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

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Introduction & Motivation

**Project:**
Software framework to track ultrasound transducer and needle Biopsy for cancer screening or neurology applications

**Problem:**
Needle location uncertain in ultrasound image

**Solution:**
Needle and ultrasound tracking and visualization

**Motivation:**
Less insertions, Analyse the right cells

**Partners:**
Klinikum rechts der Isar, Framos GmbH
Reading papers

Ultrasound image is displayed

Qt user interface created

OpenIGTLink is included

Software was tested with a stub

Features: Grid, Screenshots, Target, Distance

Tests with a transducer and needle to receive images and poses

Improving class structure (Threads)

Error fixing and optimization (signal slot)
State of the art

- Reading papers
- Ultrasound image is displayed
- Qt user interface created
- OpenIGTLink is included
- Software was tested with stub
- Features: Grid, Screenshots, Target, Distance
- Tests with transducer and needle to receive images and poses
- Improving class structure (Threads)
- Error fixing and optimization (signal slot)
Sequence Diagram

1. Start ImageClient()
2. Start PoseServer()
3. Create Calculation()
4. Send Image()
5. Send USPose()
6. Send NPose()
7. Return Result()
Use Case Diagram

User

- Start ImageClient
- Start PoseServer
- Change Features
- Mark Target

Calibrate Needle

Expert
Project status

Current Tasks:

• Calculating transformation matrices
  (Pivot Calibration, Assembla Plus, recordings → transformation matrix
  Mouseclick in Image → transformation matrix to target)

• Calculations should be done in real-time
  (Transformation matrices, intersection point, shortest distance)

• Improving the user interface
  (Changing IP, Port, Grid, Colors and other Settings, Maybe 3D Vision)

Problems:

• Synchronisation problem
  (Mutex, Qt::QueuedConnection, Transfer object not the reference)

• Needle is flexible
  (Assumption: Needle is rigid → additional feature)
Ultrasound Transducer

Optical Tracking System (OTS)

Biopsy Needle

Needle Tracking System
Calculation of transformation matrix

\[ R_X R_Y R_Z \]

\[
\begin{bmatrix}
1 & 0 & 0 \\
0 & \cos A & -\sin A \\
0 & \sin A & \cos A
\end{bmatrix}
\begin{bmatrix}
\cos B & 0 & \sin B \\
0 & 1 & 0 \\
-\sin B & 0 & \cos B
\end{bmatrix}
\begin{bmatrix}
\cos C & -\sin C & 0 \\
\sin C & \cos C & 0 \\
0 & 0 & 1
\end{bmatrix}
\]

\[
\begin{bmatrix}
\cos B \cos C & -\cos B \sin C & \sin B \\
\sin A \sin B \cos C + \cos A \sin C & -\sin A \sin B \sin C + \cos A \cos C & -\sin A \cos B \\
-\cos A \sin B \cos C + \sin A \sin C & \cos A \sin B \sin C + \sin A \cos C & \cos A \cos B
\end{bmatrix}
\]

\[
\begin{bmatrix}
-0.411886 & -0.709998 & 0.571185 & -1.45998 \\
0.709998 & 0.142857 & 0.689561 & 49.9787 \\
-0.571185 & 0.689561 & 0.445257 & -1.45998 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]
Gantt Chart
References

References for the slides:

- Images from FRAMOS GmbH
- Gantt Chart: http://www.tomsplanner.de
- UMLet for Use Case Diagram and Class structure
- Sequence Diagram: http://creately.com
- Latex for formulas
- Blender for 3D Images
Thank you for your attention!

Do you have any questions?