



*Project Management and Software Development for
Medical Applications*

A Virtual Multi-View Optical Tracking System

Final Presentation – WS / 9FEB17

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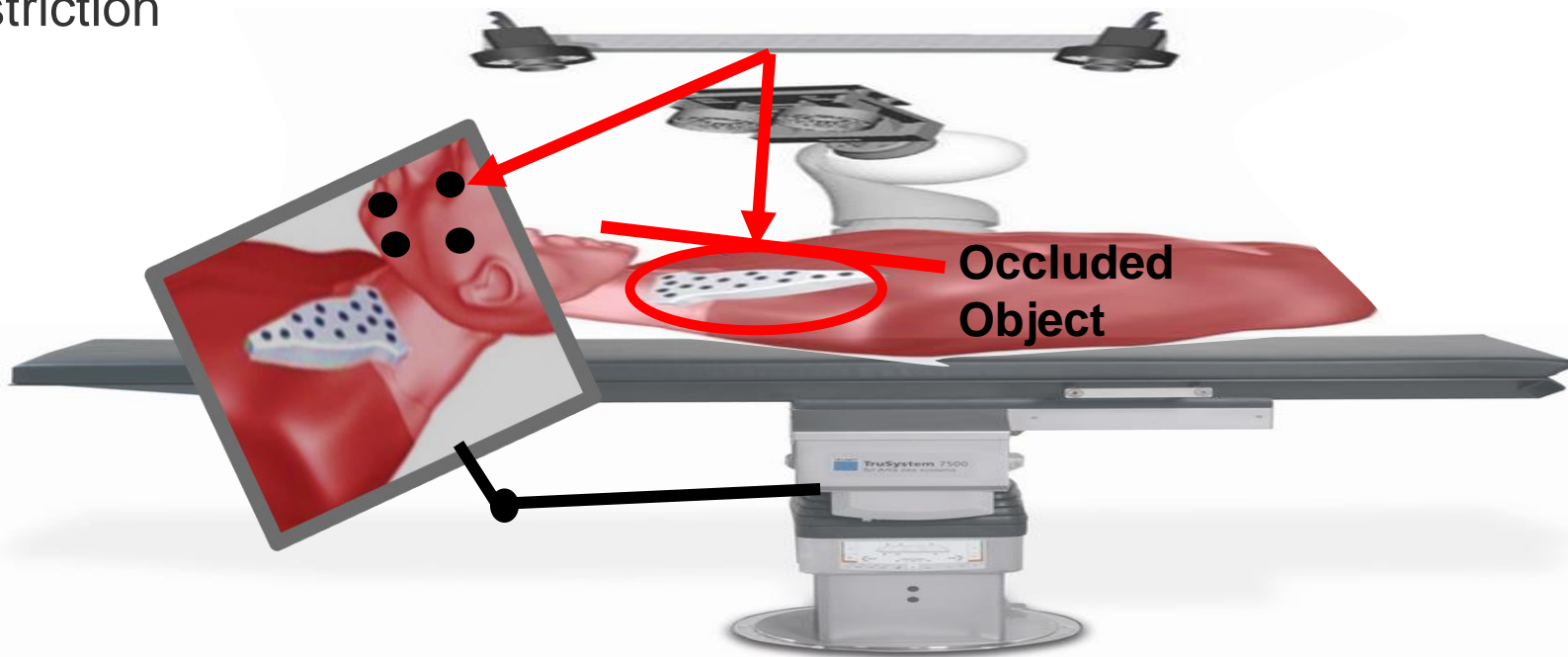
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Partners: FRAMOS & IFL

Motivation & Problem Statement

- Need to track medical instruments and imaging devices
- All available tracking systems suffer from some problem
- Optical Tracking System: Suffers from strong line of sight restriction



Requirements & Achievements

Requirements	Status
OTS Setup	
<ul style="list-style-type: none">- Setting OpenIGTLink communication interface- Collecting 6D pose of tracked Mirror & Objects	
Virtual Camera Estimation	
<ul style="list-style-type: none">- Estimate virtual camera position- Fuse estimated virtual data with real data	
GUI & Visualization	
<ul style="list-style-type: none">- Real time visualization of tracked & aligned Objects- Server-Client implementation	



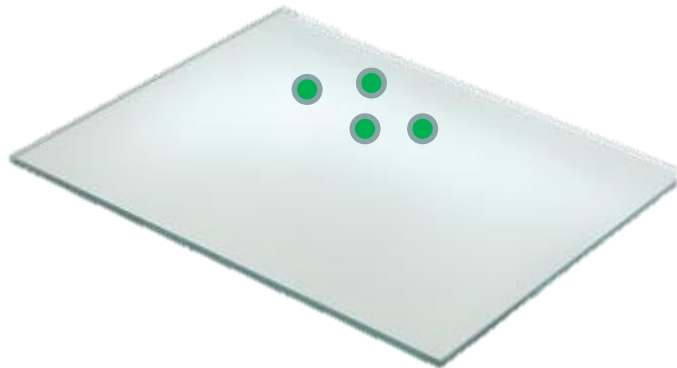
Our Setup



Stereo Optical Tracking System



US Transducer



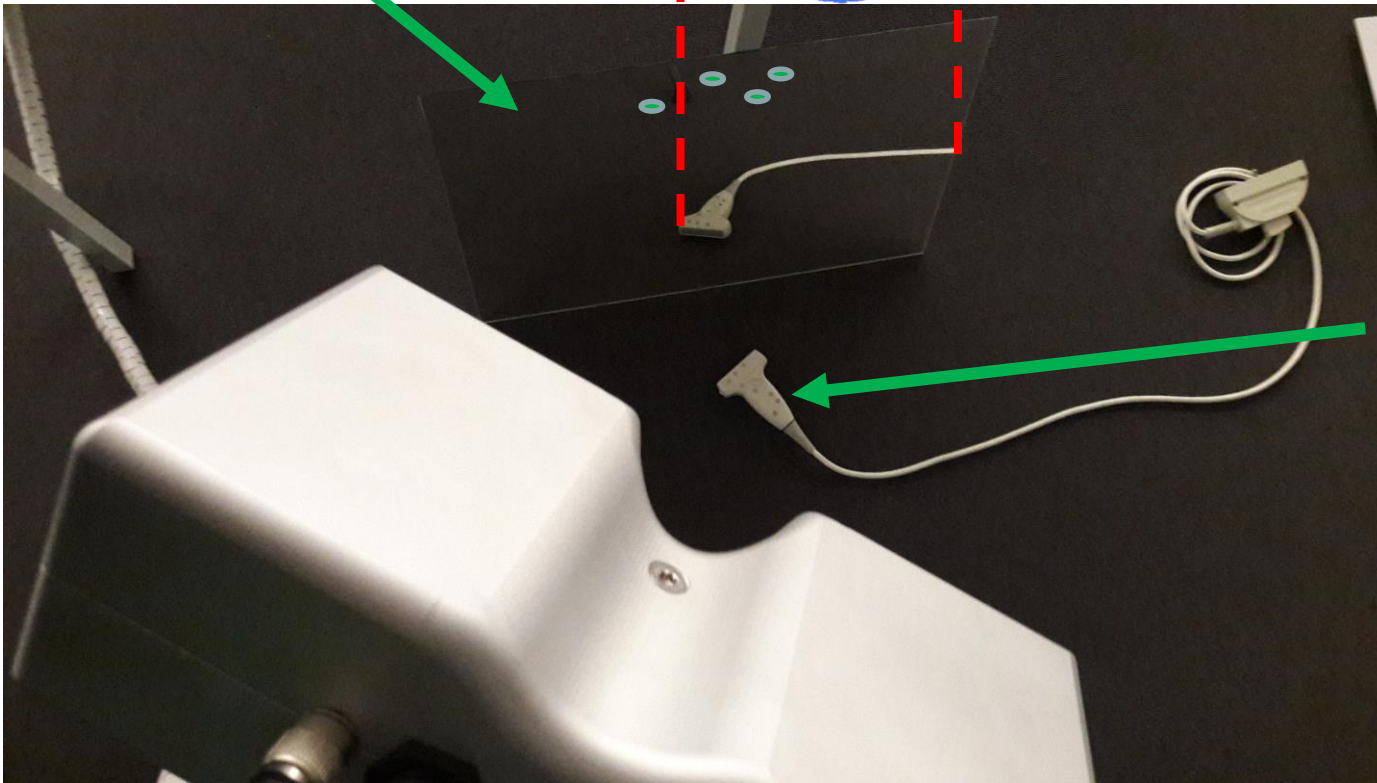
Movable tracked Mirror



Our Setup

P_us_Via_Mirror

P_Mirror



P_US



Our Setup - Reflection Matrix

- $\text{Pus_reflected} = \text{ReflectionFunction}(\text{P_mirror}, \text{Pus_via_Mirror})$
- $\text{Pus_reflected} \neq \text{Pus}$

$P_0(x_0, y_0, z_0)$, $P_1(x_1, y_1, z_1)$ and $P_2(x_2, y_2, z_2)$: $\mathbf{a} = P_1 - P_0$ and $\mathbf{b} = P_2 - P_0$

$$\mathbf{n}_e := \frac{\mathbf{n}}{|\mathbf{n}|} = (c_x, c_y, c_z)$$

$$\mathbf{n} = \mathbf{a} \times \mathbf{b}.$$

$$\mathbf{R}_{reflect} = \begin{bmatrix} 1 - 2c_x^2 & -2c_x c_y & -2c_x c_z & -2c_x d \\ -2c_x c_y & 1 - 2c_y^2 & -2c_y c_z & -2c_y d \\ -2c_x c_z & -2c_y c_z & 1 - 2c_z^2 & -2c_z d \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad d = -c_x x_0 - c_y y_0 - c_z z_0$$

[1]

$$\text{Pus_Reflected} = R * \text{Pus_viaMirror}$$



[1] Emőd Kovács, "Rotation about an arbitrary axis and reflection through an arbitrary plane", *Annales Mathematicae et Informaticae* 40 (2012) pp. 175–186

Visualization

The screenshot displays the 'Multi-View Optical Tracking System' interface. It features three main control panels on the left and a central visualization window. The 'Mirror Data' panel includes fields for 'Mirror Server', 'Port', and 'FrameRate', along with 'Connect' and 'Disconnect' buttons. The 'Object Data' panel includes fields for 'Object Server', 'Port', and 'FrameRate', also with 'Connect' and 'Disconnect' buttons. The 'Object via Mirror Data' panel includes fields for 'OvM Server', 'Port', and 'FrameRate', with 'Connect' and 'Disconnect' buttons. The central visualization window shows a 3D scene with two green wireframe spheres and two red wireframe spheres, each with colored lines extending from them. The text '313.8 FPS' is visible in the bottom left of the visualization area. A red arrow points from the text 'Separate Threads' to the 'Disconnect' button in the 'Mirror Data' panel. Another red arrow points from the same text to the 'Connect' button in the 'Object Data' panel. A third red arrow points from the text to the 'Connect' button in the 'Object via Mirror Data' panel.

Separate Threads

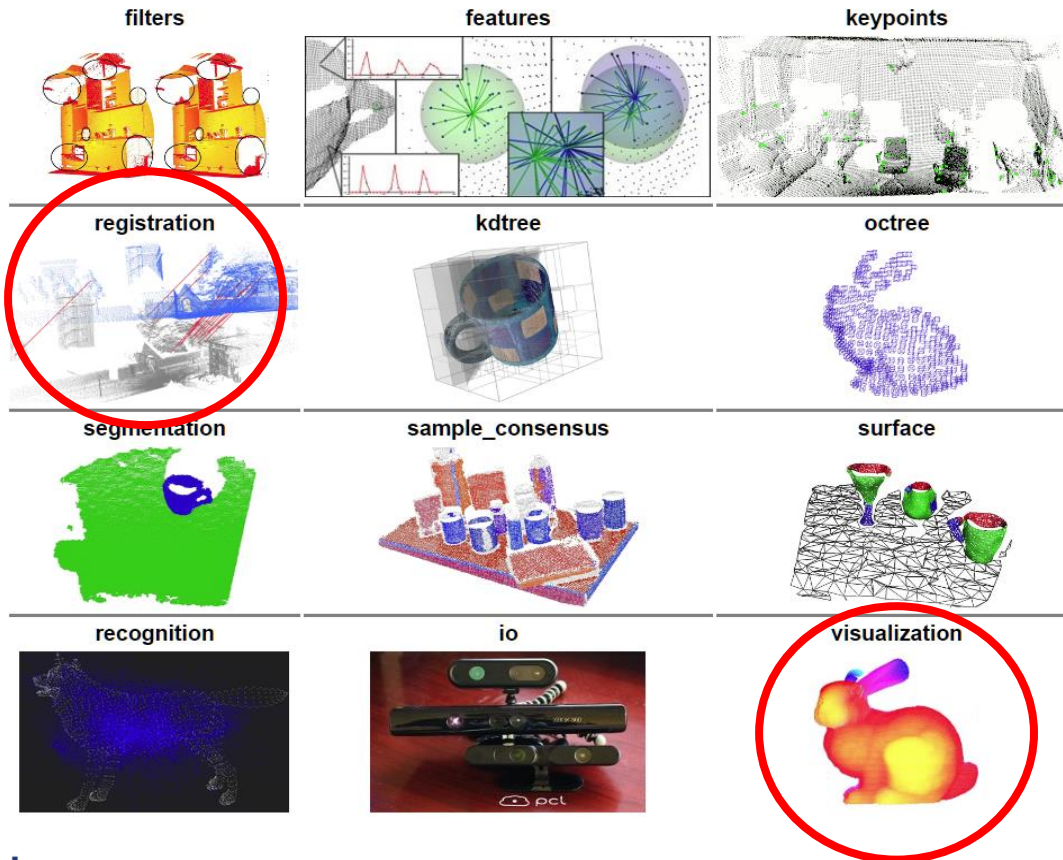


Visualization

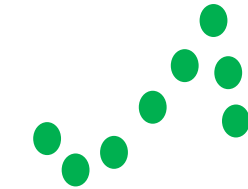
PCL: Point Cloud Library, VTK: Visualization Toolkit

Environment:

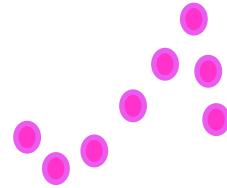
- Ubuntu
- C++
- QT
- Eigen



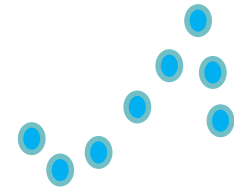
Visualization / Demo



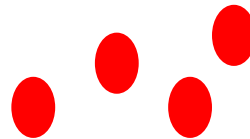
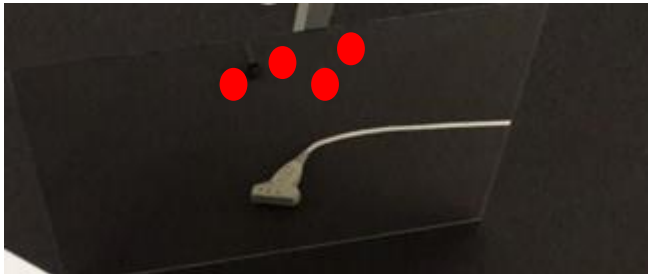
US



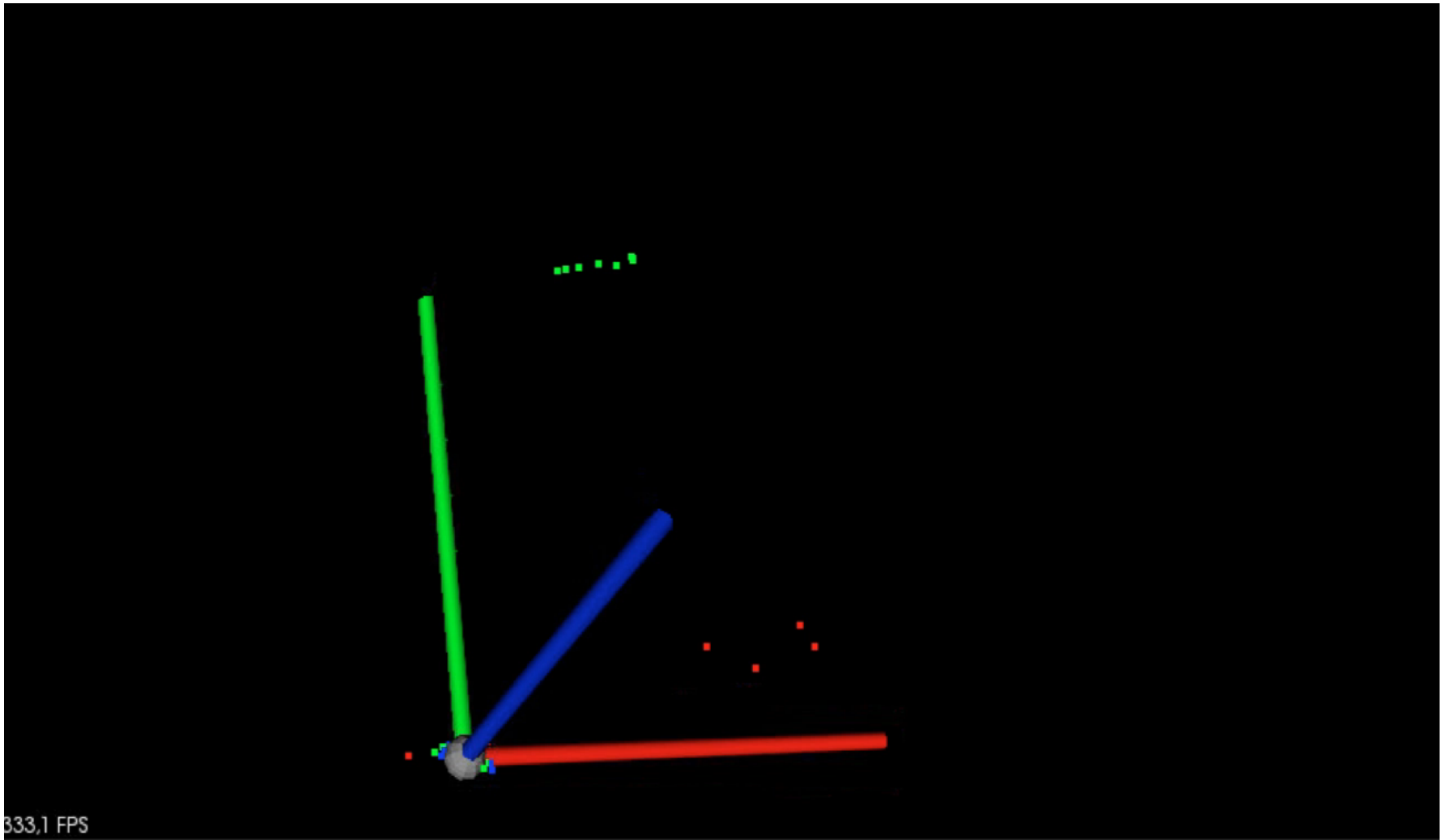
US_Reflected



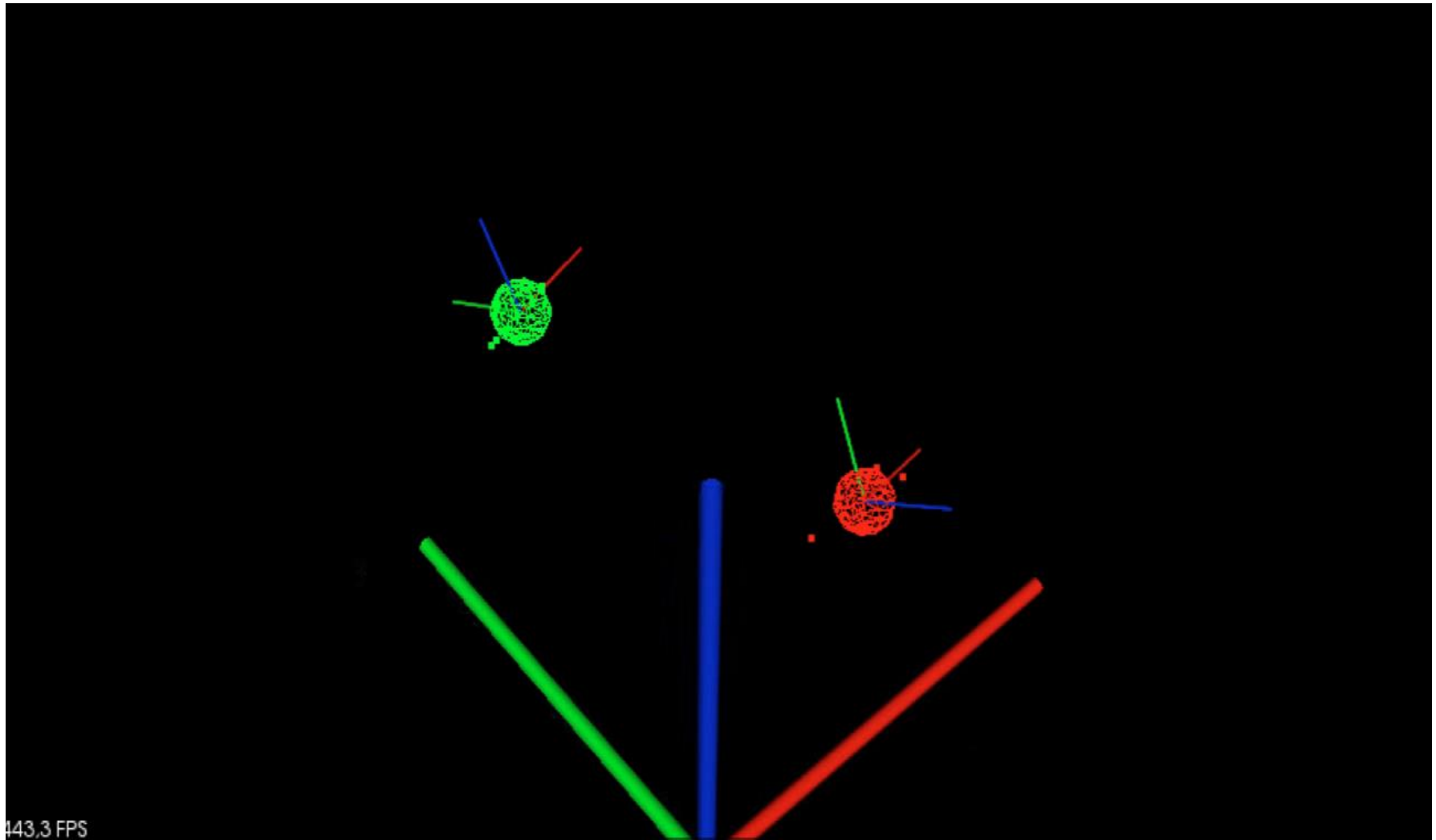
US_via_Mirror



Visualization / Demo

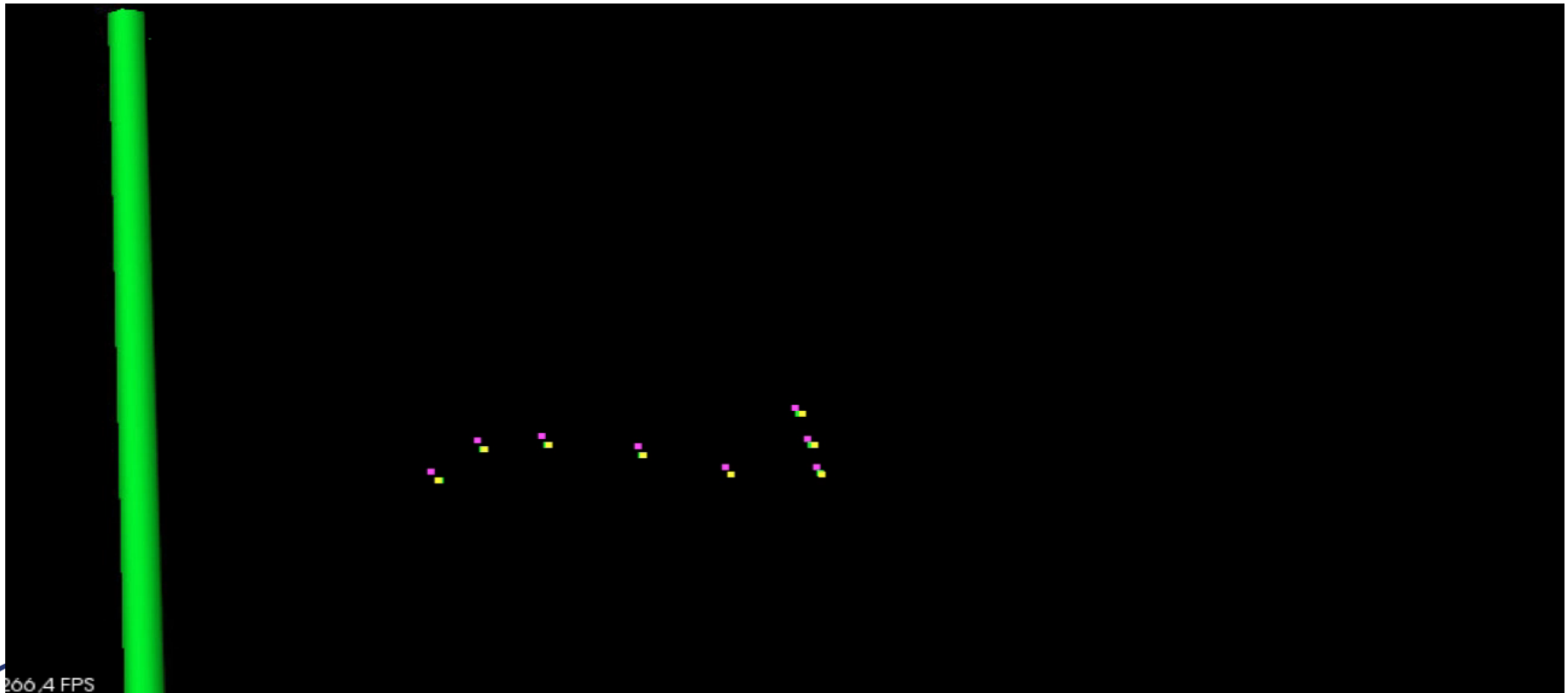


Visualization / Demo



Visualization - Iterative Closest Point (ICP)

- Minimize the difference between two point Cloud for each pose
- Average all ICP matrices to get one transformation



Results

- % error analysis for translation vector

$$\% \text{ Error} = \left| \frac{\text{Theoretical Value} - \text{Experimental Value}}{\text{Theoretical Value}} \right| \times 100$$

Normal Alignment without ICP: %x = 1.4799 %y = 1.475 %z = 0.2

With ICP: %x = 1.38 %y = 0.8 %z = 0.2

% of Improvements using ICP x = 6.7% y = 45% z=0%



Conclusion

Why Use mirror over another OTS?

- Very High Accuracy
- Very Cheap
- Flexible movements & easy to setup
- Can be sterilized



Conclusion

- All tasks Completed
- Optical Tracking System Setup
- Virtual Camera Estimation
- GUI & Visualization
- Prototype testing & performance evaluation
- Advanced Alignment methods (ICP, Registration,..)



Reflection

- Improved Communication and presentation skills
- What to expect in master thesis
- What to expect in Industry
- Don't underestimate tasks
- New Insight from PMSD presentation by other colleges
- Always push your code

