Using Multiple On-Site Markers to Create Large-Scale Augmented Reality Experiences on Smartphones

AUTHOR: Alex Maat

SUPERVISORS: Michael Weinmann & Baran Usta

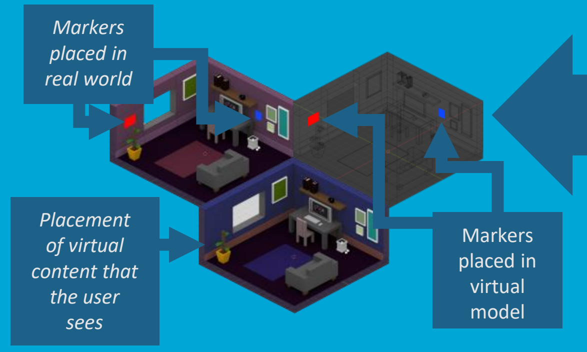
PROFESSOR: Elmar Eisemann

1 INTRODUCTION

- Small virtual models most common in AR
- Large-scale AR displays entire buildings
- Large-scale AR allows site exploration from a different time frame
- Virtual content needs proper alignment
- Smartphone application for increased accessibility
- Baratoff et al. used multi-marker system, but focus lied on small-scale [1]
- No research on implications for large-scale AR

2 RESEARCH QUESTION

How can we align virtual content using multiple markers using today's smartphones to allow for large-scale mobile AR applications?



3 MARKER ALIGNMENT

- Each location contains *virtual model* with *virtual markers* and *virtual content*
- *Detected markers* are overlayed
- Goal is to align virtual model with detected markers
- Application split into three parts: setup, initialize, update

Fig. 1: *The real-world setup (left) has a corresponding virtual model (center). Detected markers are overlayed based on AR Session origin (right).*

SETUP
- Populate environment with uniquely identifiable QR markers
- Create virtual model of the environment

INITIALIZE
- AR Session instantiated with virtual camera

UPDATE
- Virtual camera is moved by ARFoundation using accelerometer and gyroscope [2]
- Process video stream to detect markers
- Detected marker is placed relative to virtual camera
- Identify corner pairs between detected and virtual markers
- Change virtual model's pivot
- Translate virtual model to align with detected markers center
- Rotate virtual model using quaternions to avoid gimbal lock [3]
- Scale virtual model by averaging all desired scales

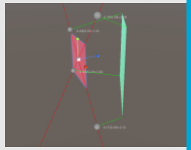


Fig. 2: *The distances between the corners of the virtual marker (red) and the detected marker (green).*

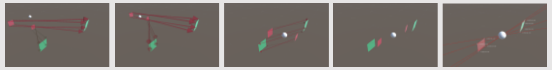


Fig. 3: *Visualization of effects on the virtual model during the update sequence.*

4 EVALUATION METRICS

ACCURACY
- Normalized distance between detected marker and virtual marker per update

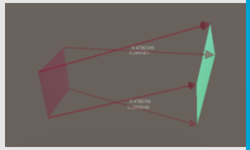


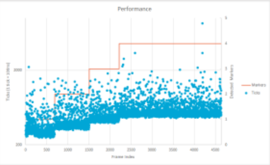
Fig. 4: *The distances between the corners of the virtual marker (red) and the detected marker (green)*

STABILITY
- Absolute positional coordinates per update
- Change in angle per update
- Absolute scale per update

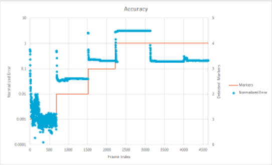
PERFORMANCE
- Number of ticks (100ns) the algorithm takes per update

5 RESULTS

PERFORMANCE



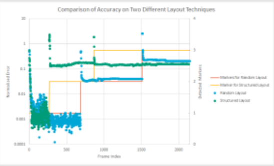
ACCURACY



STABILITY

6 RESULTS

DENSITY



LAYOUT

7 DISCUSSION & CONCLUSIONS

- Marker detection and identification needs improvement
- Using markers gives application fresh updates
- The runtime performance is linear in the number of markers
- A few updates are required to restabilize
- Higher density marker distributions yield larger stability
- Uniform layouts yield larger accuracy

8 REFERENCES

[1] G. Baratoff, A. Neubeck, and H. Regenbrecht. Interactive multi-marker calibration for augmented reality applications, 2002.
[2] Intro to AR Foundation – dots-tutorial.moetsi.com. https://dots-tutorial.moetsi.com/ar-foundation/intro-to-ar-foundation, 2021. [Accessed 19-Jun2022].
[3] E.E.L. Mitchell and A.E. Rogers. Quaternion parameters in the simulation of a spinning rigid body. SIMULATION, 4(6):390–396, June 1965.