Augmentation of 3D Object Tracking using 2D Visual Information

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Context

Master Thesis "3D Reconstruction with Focus on Minimally-Invasive Surgery"

- Thesis lays basis to generate new ways of training media
- Makes free viewpoint selection, interactions and simulations possible
- New endoscopic multi-camera systems with omnidirectional views up to 360°
- Overlapping field of views allows stereo vision
- 3D models from CT or MRI scans used for underlying anatomy

Figure: Insect-eye inspired endoscopic camera system, [Cogal and Leblebici, 2017]

Context

High level view on procedure

- Environment is reconstructed
- 3D model is registered to 3D reconstruction
- In the first frame manual initial registration is needed
- Later, registration is initialized with model position from previous frame

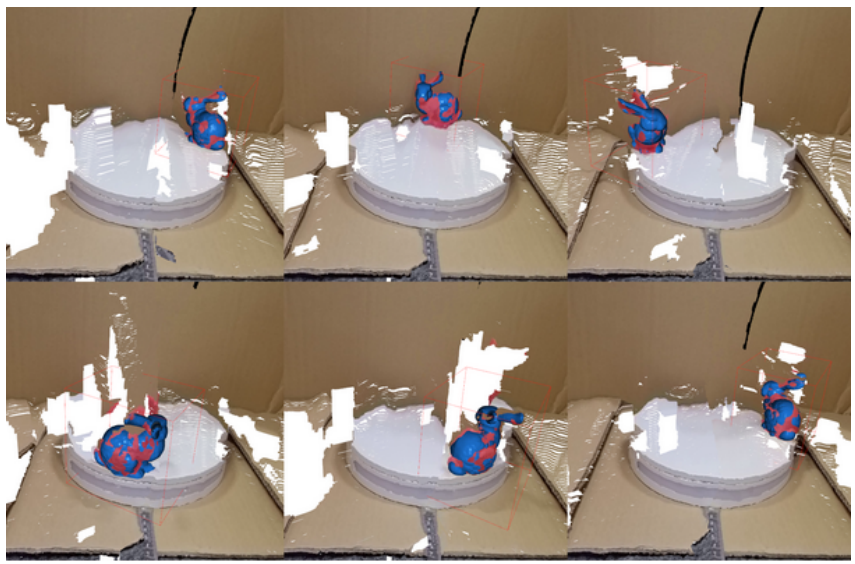


Figure: Image sequence with the reconstructed environment (red) and the tracked object (blue), Source: 3D Reconstruction with Focus on Minimally-Invasive Surgery

Goal of this Thesis

Improve 3D object tracking with 2D information

- Scene is projected to 2D and then tracked
- Pixels belonging to object are re-projected to 3D to get an approximate position
- The approximate position is used to initialize the 3D registration

Figure: Optical flow method applied to two consecutive frames, Source: https://arijitkar98.github.io/2018/05/28/weeks-1-and-2.html

Goal of this Thesis

Advantages

- Speedup due to reduced 3D search space
- Larger displacements of the object can be handled
- Accuracy and robustness can be improved

Challenges

Find and select interesting and applicable methods for 2D Tracking

- Many different methods available
- E.g. optical flow methods like [Lucas and Kanade, 1981], [Horn and Schunk, 1980] or [Bruhn et al., 2005]

Implement and compare selected methods

- Find expressive properties to compare

Challenges

Extend the 3D object tracking method to a multi-step approach that includes a 2D tracking phase

- Familiarize with provided framework

Evaluation of the result

- Find metrics to compare to existing project

Related Work

Combined 3D and 2D object tracking

- A novel point cloud registration using 2D image features [Lin et al., 2017]
- 3D Object Trajectory Reconstruction using Stereo Matching and Instance Flow based Multiple Object Tracking [Bullinger et al., 2019]

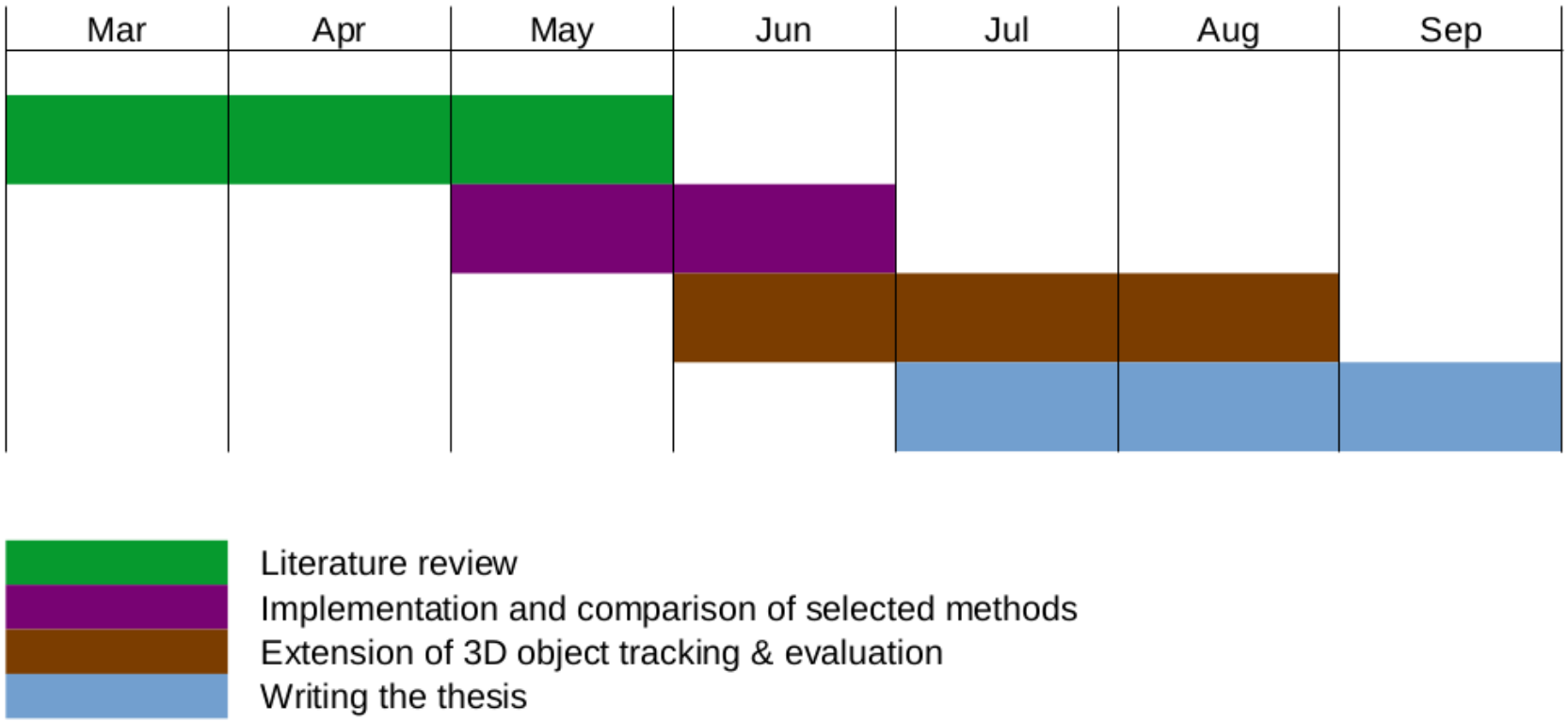
2D tracking methods

- An Iterative Image Registration Technique with an Application to Stereo Vision [Lucas and Kanade, 1981]
- Determining Optical Flow [Horn and Schunk, 1980]
- Lucas/Kanade Meets Horn/Schunck: Combining Local and Global Optic Flow Methods [Bruhn et al., 2005]

3D tracking methods

- Efficient variants of the ICP algorithm [Rusinkiewicz et al., 2001]

Timeline


Mar
Apr
May
Jun
Jul
Aug
Sep
Literature review
Implementation and comparison of selected methods
Extension of 3D object tracking & evaluation
Writing the thesis

References

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