Image Guided Therapy in Slicer3

Introduction to Navigation using OpenIGTLink

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Acknowledgements

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Learning objective

Following this tutorial, you will:

– Understand how to use tracking devices with Slicer3 using the OpenIGTLink module

– OpenIGTLink can also be used to interface with other devices, such as imaging devices and medical robots
Material

• This course requires a simple VTK tool model plus *either* the SPL-PNL brain atlas or the SPL abdominal atlas:

VTK model:  

Brain and abdominal atlases:

Required software

This tutorial requires the OpenIGTLink Slicer3 module and a tracker simulator:

- For both of these, you have the choice of either downloading a precompiled version (binary) OR building it yourself from the source code.

For installation instructions, see the wiki page at http://wiki.na-mic.org/Wiki/index.php/IGT:ToolKit/Navigation-tutorial

Disclaimer: It is the responsibility of the user of 3D Slicer to comply with both the terms of the license and with the applicable laws, regulations and rules.
Prerequisites

• Data Loading and Visualization in Slicer3:
Tutorial outline

1. **Introduction to surgical navigation**
2. Interfacing Slicer3 with external devices using OpenIGTLink
3. Hands-on navigation using a tracking simulator
4. Examples of OpenIGTLink in use
3D Slicer

- Integrates algorithms and utilities for medical image computing research and Image Guided Therapy into a single framework
- Is both an end-user application and a platform for research
- The precompiled program and the source code are both freely downloadable
Image Guided Therapy (IGT) in Slicer3

Slicer3 has extensive support for IGT, including:

- Visualization
- Registration
- Segmentation
- Model making
- Diffusion Tensor Imaging
- Quantification
- Filtering
- Interfacing to imaging devices, trackers and medical robots

Focus of this tutorial
Navigation in IGT

- Determining the positions and orientations of surgical tools using a tracking system
- Displaying virtual representations of those tools on the screen for the surgeon
Navigation in IGT

• Selected clinical uses:
  – Real-time update of tool position and orientation in augmented reality environments (ex. for minimally-invasive cardiac surgery)
  – Image-to-patient registration using tracked pointer tools (ex. for total hip replacement surgery)
  – Image-to-patient registration using tracked intraoperative imaging devices (ex. ultrasound)

In order to perform navigation, software must be able to receive position and orientation data from tracking devices!
Tutorial outline

1. Introduction to surgical navigation
2. **Interfacing Slicer3 with external devices using OpenIGTLink**
3. Hands-on navigation using a tracking simulator
4. Examples of OpenIGTLink in use
What is OpenIGTLink?

- OpenIGTLink is a communication protocol that allows Slicer3 to communicate with external devices.
What is OpenIGTLink?

OpenIGTLink

Slicer3
OpenIGTLink module

Imaging devices (ex MRI, US)

Tracking devices

Medical robots

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OpenIGTLink

- OpenIGTLink uses a “Client-Server” architecture.

OpenIGTLink

1. Makes requests

OpenIGTLink

2. Fulfils the requests
OpenIGTLink

- Surgical robot example:

1. Makes requests
   Ex. Get current coordinate

2. Fulfils the requests
   Ex. Returns current coordinate

Courtesy www.slicer.org
OpenIGTLink

- The OpenIGTLink protocol specifies the structure of the messages sent between the client and the server.
- **Slicer3** can be either the client or the server, depending on the application.

<table>
<thead>
<tr>
<th>CLIENT</th>
<th>OpenIGTLink</th>
<th>SERVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Makes requests</td>
<td></td>
<td>2. Fulfils the requests</td>
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The OpenIGTLink module in Slicer3

- OpenIGTLink is a **protocol**

- There is an **OpenIGTLink module** in Slicer3 that implements the protocol so that Slicer3 can communicate with external devices
OpenIGTLink and IGSTK

- IGSTK = Image-Guided Surgery Tool Kit
- OpenIGTLink functionality has been added to IGSTK: you can now use IGSTK to write programs that interact with both Slicer3 and the physical device.
The tracking simulator

- In this tutorial, a tracking simulator is used instead of using an actual tracking device.
- The tracking simulator acts as the client to send simulated data to Slicer3 (the server) over OpenIGTLink.
Tutorial outline

1. Introduction to surgical navigation
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3. **Hands-on navigation using a tracking simulator**
4. Examples of OpenIGTLink in use
Hands-on navigation

• Using a tracking simulator, you will learn how to:
  – Set up an OpenIGTLink connection in Slicer3
  – Show the resulting transforms using both the Slicer3 “locator” and a vtk model
  – Add a calibration matrix
  – Reslice image volumes using the tracker transform
Note

- Although the screenshots used in this tutorial use the SPL abdominal atlas, the SPL-PNL brain atlas can also be used.
Load the atlas

Click on File
-> Load Scene
Load the atlas

Select the scene file for the atlas (brain_atlas_2008.mrml or Abdominal_Atlas_2008.mrml) and click “Open”
Load the atlas

All of the atlas components are shown in the MRML scene within the Data module.
Load the atlas

If you are using the abdominal atlas, change the label map to “None”
Load the atlas

If you are using the brain atlas, turn off the visibility of the images:

Click the “Link” button

Click the “Visibility” button
Make the models invisible

Open the Models module
Make the models invisible

For each of the major headings in the model hierarchy, turn the visibility off
Make the models invisible

When you are finished, no models will be shown
Make the fiducials invisible

If you are using the abdominal atlas, open the Fiducials module.
Make the fiducials invisible

If you are using the abdominal atlas, turn off the visibility of the fiducials
Set up the OpenIGTLink connection

Open the OpenIGTLink module
Set up the OpenIGTLink connection

The Connectors pane shows the OpenIGTLink connections that Slicer3 is connected to.

Add a new connection by clicking the "Add" button.
Set up the OpenIGTLink connection

Set Slicer3 to be the server by clicking on the Server box.

Note that the connector type is now set to "S" instead of "?"
Set up the OpenIGTLink connection

Make the connection active by clicking on the “Active” button

Note that the connector status is now set to “WAIT” instead of “OFF”
Start the tracker simulator

LINUX and MAC:

Run the TrackerSim program:

- 1 = number of frames per second
- c = TrackerSim is the client
- localhost = the host name
- 18944 = the port number
Start the tracker simulator

WINDOWS:
Run the RunTrackerSim program by double clicking on it.
Start the tracker simulator

The transforms being sent are written to the terminal.
Start the tracker simulator

Open the Data module
Start the tracker simulator

The new tracker node is a transform node - you can see it at the bottom of the MRML tree.
Start the tracker simulator

Open the OpenIGTLink module
Start the tracker simulator

Note that the connector status is now set to “ON” instead of “WAIT”
Start the tracker simulator

Open the Transforms module

Click on the new Tracker transform to see the changing transformation matrix
Show the transform using the locator

Open the OpenIGTLink module

In the Visualization/Slice Control pane, click the “Show Locator” button

If the locator does not appear, make sure that the IGTLocator model is set to “visible” in the Models module
Show the transform using the locator

The round end shows the simulated tool’s position, and the cylinder shows the simulated tool’s orientation.
Show the transform using the locator

Open the Data module

The new locator node is a model node at the bottom of the MRML tree
Show the transform using the locator

Drag the locator node under the Tracker node

The Tracker transform is now applied to the locator model - it will move according to the transforms from the tracker simulator
Show the transform using a model

Other objects, such as models or images, can be moved according to the tracking transforms.

Open the OpenIGTLink module
Show the transform using a model

In the Visualization/Slice Control pane, turn off the locator
Show the transform using a model

Open the Models module

Click on the folder icon to load a model
Show the transform using a model

Click on tool.vtk and then click “Open”
Show the transform using a model

In the Models module, change the colour of the model to yellow.
Show the transform using a model

Open the Data module

Drag the tool.vtk node under the Tracker node

The Tracker transform is now applied to the tool model - it will move according to the transforms from the tracker simulator
Add a calibration matrix

Transforms can be multiplied together - we will incorporate an additional translation.

Open the Transforms module.
Add a calibration matrix

Add a new transform node
Add a calibration matrix

Open the Data module

Rename the new transform to “Calibration Matrix” by selecting it and then changing the name in the MRML node inspector.
Add a calibration matrix

Open the Transforms module

Set the PA (posterior-anterior) translation to 50
Add a calibration matrix

Open the Data module

Drag the Tracker node under the Calibration Matrix node

The model will be translated along its length axis
Reslice the images using the tracker transform

Delete the Calibration Matrix by right-clicking and selecting “Delete Node”
Reslice the images using the tracker transform

Delete the tool model by right-clicking on tool.vtk and selecting “Delete Node”
Reslice the images using the tracker transform

Open the OpenIGTLink module
Reslice the images using the tracker transform

In the Visualization/Slice Control pane, click the “Show Locator” button
Reslice the images using the tracker transform

Open the Models module

Select the IGTLocator model as the selected model and change its colour to red
Reslice the images using the tracker transform

Open the OpenIGTLink module
Reslice the images using the tracker transform

Set the driver for the red (axial) slice to “Locator”
Reslice the images using the tracker transform

The axial slice moves as the locator moves
Reslice the images using the tracker transform

Click on the “visibility” button

Change the view in the 3D viewer by clicking on the “I” (inferior) button on the “Manipulate 3D View” pane
Reslice the images using the tracker transform

Note that the axial slice moves as the locator moves.
This is because the center of the axial slice is set to the locator’s position.
Reslice the images using the tracker transform

Set the driver for the red (axial) slice to “User” and the driver for the yellow (sagittal slice) to “Locator”

Click on the “P” (posterior) button on the “Manipulate 3D View” pane
Reslice the images using the tracker transform

Note that the sagittal slice moves from left to right as the locator moves.

(The axial slice didn’t move up and down because the locator does not move in the superior-inferior direction.)
Reslice the images using the tracker transform

You can click on the “Locator All” button to set the driver to “Locator” for all of the slice views.

The image origin is set to the locator’s position.
Reslice the images using the tracker transform

Check the “oblique” box to slice the image volume according to the tool’s orientation - the coordinate system is setup so that one axis is parallel to the locator’s orientation.
Reslice the images using the tracker transform

Check the "Freeze" box to freeze the images in both the 3D Viewer and the three slices viewers (the locator keeps moving)
Turn off the OpenIGTLink connection

Click on the “Active” box to disconnect the OpenIGTLink connection.
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Examples of OpenIGTLink in use

Prostate biopsy robot under MRI-guidance

Volume-rendered 4D ultrasound
Overview

• In this tutorial, you learned:
  – How OpenIGTLink can be used to perform navigation in Slicer3
  – How to set up OpenIGTLink connections using the OpenIGTLink module in Slicer3
  – How to visualize the tracker transforms
  – How to reslice image volumes using the tracker transforms
  – How OpenIGTLink is currently being used in practice
Conclusions

• Slicer3 can interact with common devices used in Image Guided Therapy

• OpenIGTLink is evolving technology - expect lots of active development!

• Slicer3 is free open-source software that allows IGT researchers to share algorithms and work within a common framework
For more information…

• The Slicer3 IGT Advanced Navigation Tutorial uses the Aurora magnetic tracking devices from NDI, and provides a more thorough explanation of the OpenIGTLink protocol:

• For a description of the OpenIGTLink protocol:
  http://www.na-mic.org/Wiki/index.php/OpenIGTLink