IoT-Enabled Environment Illuminance Optimization for Augmented Reality

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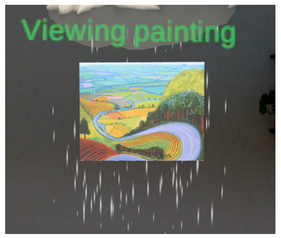
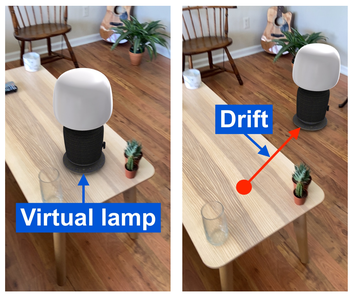
Introduction

- Augmented reality (AR) overlays virtual content onto a view of the real world
- Mobile AR recently popular due to smartphone platforms (e.g., ARCore, ARKit) and AR headsets (e.g., Microsoft HoloLens 2, Magic Leap One)
- Markerless mobile AR positions virtual content by tracking natural features in the surrounding environment

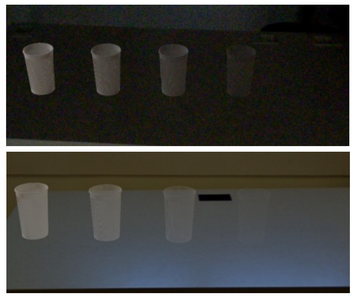


Motivation

- Environment properties (e.g., light, texture) impact virtual content stability [1], as well as eye tracking functionality [2] and virtual content visibility on AR headsets
- Both environment properties and requirements are dynamic; requirements often in conflict with each other
- We require a method of optimizing an environment for AR, based on multiple sensor inputs, while avoiding dissemination of environment images to the cloud



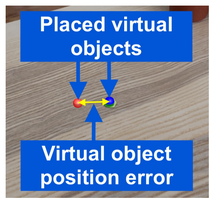
Virtual content (lamp) stability error on the iPhone 11 (ARKit 4)

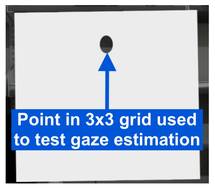


Virtual content (cup) visibility on the Magic Leap One

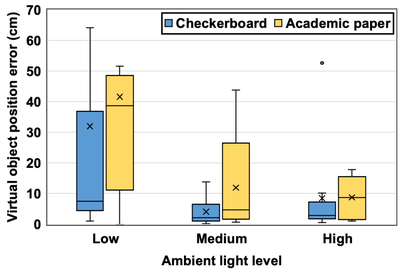
Impact of Environment in Augmented Reality

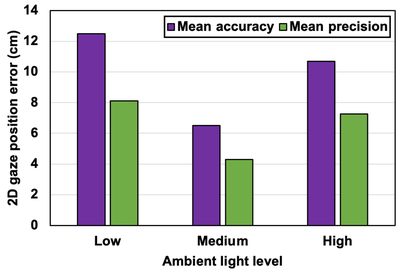
- We studied the impact of light level on virtual content stability and eye tracking performance
- We used our open-source app **ARStats** (https://github.com/timscargill/ARStats) to measure virtual content stability on the Samsung Galaxy Note 10+
- We developed a custom AR app to measure gaze estimation accuracy and precision on the Magic Leap One headset





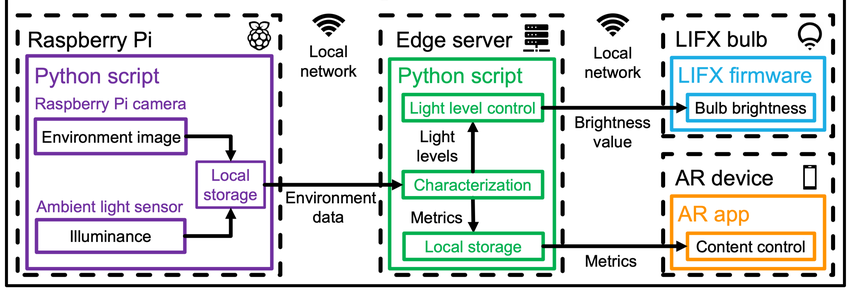
- Virtual content stability lower at lower light levels, but effect is greater for fine environment textures (e.g., an academic paper) more affected by noise in camera images
- Gaze estimation accuracy and precision degrades at both low and high light levels





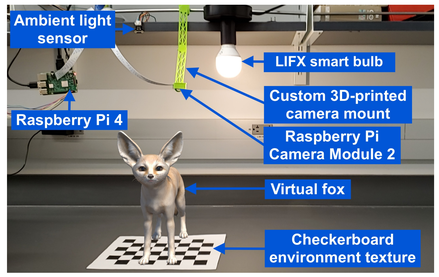
Edge Computing System Architecture

- Proof-of-concept edge system optimizes environment light level based on ambient light and visible texture:



Environment Illuminance Optimization

- Edge server analyzes data from IoT sensors and controls IoT bulb at low latency (< 0.5s), and stores characterization results
- Light level is raised when fine texture of academic paper is detected, to ensure high virtual object stability



Conclusions & Future Work

- Developed an edge-based AR environment optimization system using IoT devices
- Extendible architecture that will support multiple sensors and control devices, and heterogeneous AR devices
- Upcoming work will include user studies in realistic AR scenarios and optimizing other environment properties

Related Publications / Citations

[1] Tim Scargill, Gopika Premsankar, Jiasi Chen, and Maria Gorlatova. 2022. Here to stay: A quantitative comparison of virtual object stability in markerless mobile AR. In *Proceedings of IEEE/ACM Workshop on Cyber-Physical-Human System Design and Implementation*.

[2] Thiago Santini, Wolfgang Fuhl, and Enkelejda Kasneci. 2018. PuRe: Robust pupil detection for real-time pervasive eye tracking. *Computer Vision and Image Understanding* 170 (2018), 40–50.

Acknowledgments

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