3D Slicer Tutorial: Prototyping Surgical Robot System Using ROS and 3D Slicer

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Background

• Growing Interest in Robot Assisted Interventions
  – Robot-assisted laparoscopy
  – Robotic catheter systems
  – Robotic radiosurgery, etc.

• R&D of Surgical Robot System
  – Image processing and visualization for surgical planning
  – Kinematics and motion planning for robot control
  – Device management and control

➡ Requires a wide range of tools and methods developed in robotics and medical image computing fields
Background (2)

- Common research platforms
  - Medical Image Computing
    - 3D Slicer
    - MITK
    - NifTK
    - OsiriX…
  - Medical Robotics
    - da Vinci Toolkit (dVRK)
    - Raven II
    - KUKA Lightweight Robot

→ Need for a bridge between ROS and OpenIGTLink
Objective of This Tutorial

• Prototype surgical robot system using widely-available software and hardware
  – 3D Slicer as planning interface
  – Lego Mindstorms as robot hardware
  – Robot Operating System (ROS) as robot control software

• Through this tutorial, you can:
  – Learn software architecture of surgical robot systems
  – Acquire hands-on experience of software-hardware integration for medical robotics
Prerequisite

- 3D Slicer Version 4.6 or later
- Lego Mindstorms EV3 with WiFi dongle
- ev3dev – Debian Linux for Mindstorms EV3
  - [http://www.ev3dev.org](http://www.ev3dev.org)
- ROS-IGTL-Bridge
  - [https://github.com/openigtlink/ROS-IGTL-Bridge](https://github.com/openigtlink/ROS-IGTL-Bridge)
Architecture

Planning Workstation

3D Slicer

OpenIGTLink over TCP/IP

EV3 Brick with ev3dev

ROS-IGTL-Bridge

Robot control node

ROS network
Tasks in Each Component

- **3D Slicer**
  - Medical Image Display
  - Segmentation
  - Procedure Planning
  - Pre/Intra Image Registration
  - Tracker support

- **OpenIGTLink**
  - Communication Protocol
  - Transformation manager

- **ROS**
  - Robot Control
  - Path Planning
  - Image Libraries
  - Sensor Integration
  - Simulation

- **ROS-IGTL-Bridge**
  - Convert ROS topics to OpenIGTLink
  - Transformation manager

- **Controller Node**
  - Control actuators
Step 1: Preoperative Planning

• Pre-operative MRI Brain Scan
• Mark three distinct points on brain for registration in Slicer
• Plan cut in Brain Stem for tumor removal in Slicer
Step 2: Pre/Intraoperative Registration

- Place scalpel over three distinct points for registration
- Send registration points through ROS to Slicer
Step 2: Pre/Intraoperative Registration (2)

• Perform registration in Slicer

• Send target points for cut to ROS
Step 3: Robotic Procedure

• Robot path is planned and sent to robot

• Robotic traces the planned trajectory
Conclusion

• Integration of 3D Slicer and ROS
  – Provide access to resources developed in two communities
  – Allows quick prototyping of surgical robot systems
  – Thanks to a wide variety of hardware supported by ROS, the system can be scaled up easily without changing the system architecture