



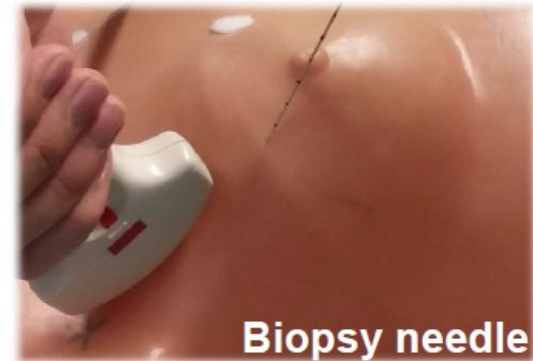
Project Management and Software Development
for Medical Applications (PMSD)

Needle tracking for ultrasound-guided biopsies with inside-out vision

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Supervisor: Benjamin Busam
Final Presentation - 27.01.2016

Motivation and problem statement

- **Problem:**
 - Needle tip location uncertain in ultrasound image
 - Analyzing wrong cells might lead to wrong diagnoses
- **Motivation:**
 - Improve the healing process by less insertions
 - Analyze the right cells
- **Solution:**
 - Software framework for needle and ultrasound tracking
 - Visualization to assist the surgeons
- **Areas of application:**
 - Biopsy for cancer screening or
 - Applications in neurology
- **Partners:**
 - Klinikum rechts der Isar (IFL)
 - FRAMOS GmbH



References: Image from FRAMOS GmbH



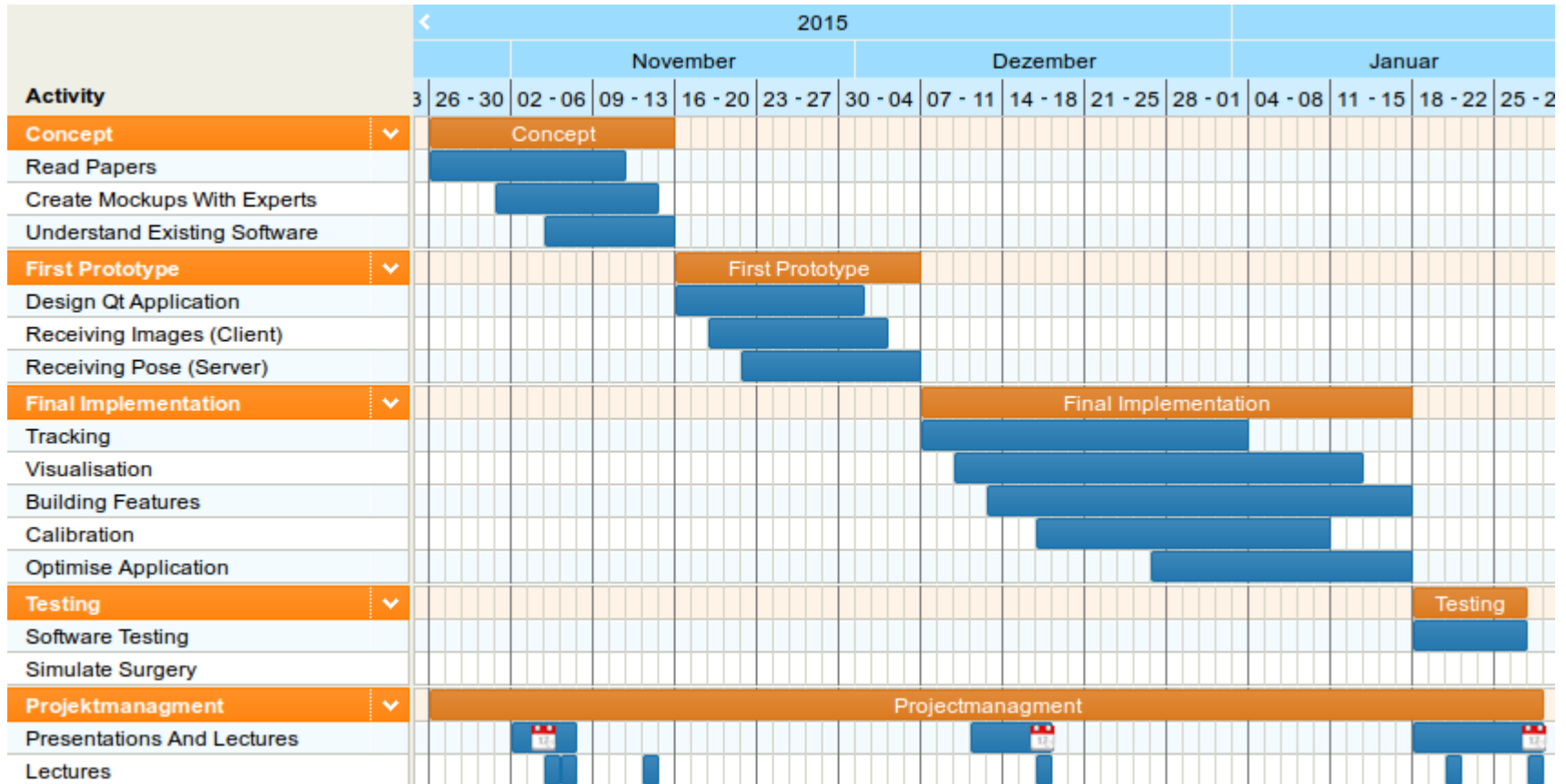
Requirements and specification

- Reading project based papers
- Receive and display ultrasound image
- Receive needle pose in real-time
- Calibrate needle, needle vector, ultrasound plane, ...
- Calculate intersection point and distances
- Create Qt user interface
- Implement 3D Vision
- Implement Features



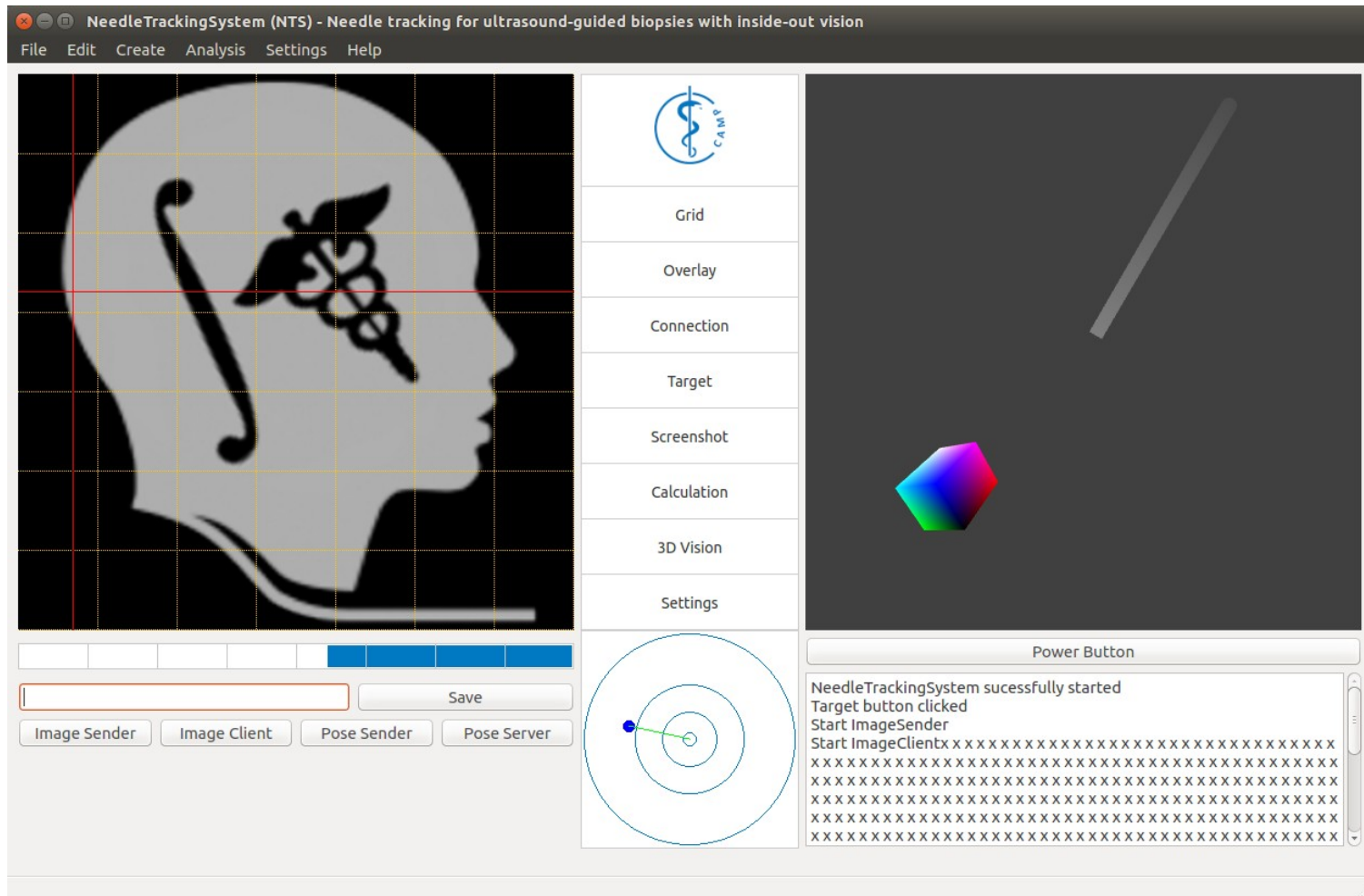
Reference: Project based on the paper:Stolka, Philipp J., et al. "Needle guidance using handheld stereo vision and projection for ultrasound-based interventions." Medical Image Computing and Computer-Assisted Intervention–MICCAI 2014. .

Gantt Chart

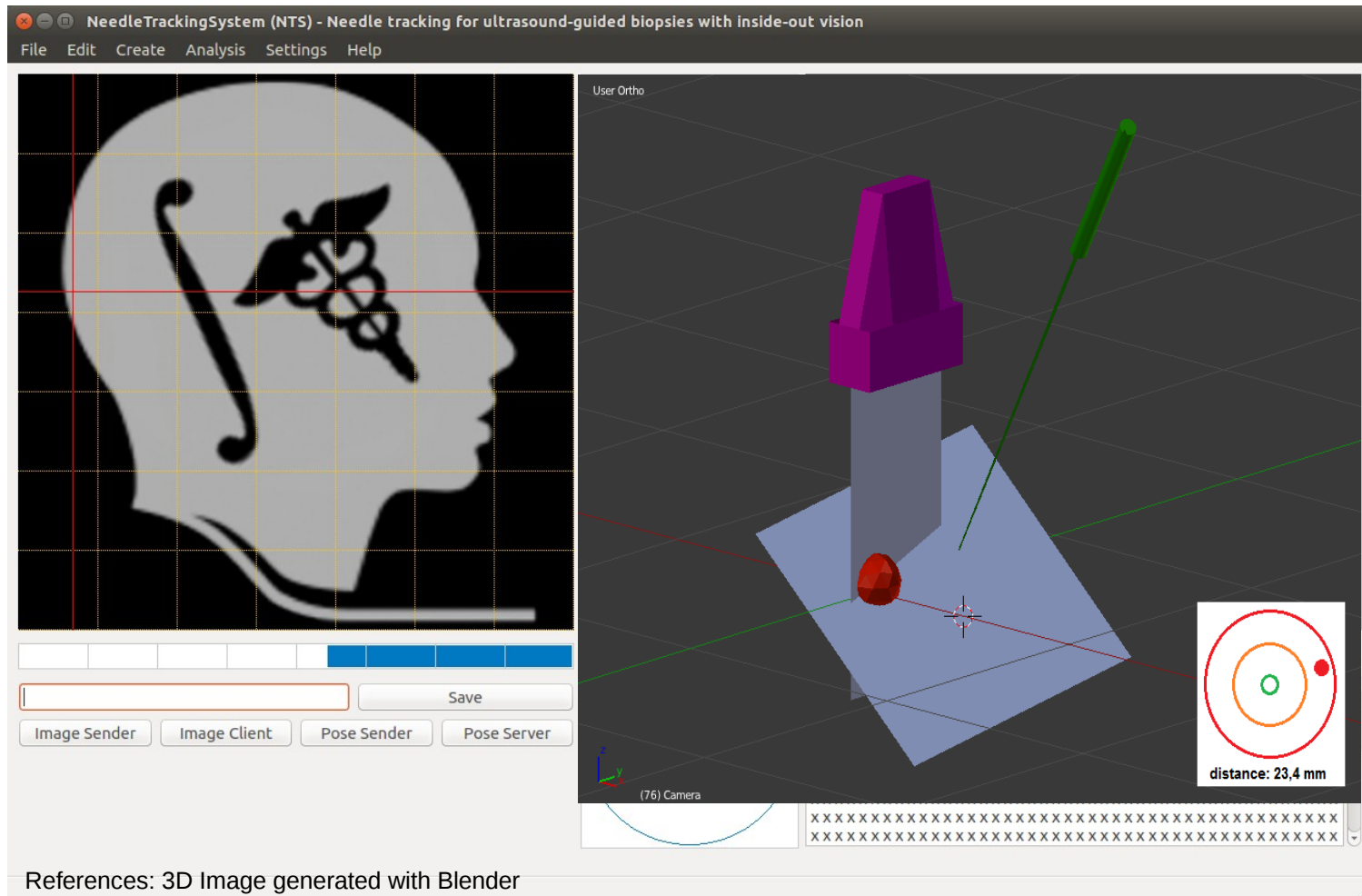


Reference: Gantt Chart generated by <http://tomsplanner.de> , 26.01.2016

NeedleTrackingSystem Software



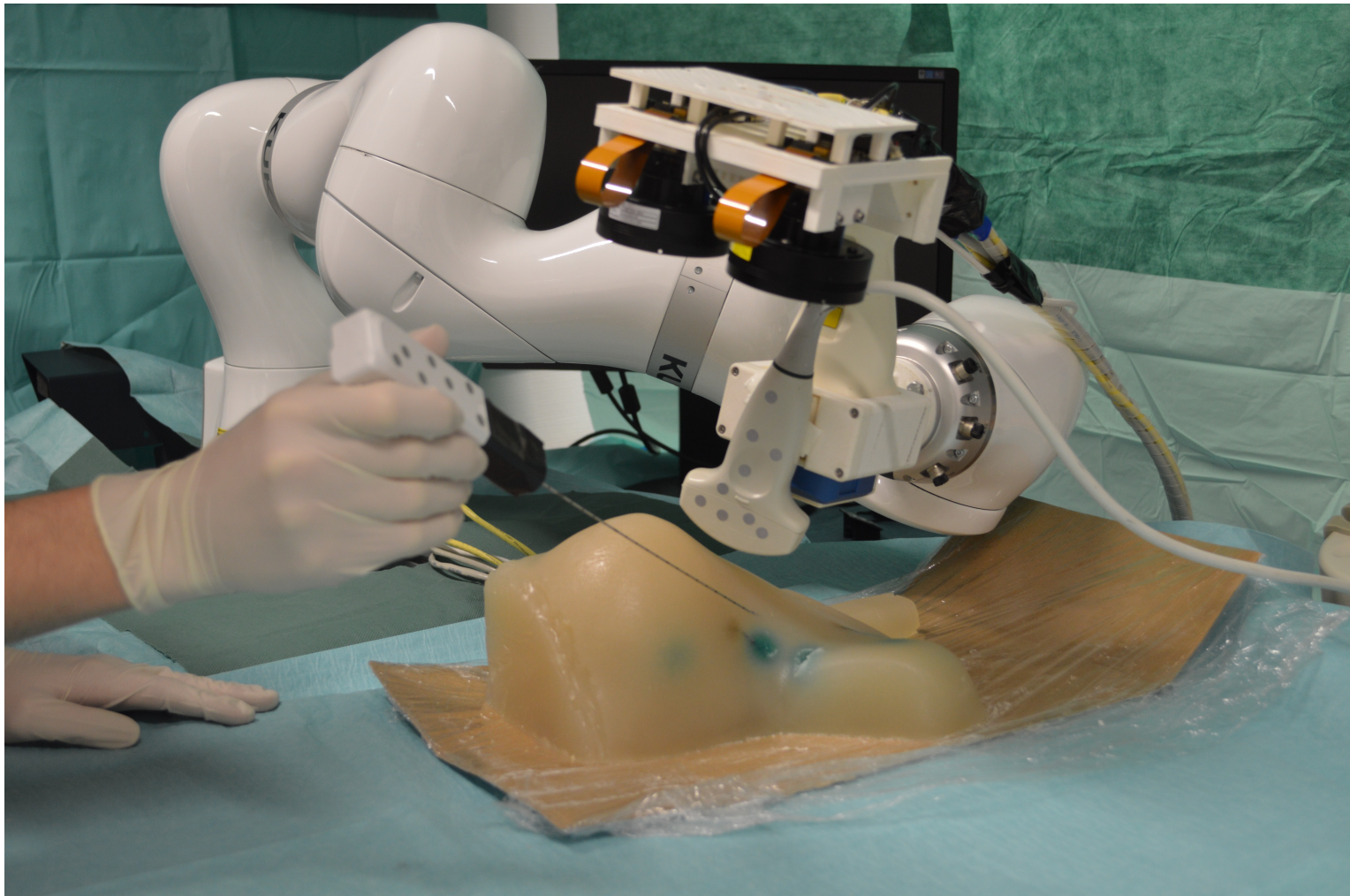
NeedleTrackingSystem Software



OpenIGTLink



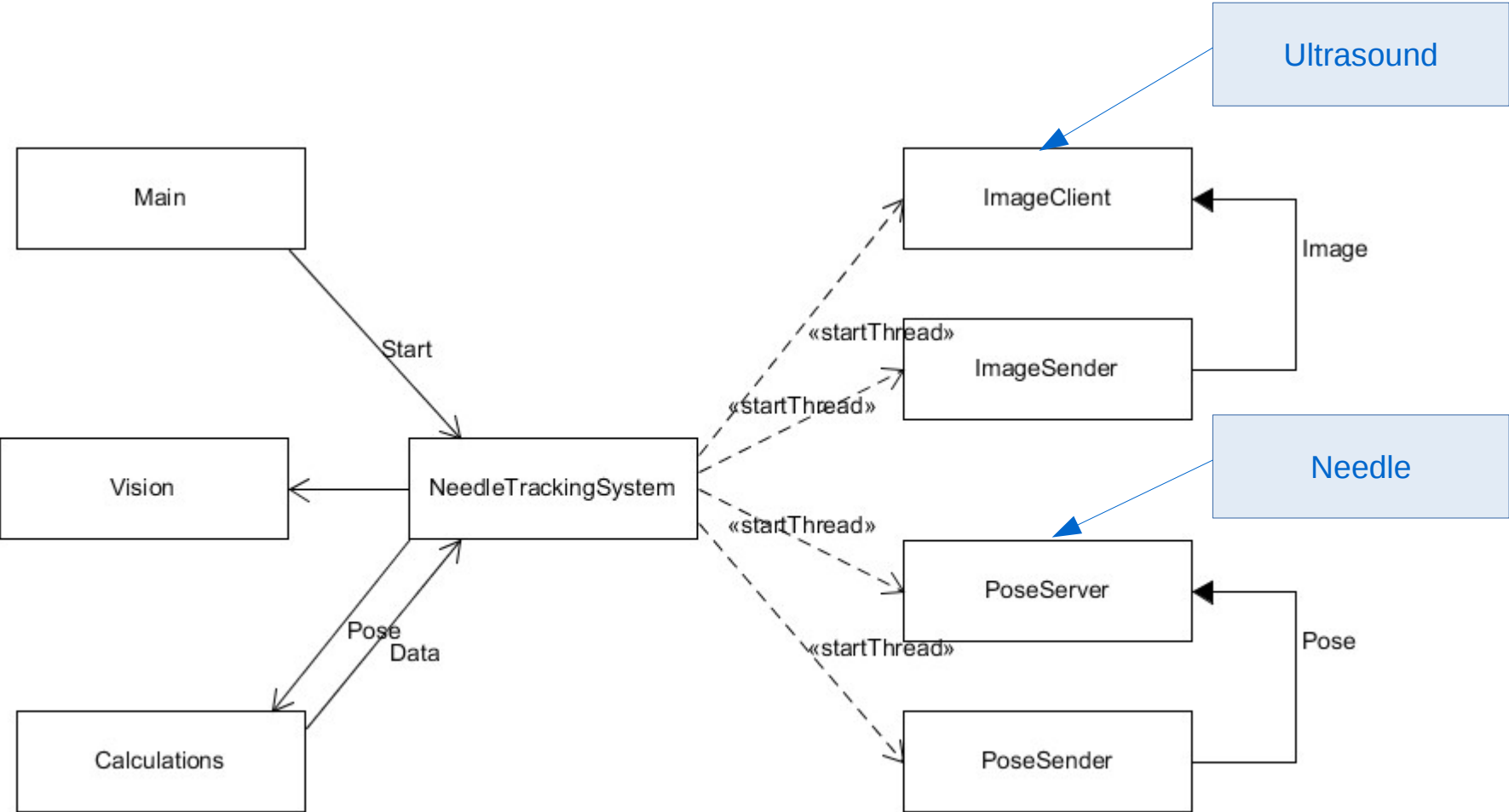
Ultrasound guided biopsy with inside out tracking



Reference: Image from „Interdisziplinäres Forschungslabor, Universitätsklinikum Rechts der Isar“

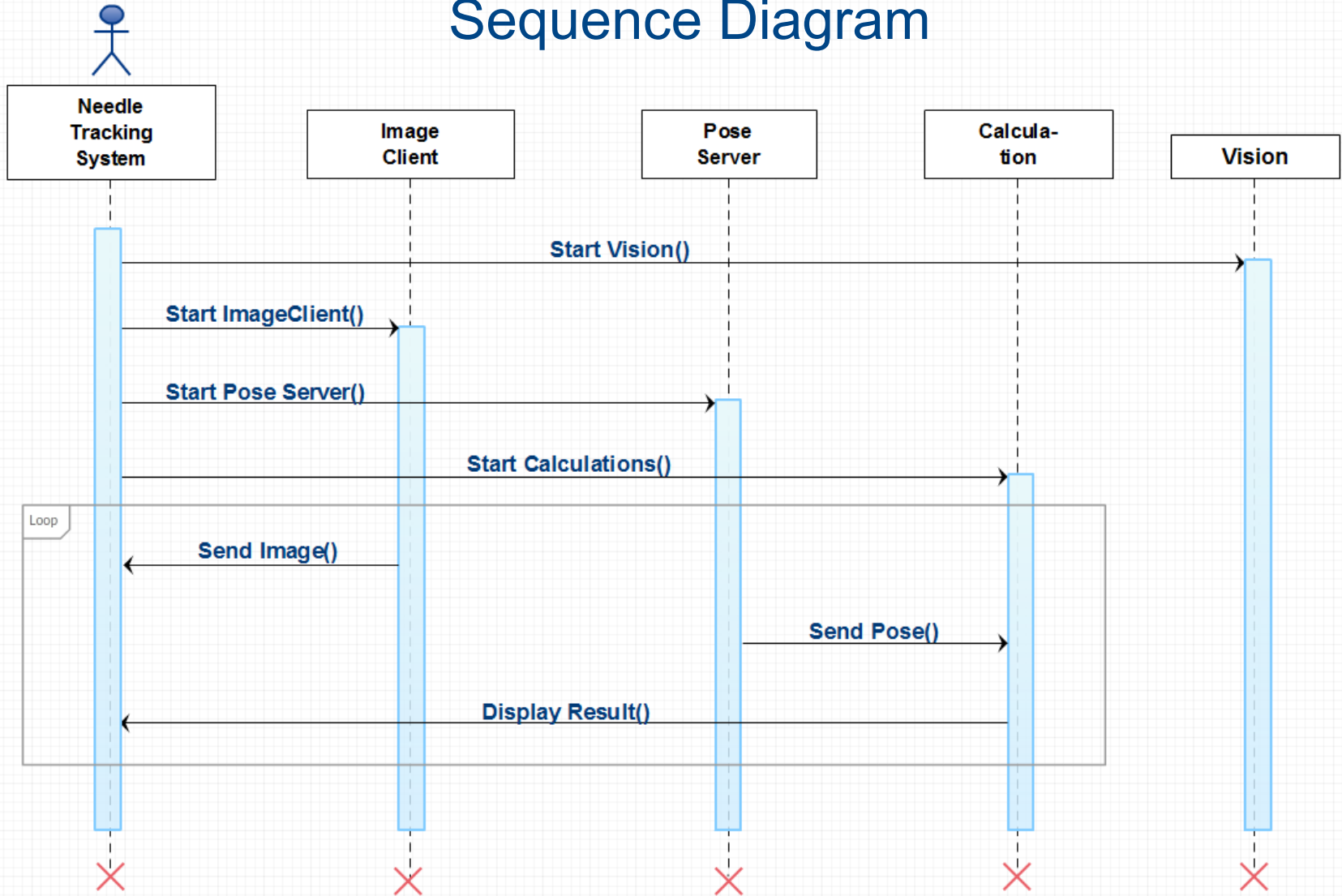


Software structure



Reference: Diagram generated by UMLet, 26.01.2016

Sequence Diagram

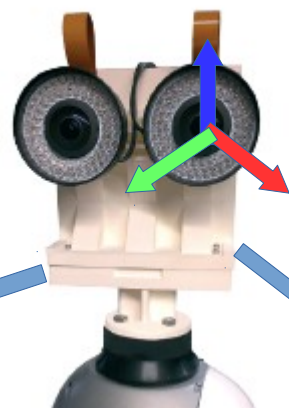


Reference: Sequence Diagram generated by <http://creately.com> , 26.01.2016

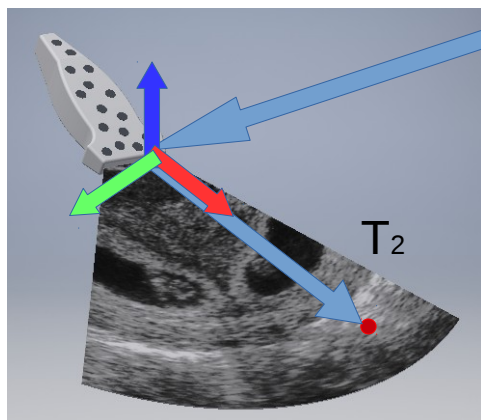




Optical Tracking System (OTS)

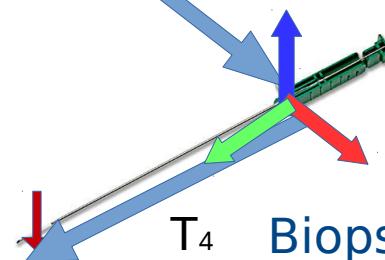


Ultrasound Transducer



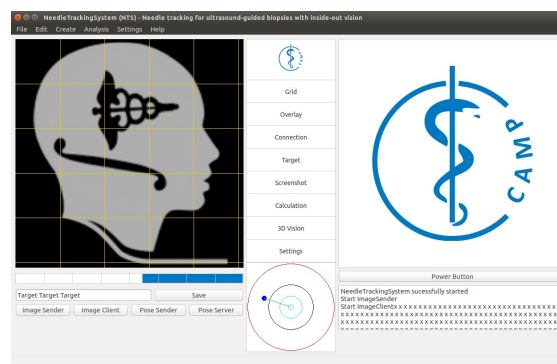
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Biopsy Needle



Needle Tracking System



Calibrations

- Pivot Calibration
(To get the transformation from needle to tip, fCal)
Move the needle with fixed tip
- Plane Fit
(To get the ultrasound plane, pcl)
Collect several points on ultrasound plane
- Line Fit
(To get the needle vector, pcl)
Guide needle through a tube
- Ultrasound startpoints
(Touch startpoints with needle tip)

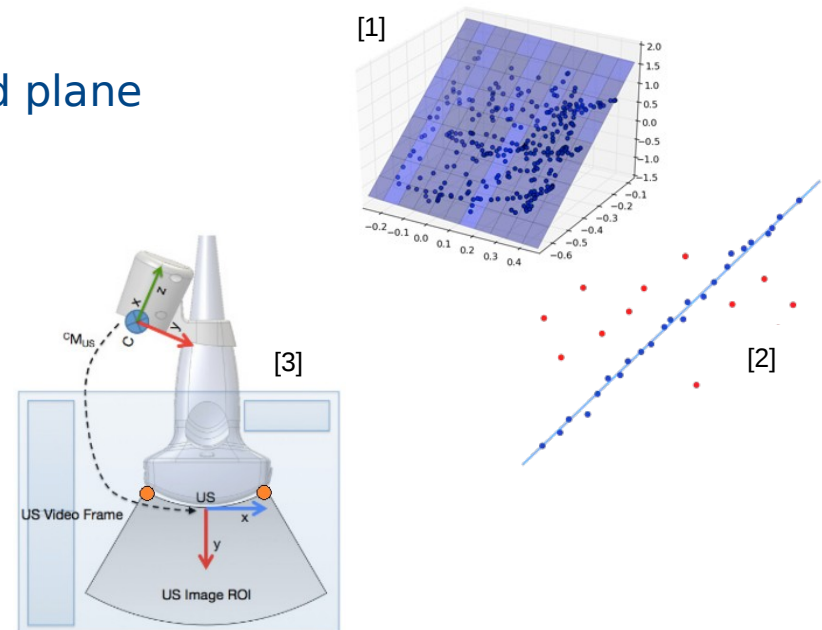
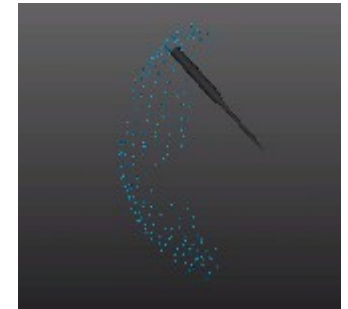


Image references:

[1] Plane Fit: http://fab.cba.mit.edu/classes/864.11/people/Moritz_Kassner/img/blue_plane.png, 26.01.2016

[2] Line Fit: http://pointclouds.org/documentation/tutorials/random_sample_consensus.php#random-sample-consensus, 26.01.2016

[3] Stolka, Philipp J., et al. "Needle guidance using handheld stereo vision and projection for ultrasound-based interventions." Medical Image Computing and Computer-Assisted Intervention–MICCAI 2014. Springer International Publishing, 2014. 684-691.



Calculations

$$P_1(x_1, y_1, z_1) \quad P_2(x_2, y_2, z_2)$$

$$P = P_1 + u(P_2 - P_1)$$

$$E : Ax + By + Cz + D = 0$$

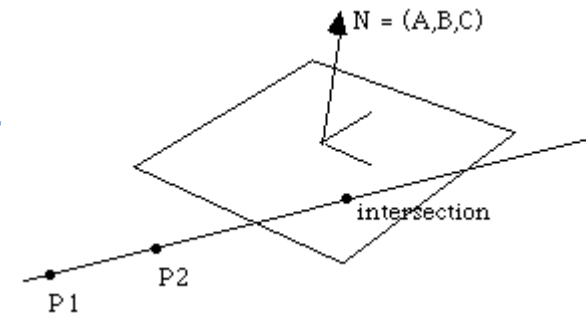
- Intersection between needle vector and ultrasound plane
Where would the needle go inside?

$$u = \frac{Ax_1 + By_1 + Cz_1 + D}{A(x_1 - x_2) + B(y_1 - y_2) + C(z_1 - z_2)}$$

- Distance between needle tip and ultrasound plane
How far the needle has to get inserted?

$$d = \frac{(Ax_1 + By_1 + Cz_1 + D)}{\sqrt{(A^2 + B^2 + C^2)}}$$

- Distance between target and needle vector
How should the needle be rotated?



References:

Image and formulas from: <http://paulbourke.net/geometry/pointlineplane/>, 26.01.2016



Project Outlook

- Improve the calibration process
(Integrate calibration process into software, Achieve better accuracy)
- Add additional features
(Target, Screencast, Config files, Select the target)
- Complete the 3D visualisation and settings
(Add navigation, Meshes for ultrasound and needle, Add options)
- Verify the software
(Guarantee that everything works correct)
- Improve the tracking device
(Smaller tracking device, Mounted on ultrasound transducer)
- Solve the needle problem
(Stiffer needle, Consider physical model for needle deflection)



Project Retrospective

- Proof of concept is provided
- Not yet usable for real biopsies
- Much more work than expected
- Too much focus on presentations



Thank you for your attention!

Do you have any questions?

