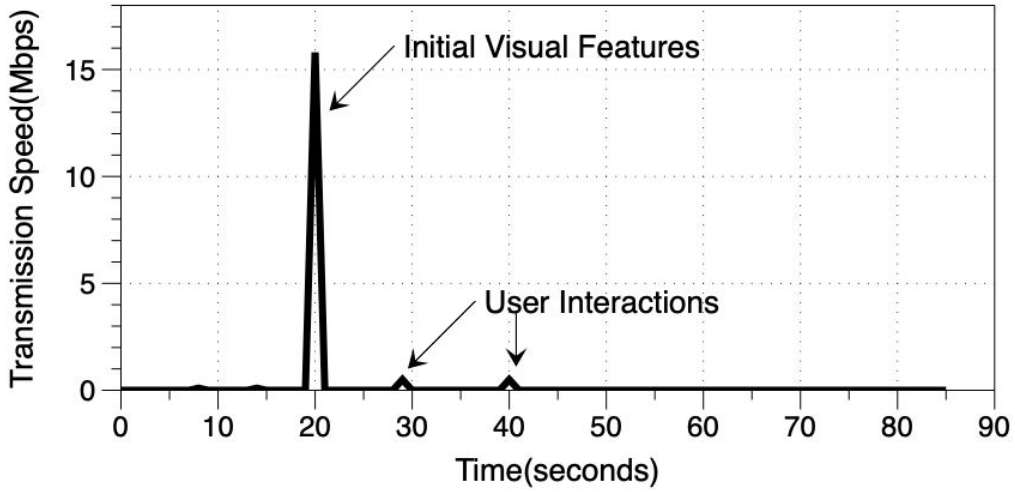
- We define the time from the host start sharing the virtual object to the other user(s) finish relocating the virtual object as the initialization latency.



Initialization Latency



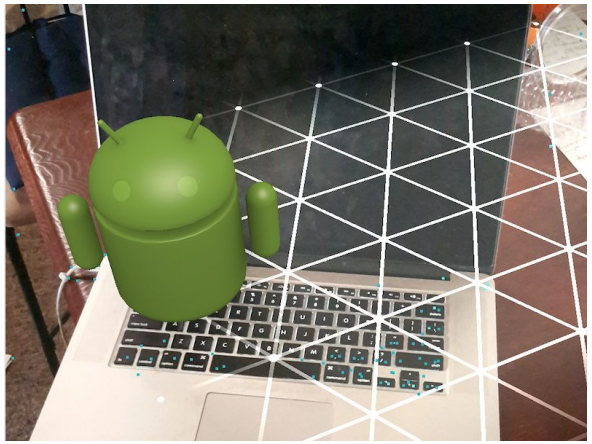
Initialization latency

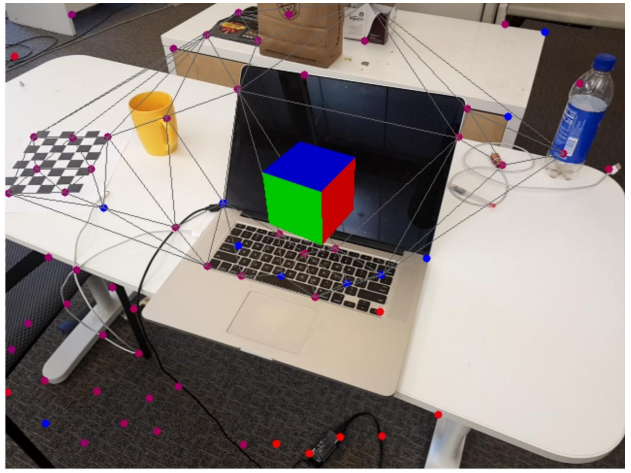


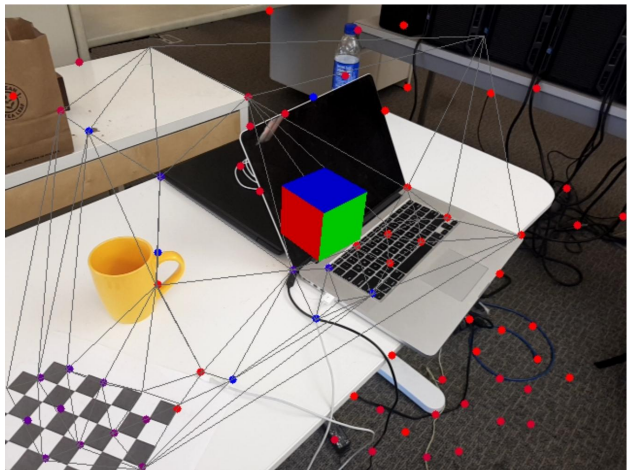
Just a Line network trace.

A large chunk of data has been sent during initialization process. What has been set? Can we speed up this process?

Drift/spatial inconsistency





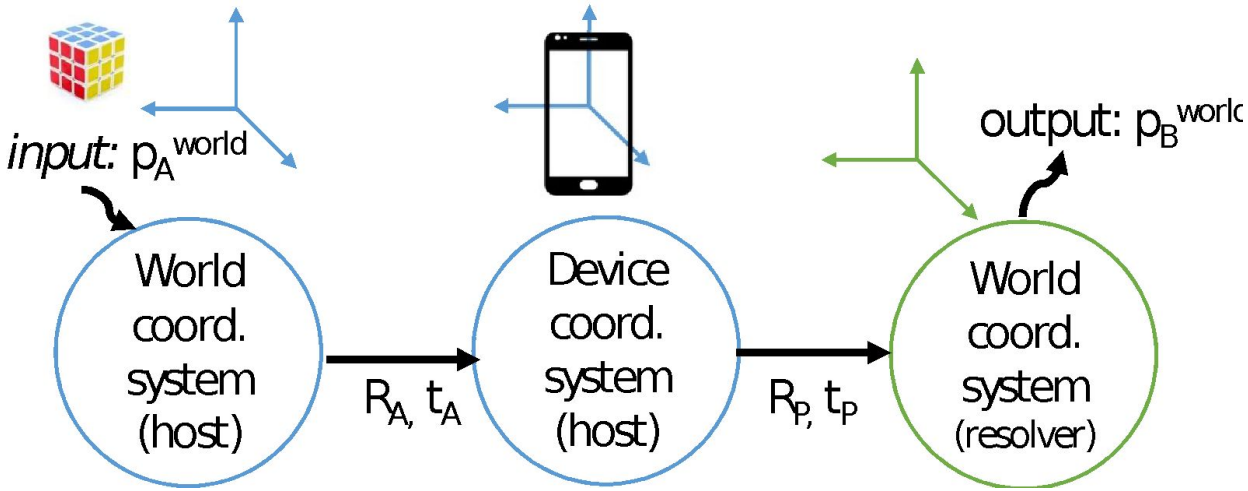


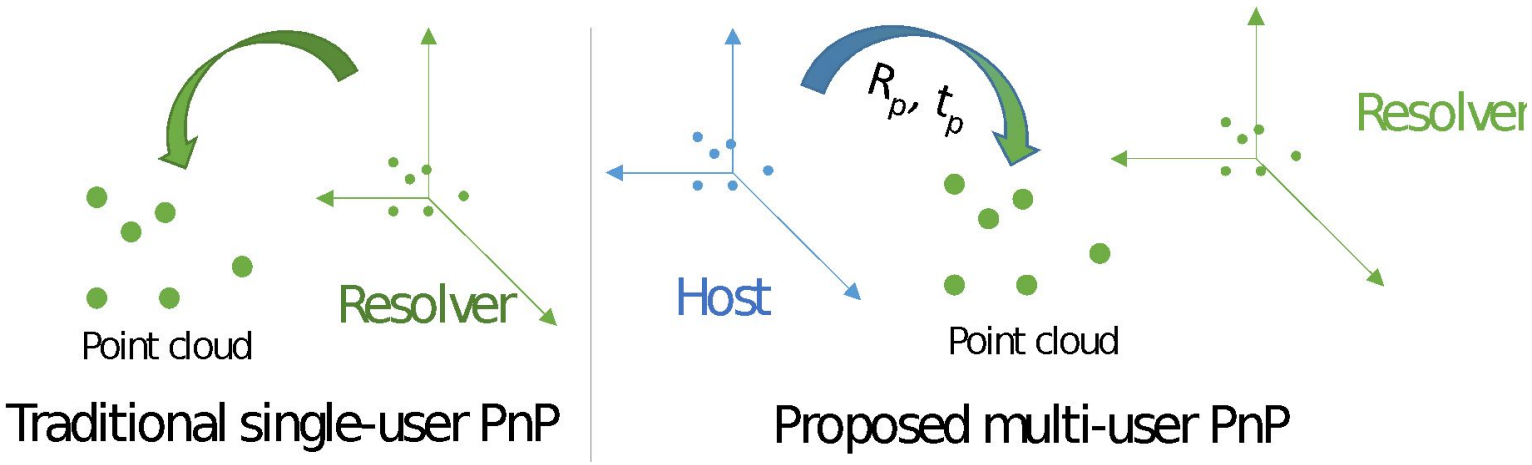
A light review of Background

- Current AR platforms such as Google ARCore, Apple ARKit, and Microsoft Hololens rely on simultaneous localization and mapping (SLAM).

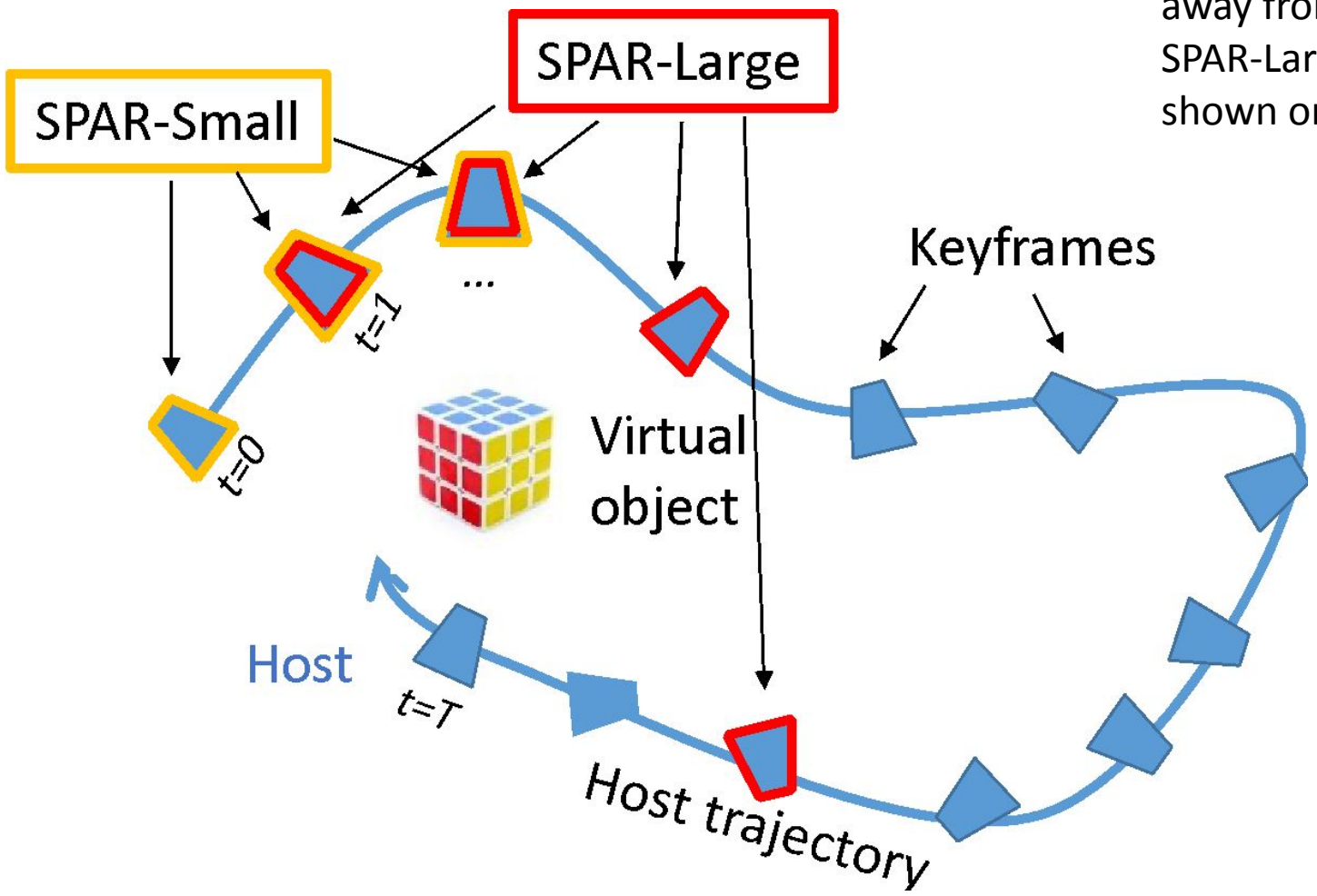
1. Extract features and construct a point cloud
2. Estimates camera location and orientation (pose)
3. Project virtual object and draw it on the screen

Coordinate system alignment



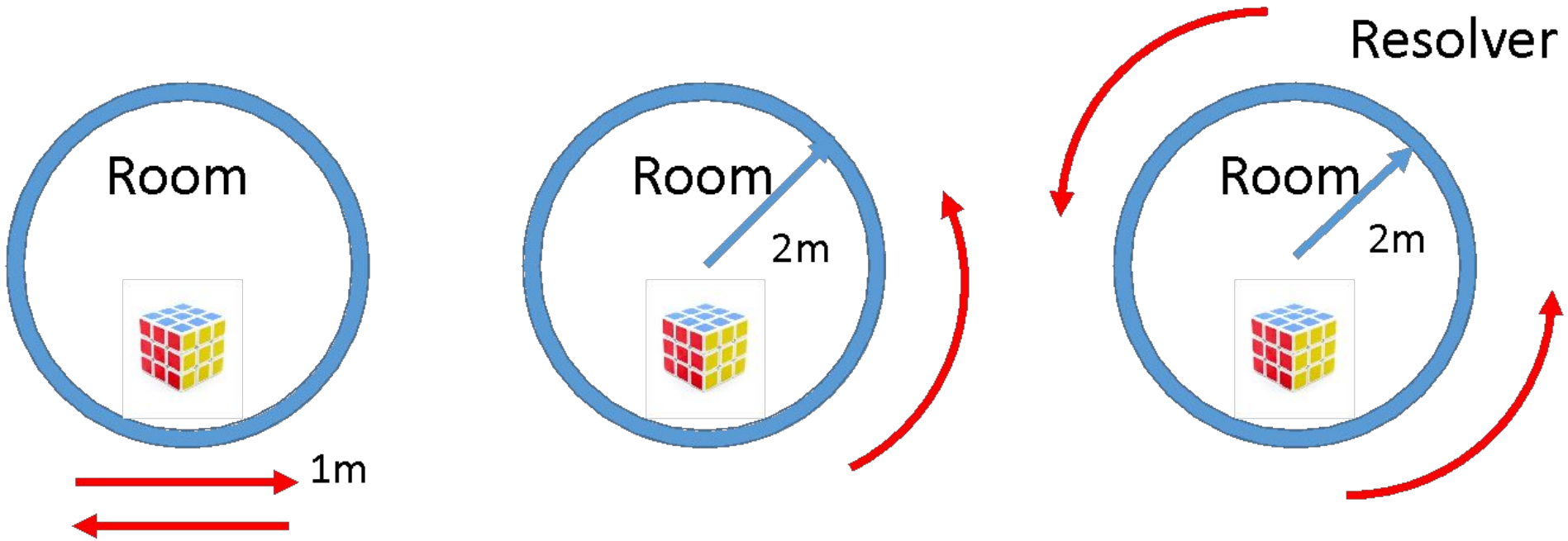


Sending strategies



SPAR-Small: Only send frames that are less than 1m away from the virtual object
SPAR-Large: Only send frames that virtual object is shown on the frame.

User mobility pattern



Host Resolver

Scenario 1

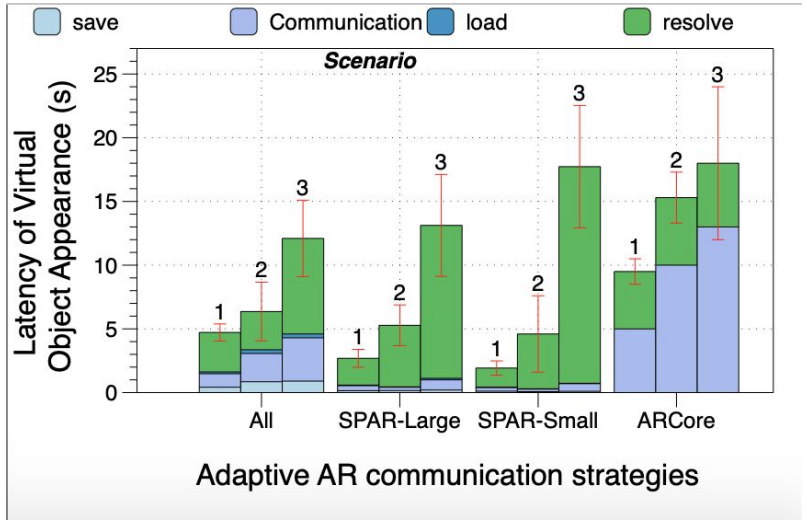
Host Resolver

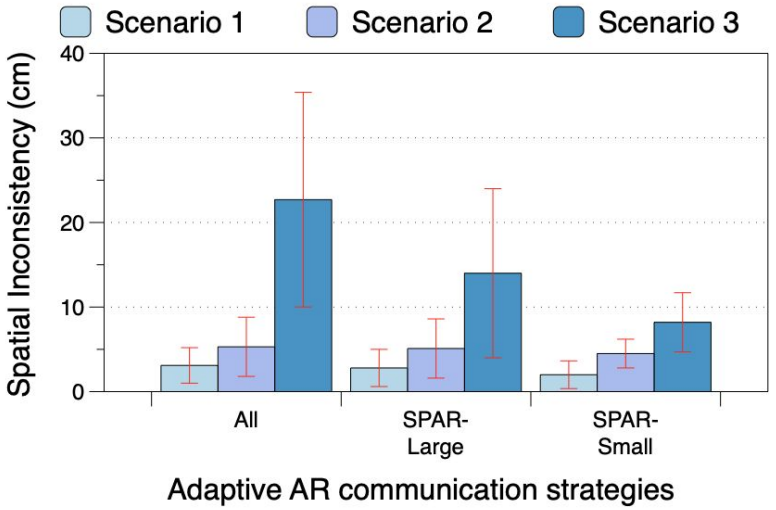
Scenario 2

Host

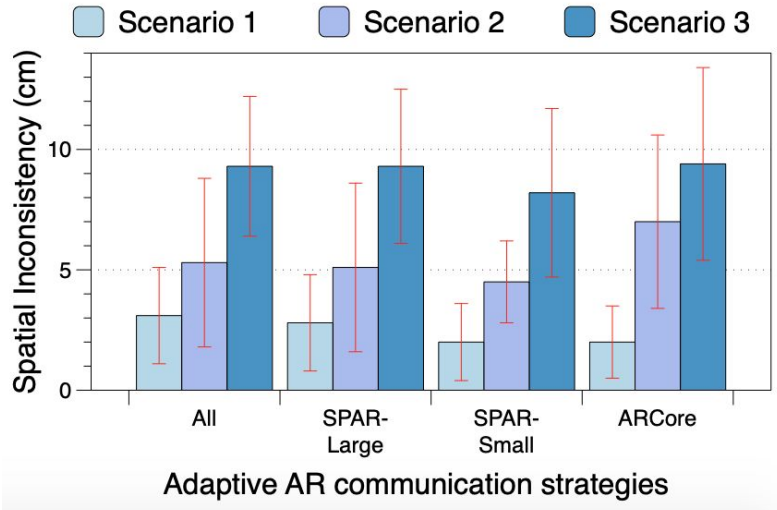
Scenario 3

Sending strategies Results





First resolve

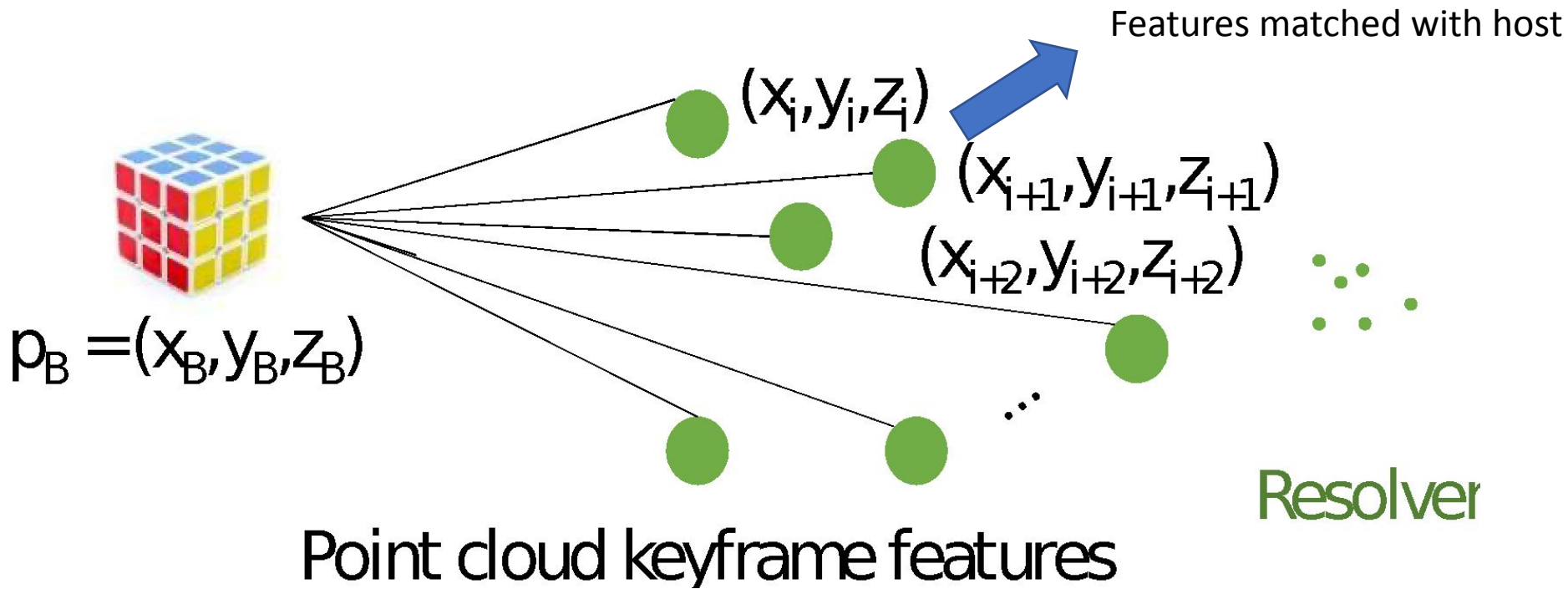


Stable

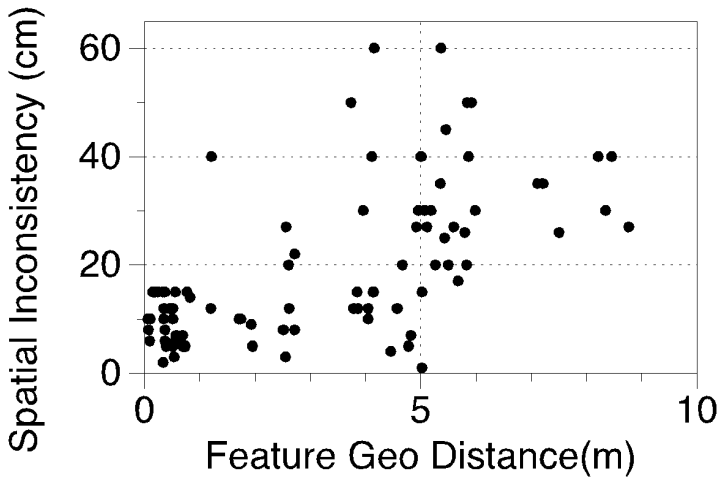
SPAR-Small can reduce initialization latency up to 55% in scenario 1 and 2
Spatial inconsistency can be reduced by up to 60%.

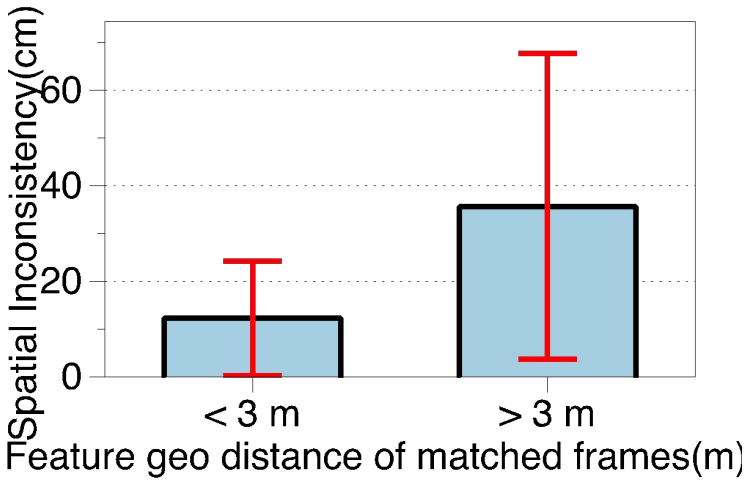
Update strategy

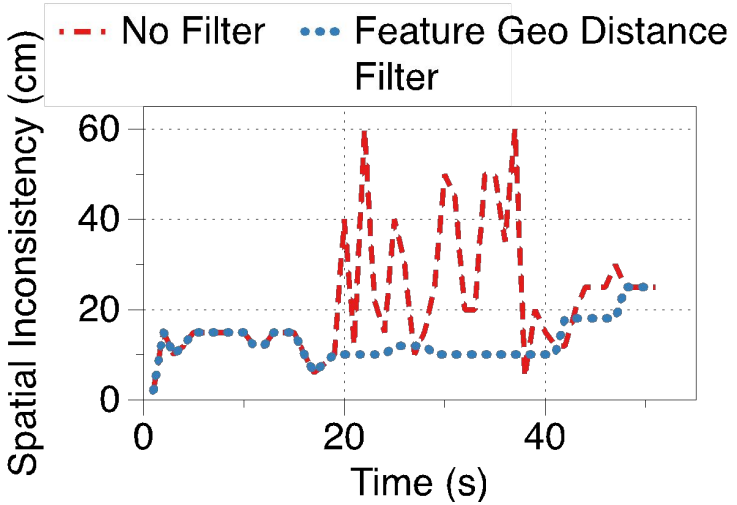
feature geo distance: the average distance to a virtual object over the common features in a pair of matched keyframes



Update Results

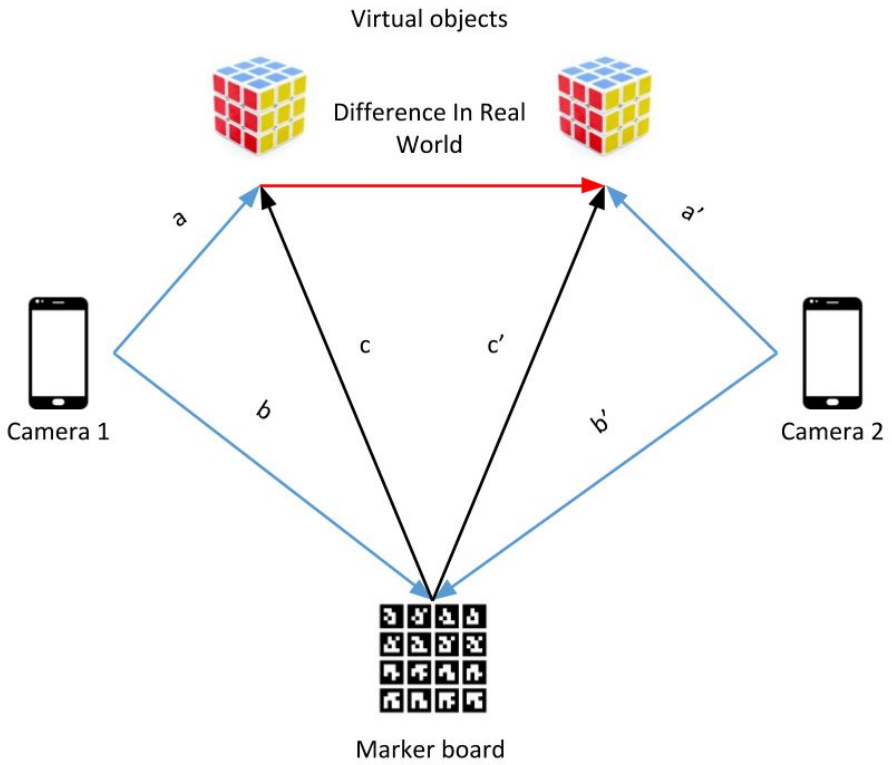


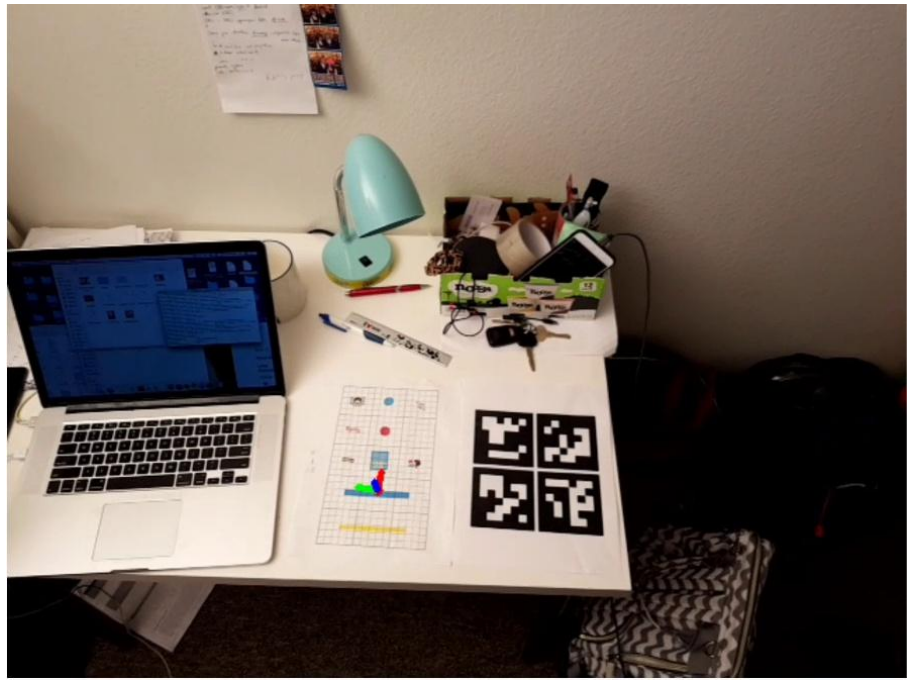




Use matches with low geo-distance can have less spatial inconsistency

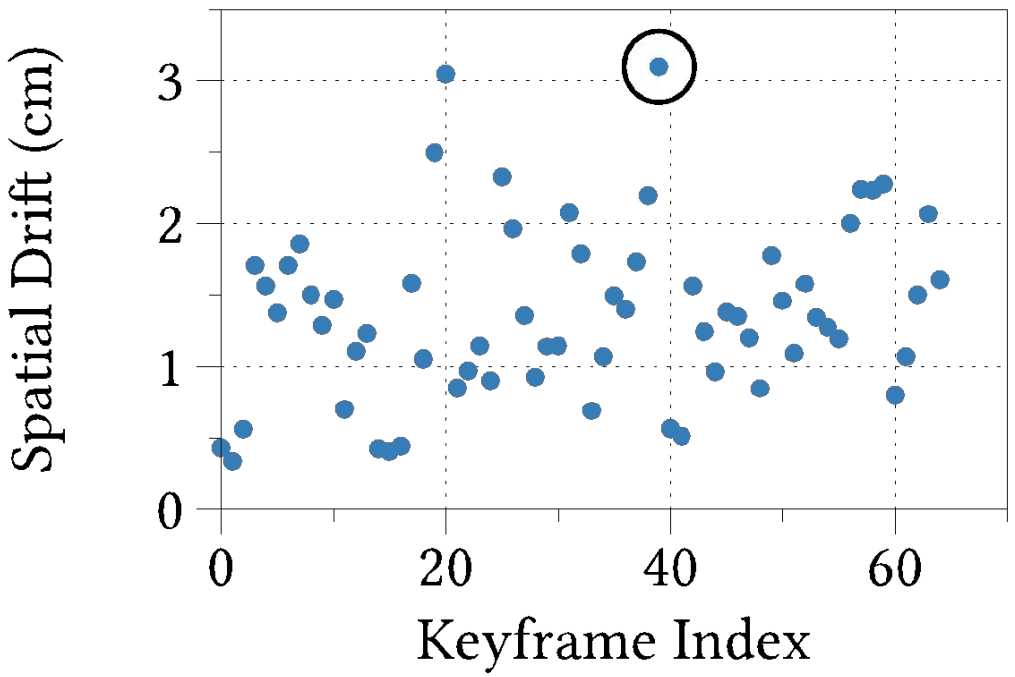
A tool for drift/spatial inconsistency measurement

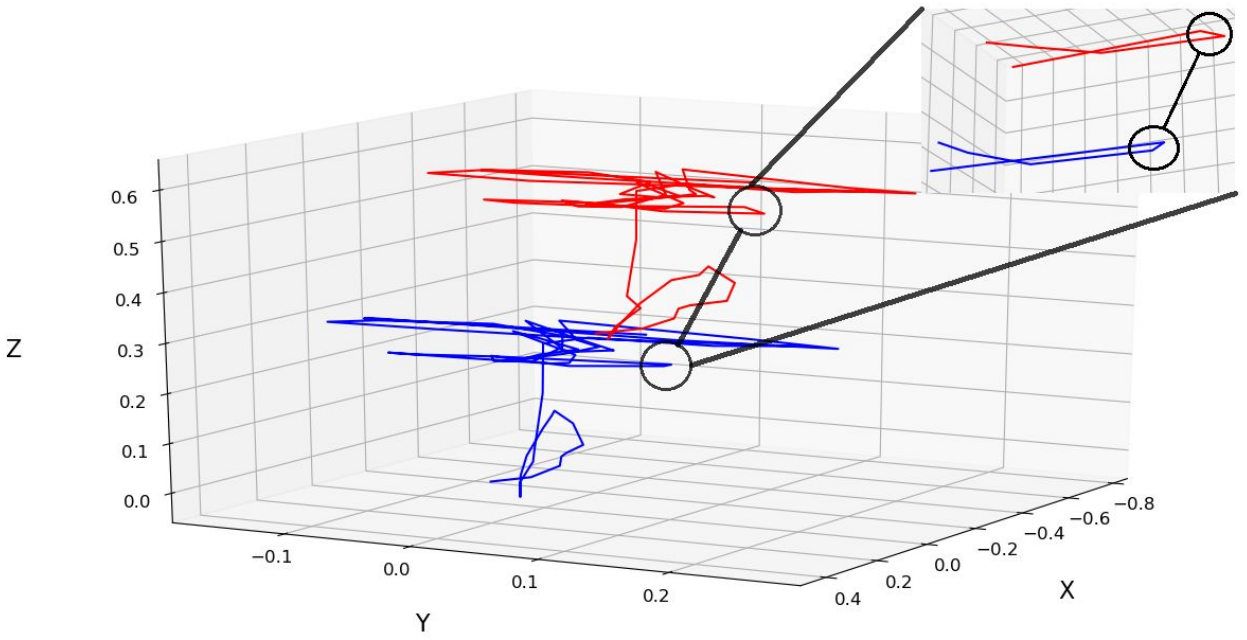




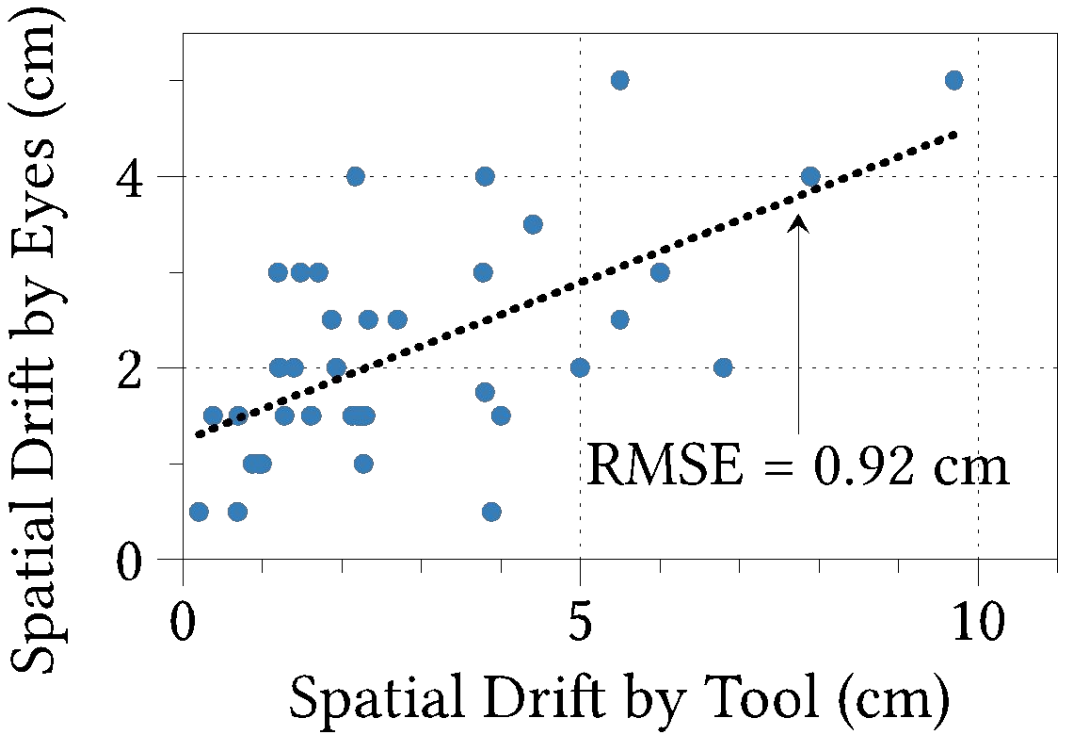
Environment setup

Tool Results





Tool Results



The tool can have a good estimation of spatial drift.

Key Take-Aways

Efficient communication strategies:
SPAR-small and SPAR-Large

Virtual object update strategy: use matched frames with low geo distance

A tool to estimate virtual object drift