Optimizing Pens for Use as 3D Raycasting Interactables with Monocular 6-DoF Object Tracking

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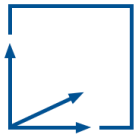

Final: Bachelor Informatics: Games Engineering

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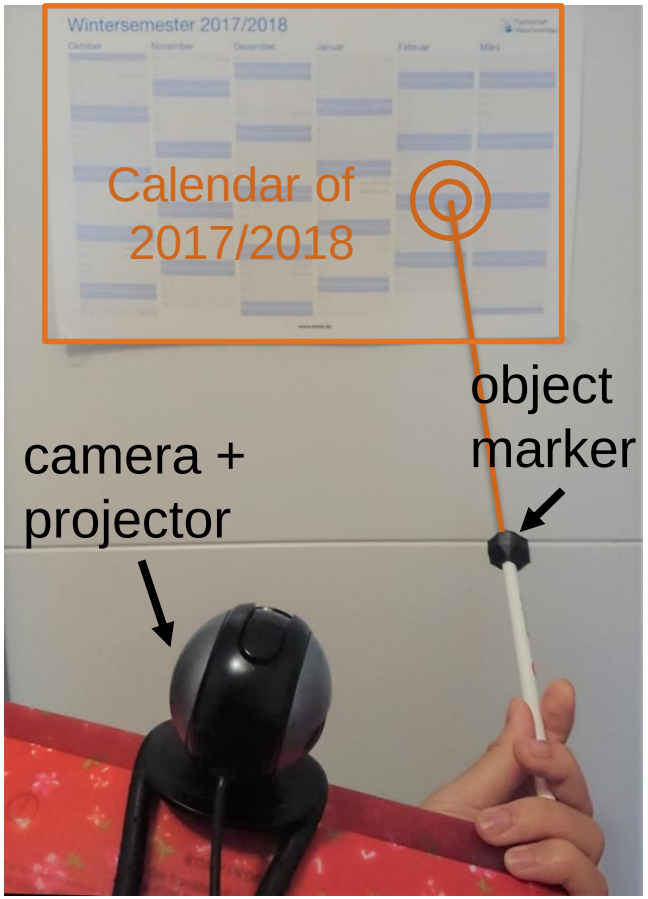
Advisor: Linda Rudolph

Introduction and Motivation

- Raise efficiency and productivity using AR
- Converting pen into interaction device
- Single mobile camera system
- Facilitated collaboration: share information using projector



Problem Description

- Object in 2D image ➔ Find pose in 3D space
  1. Find 2D keypoints
  2. Get 3D location of 2D points
  3. Fit model to these 3D points
- Define object to be tracked

Existing Solutions / Related Work

- “Vuforia” (PTC Inc.)
- “ARKit” (Apple Inc.)

} proprietary frameworks

- “6DoF Object Tracking based on 3D Scans for Augmented Reality Remote Live Support” (Rambach, Pagani, Schneider, Artemenko, and Stricker, 2018)

Goals of this Thesis

- Detect known object in images with single camera
- Track pose (6-DoF) of object in real-time
- Design optimal object marker (prototypes)

Proposed Approach

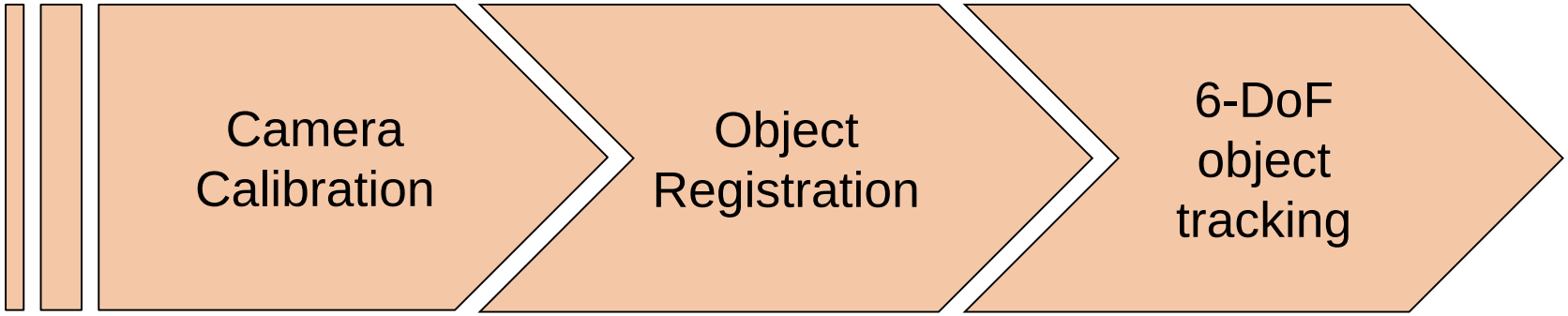
Implementation
of Tracking and Detection Algorithm

Design
of Object Marker

Evaluation
of 6-DoF Tracking Including Issues and Limitations

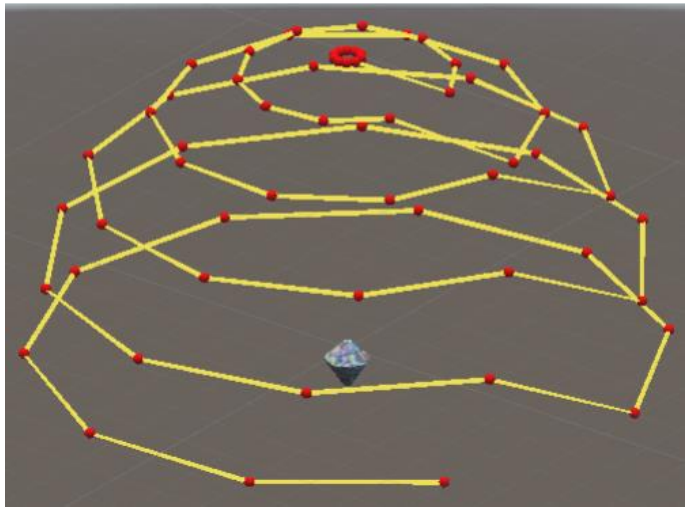
Implementation: Overview

- OpenCV
- Solve PnP problem with RANSAC approach

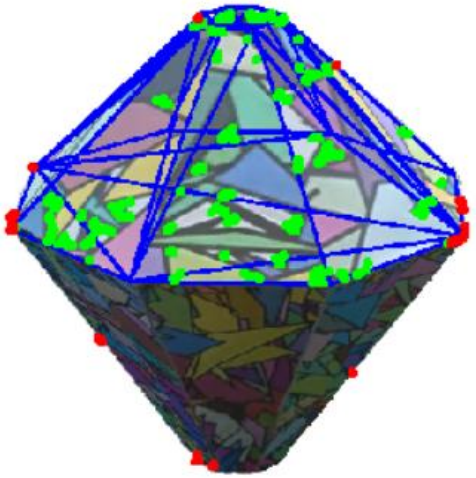


Implementation: Object Registration

- Synthetic data creation with Unity physical camera rendering
- Object reconstruction via 3D scanning
- Create ORB model (ORB descriptors & 3D locations)

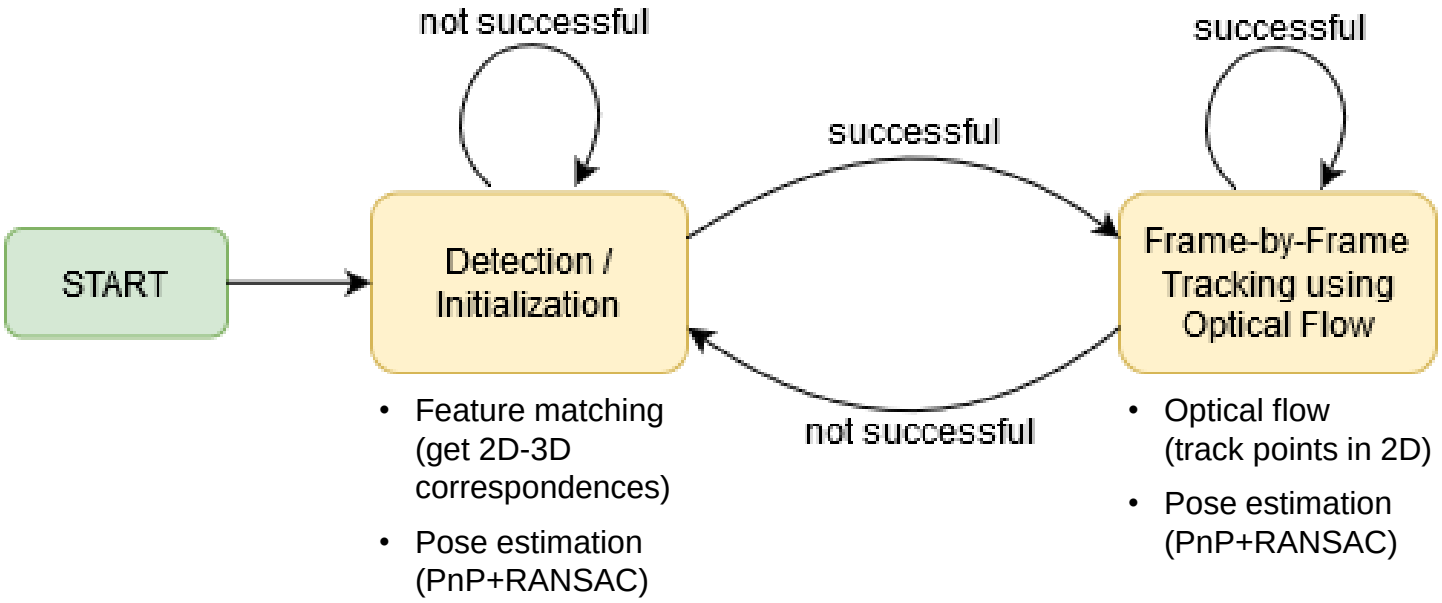


Trace of camera positions

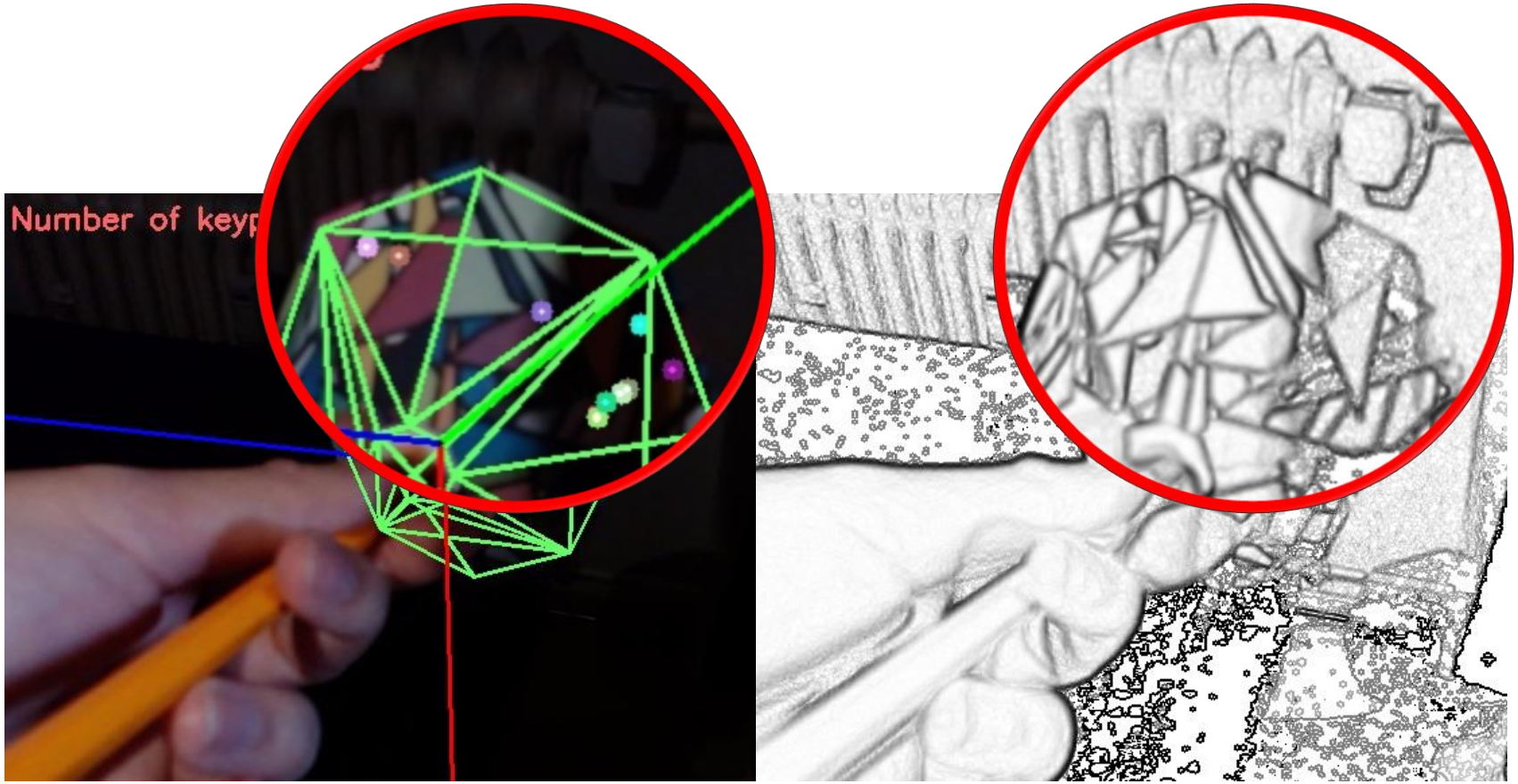


Registration image with overlaid mesh and ORB feature points

Implementation: 6-DoF Object Tracking



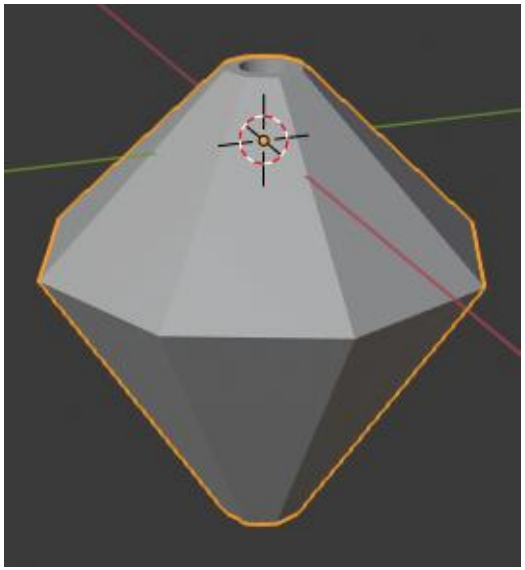
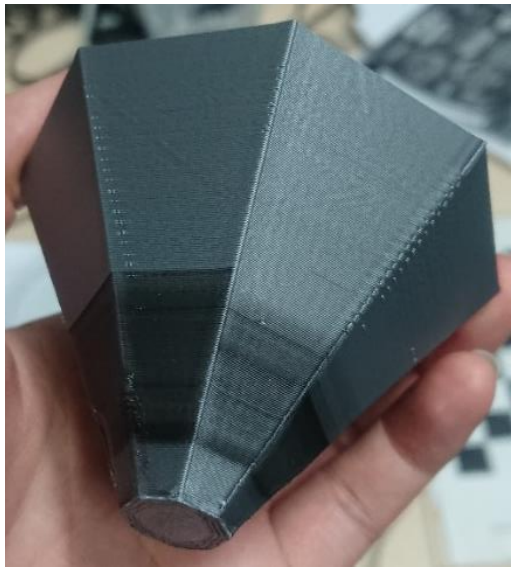
Implementation: Pencil Filter



Without pencil filter

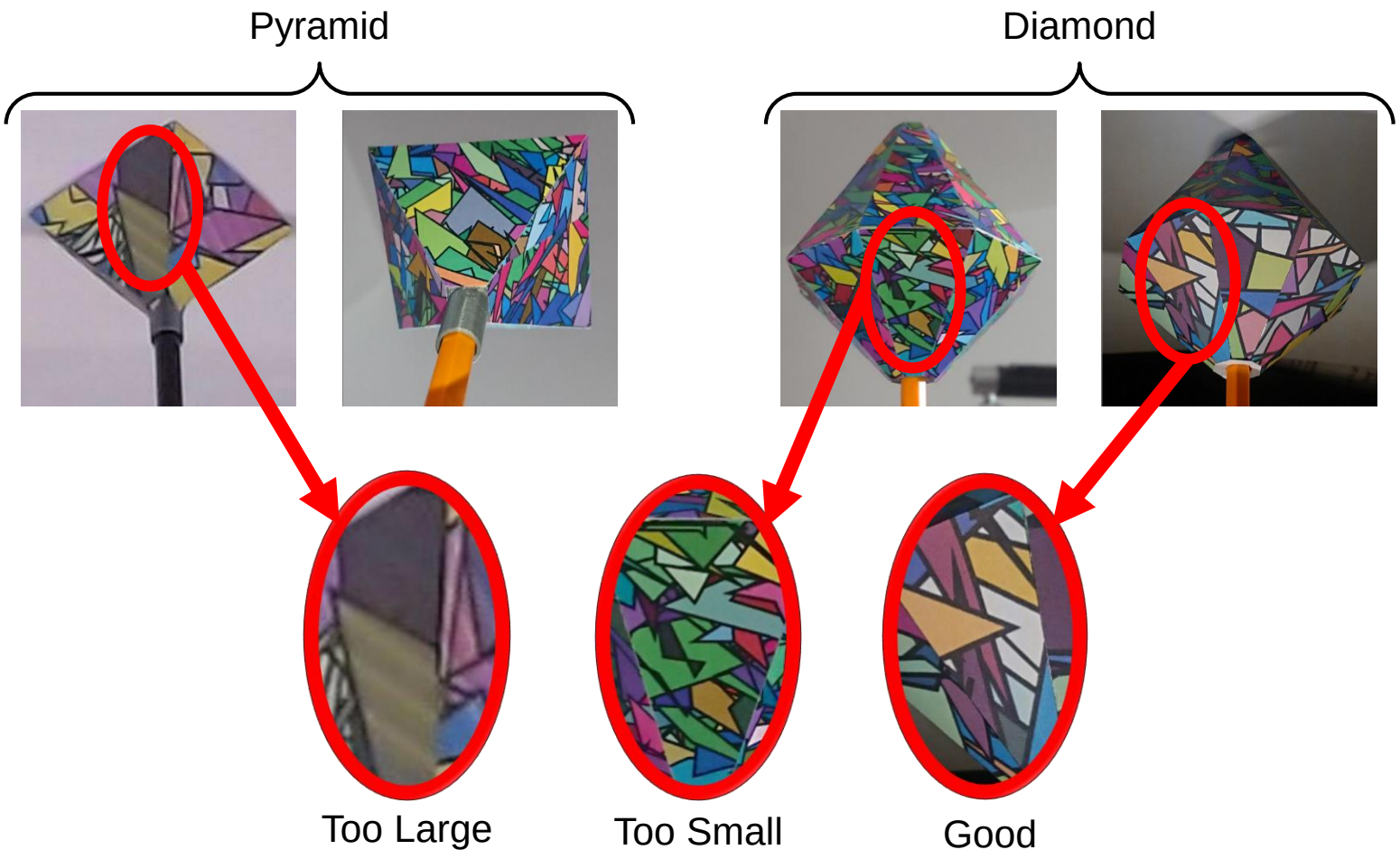
With pencil filter
(as described by Rambach, Deng, Pagani, and Stricker, 2018)

Design


3D Modelling → 3D Printing → Texturing

Design: Shape and Texture



Evaluation

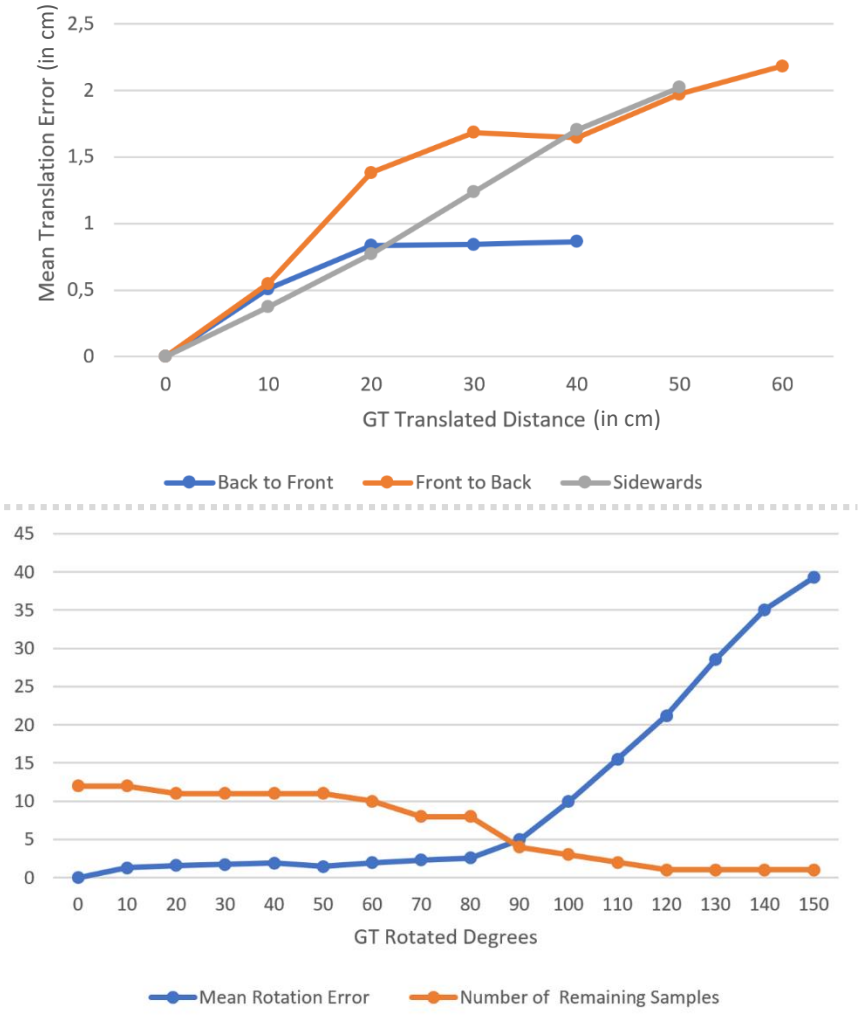
- Tracking & detection quality
- Speed (frames per second)
- Issues and Limitation

Evaluation: Frame-by-Frame Tracking Quality

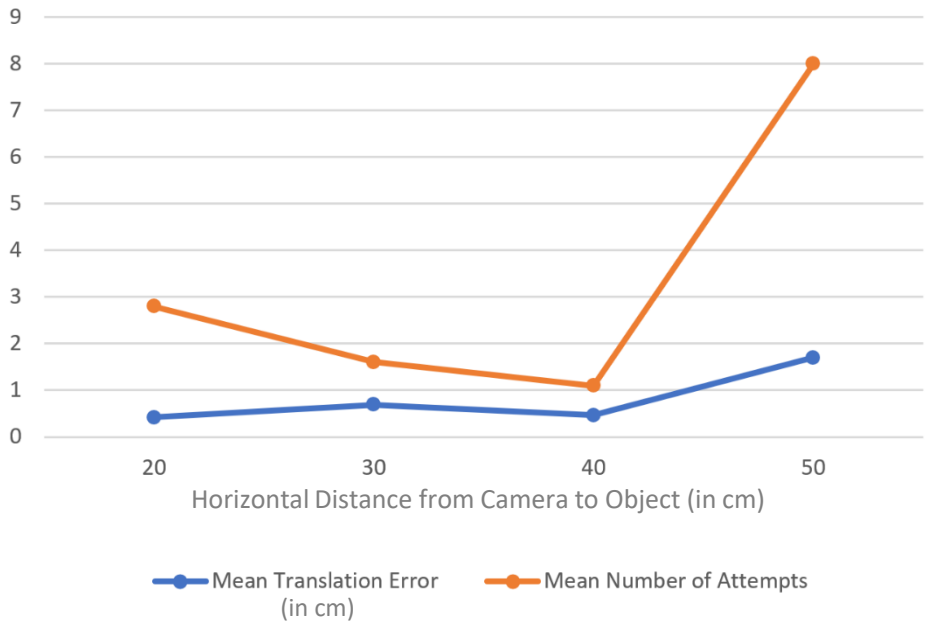
- Up to at least ~50 FPS

Translation
- Only successful attempts
- blue (5 samples)
- orange (5 samples)
- gray (3 samples)

Rotation
- Start with 12 samples
- Stable until 90°
- Not tracking correctly when keypoints not visible



Evaluation: Detection Quality

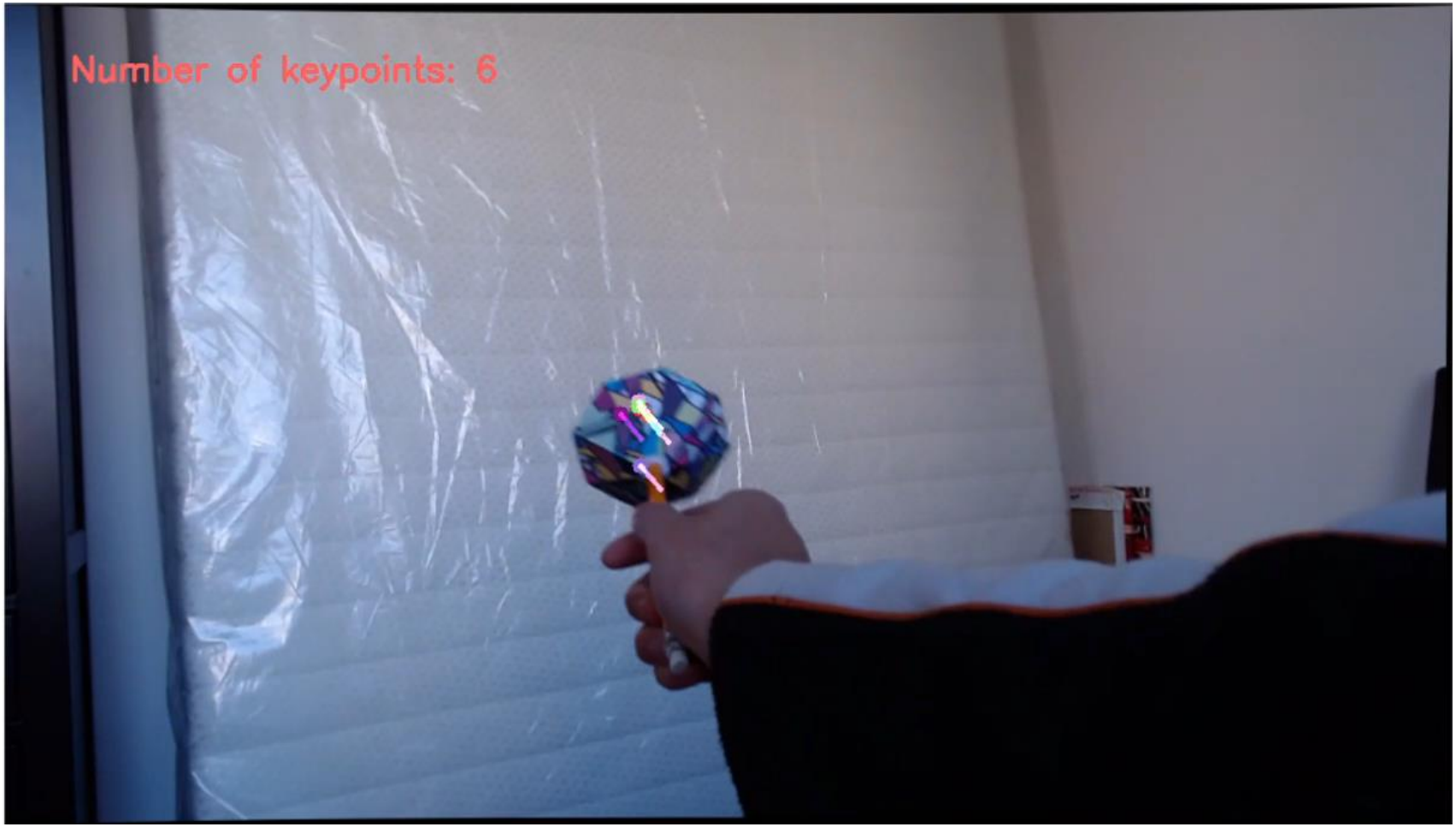


- ~2 FPS
- 10 samples for each distance
- Focus to infinity
- Dependent on registration images

Evaluation: Problems and Limitations

- Matching of features at longer distance is challenging
- Low detection/initialization speed
- Detection dependent on good illumination
- Not robust to motion blur and high reflections

Demo Video



Conclusion and Suggested Future Work

- Tracking and detection algorithm using
  - Feature matching
  - Optical flow

- Now: slow detection and only short range
- Future:
  - Pose correction for frame-by-frame tracking (e.g. Integrate threading)
  - Test more complex shapes and other texture for object marker

List of References

1. Apple Inc., “ARKit”, https://developer.apple.com/augmented-reality/arkit/.
2. PTC Inc., “Vuforia”, https://www.ptc.com/en/products/augmented-reality/vuforia.
3. J. Rambach, A. Pagani, M. Schneider, O. Artemenko, and D. Stricker. “6DoF Object Tracking based on 3D Scans for Augmented Reality Remote Live Support”. In: *Computers* 7.1 (2018), doi: 10.3390/computers7010006.
4. G. Bradski. “The OpenCV Library”. In: Dr. Dobb’s Journal of Software Tools (2000).
5. Unity Technologies. Unity. url: https://unity.com/.
6. Autodesk Inc. ReCap Pro: ReCap Photo. url: https://www.autodesk.de/products/recap/overview.

List of References

7. E. Rublee, V. Rabaud, K. Konolige, and G. Bradski. “ORB: An efficient alternative to SIFT or SURF”. In: 2011 International Conference on Computer Vision. Ed. by IEEE. IEEE, 6.11.2011 - 13.11.2011, pp. 2564–2571. isbn: 978-1-4577-1102-2. doi: 10.1109/ICCV.2011.6126544.
8. J.-Y. Bouguet. Pyramidal Implementation of the Affine Lucas Kanade Feature Tracker Description of the algorithm. Ed. by Intel Corporation. 2001.
9. B. Belousov. Distance between rotations. 2016. url: http://www.boris-belousov.net/2016/12/01/quat-dist/.

List of References

10. J. Rambach, C. Deng, A. Pagani, and D. Stricker. “Learning 6DoF Object Poses from Synthetic Single Channel Images”. In: *2018 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*. Ed. by IEEE. IEEE, 16.10.2018 - 20.10.2018, pp. 164–169. isbn: 978-1-5386-7592-2. doi: 10.1109/ISMARAdjunct.2018.00058.
11. Blender Online Community. Blender. Blender Institute, Amsterdam. url: http://www.blender.org.
12. Ultimaker. Ultimaker Cura. url: https://ultimaker.com/software/ultimakercura.
13. Brosvision. AUGMENTED REALITY MARKER GENERATOR. Ed. by Brosvision. url: https://www.brosvision.com/ar-marker-generator/.