Navigation of an ETV Simulator

(Endoscopic Third Ventriculostomy)

COD310

under Professor Subodh Kumar

github.com/pratyush911/ETVSimulation

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Objective

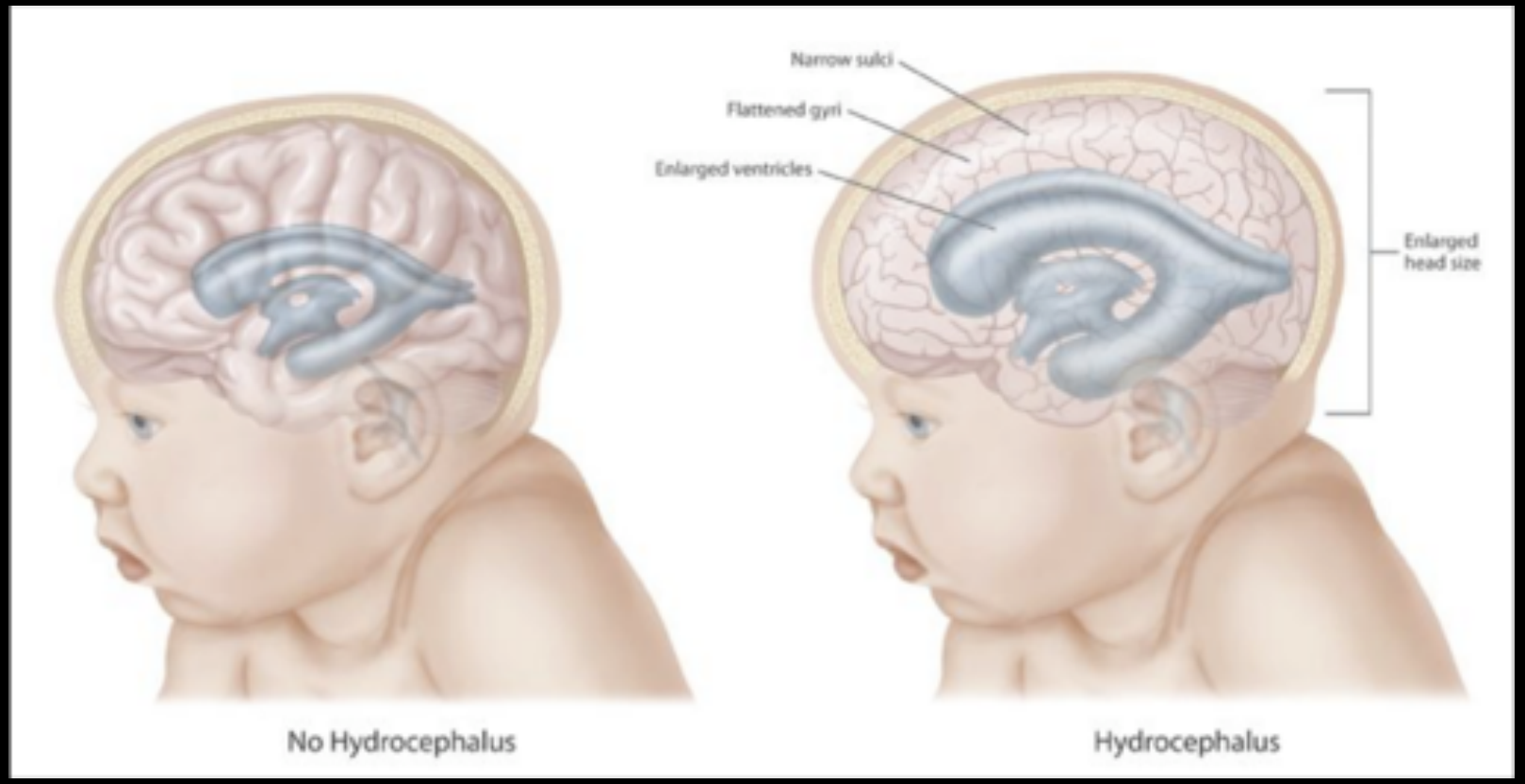
- To create a **navigation** system for an ETV simulator that correctly guides a user to do an ETV. The navigation should be intuitive in the sense that it has strong correlations between the real and physical world.

Work Timeline

- Understanding the Problem and getting the system ready
- Understanding the Procedure
- Learning Basics of OpenGL
- Working with Chai3D and Haptic Devices: Stanford CS277
- Make Small tweaks in the code and run it
- Coordinated Movement on a Cylinder
- Making the Movement more intuitive
- Implementing with the Endoscope Version
- Get Phantom Model 3D Printed and adjust camera view
- Calibration of haptic device with Phantom Model
- Navigating

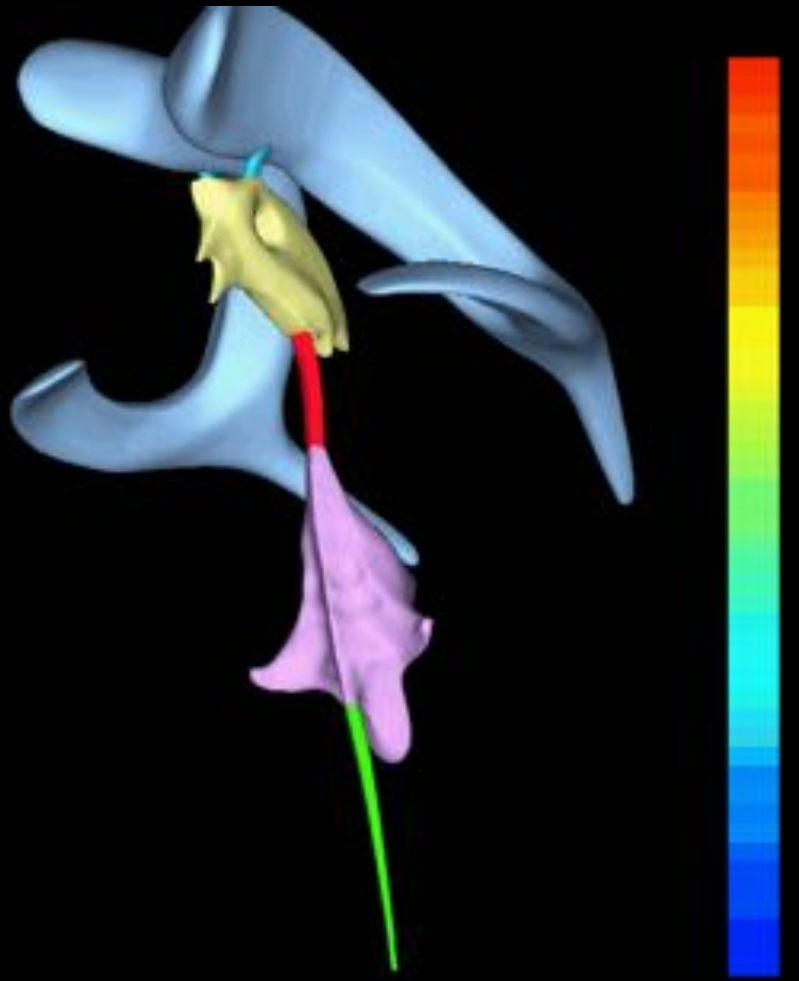
Understanding the Problem

- Hydrocephalus



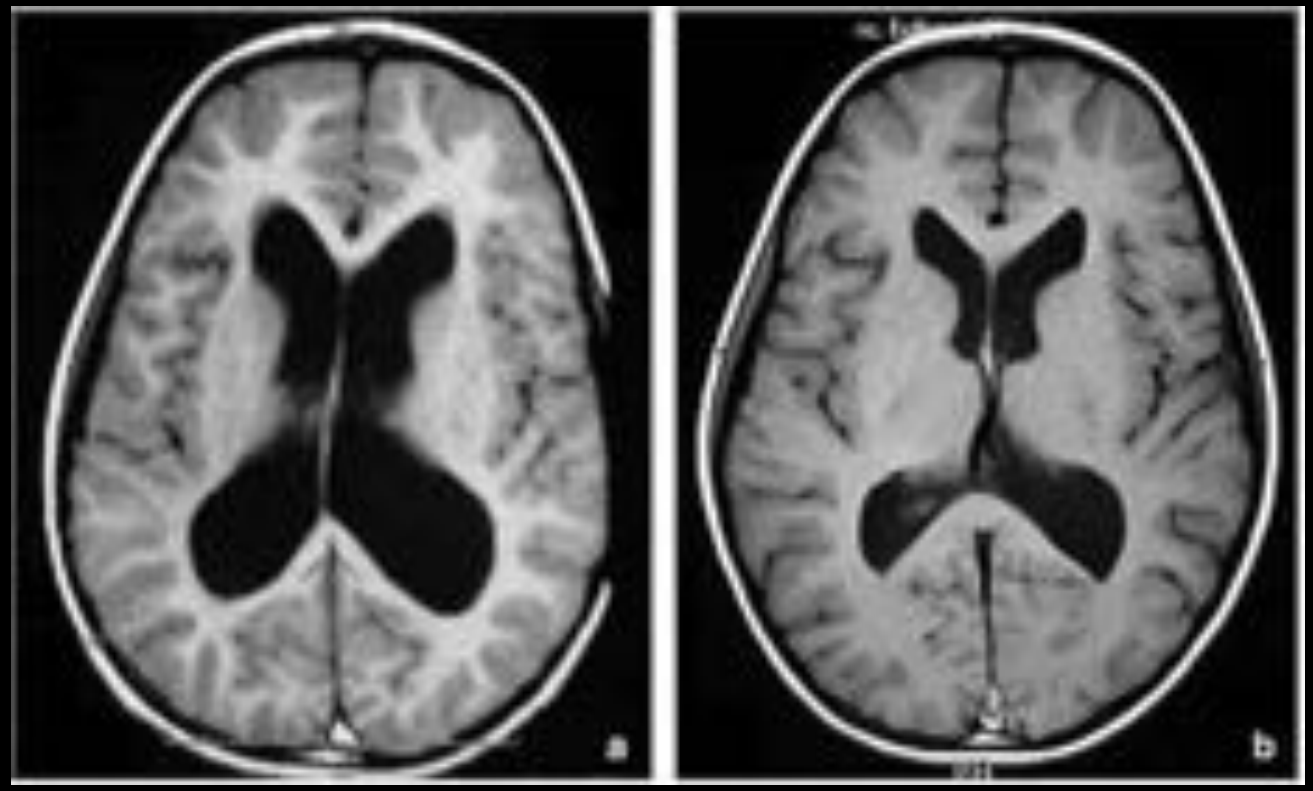
Understanding the Problem

- Four Ventricles in Brain
- 2 Lateral Ventricles, Third, Fourth Ventricle
- Aquaduct joining Third and Fourth Ventricle gets blocked
- CSF (Cerebro Spinal Fluid) get trapped
- Enlargement of Third and Lateral Ventricles



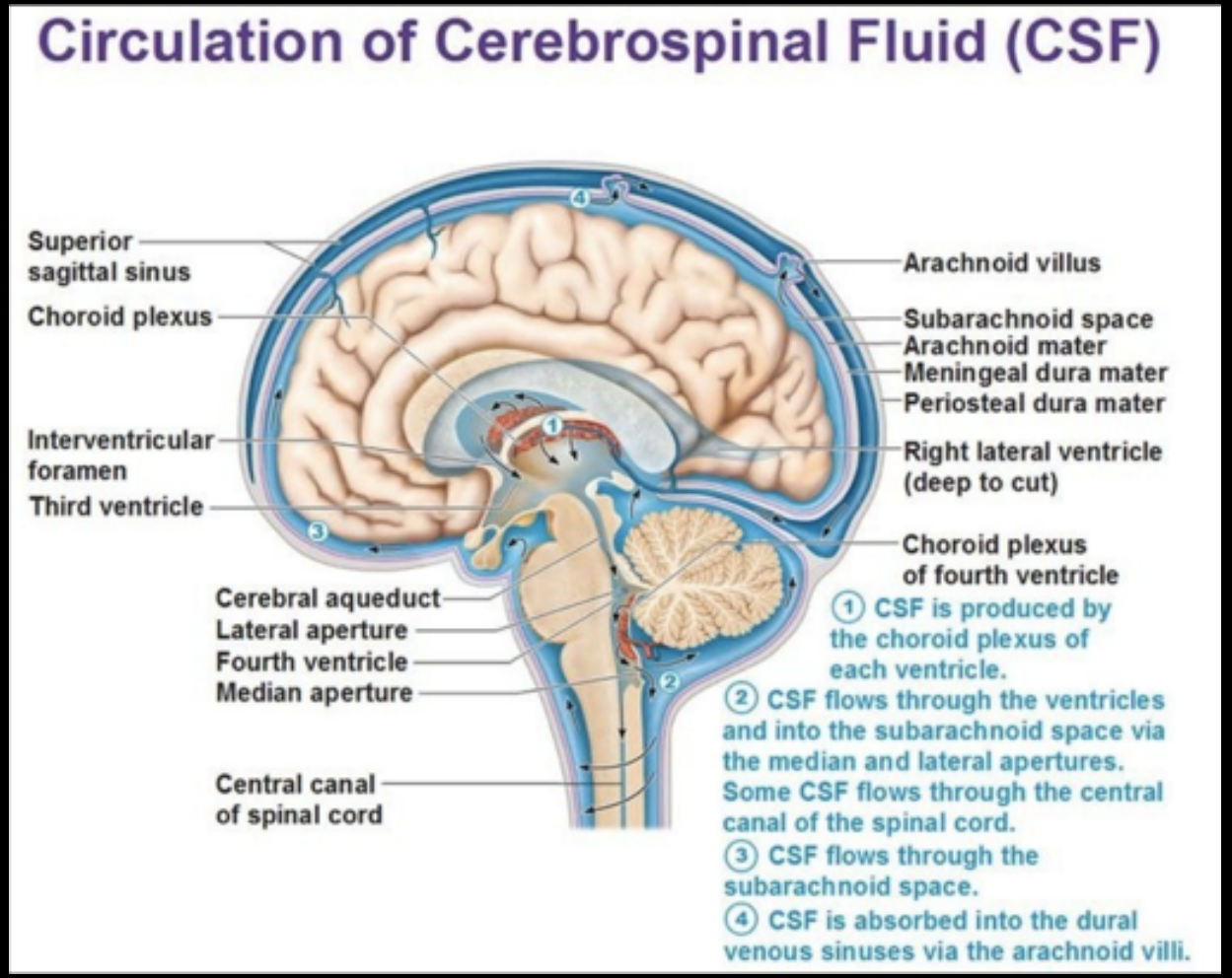
Understanding the Problem

- Reading through MRI Images



Understanding the Problem

- Choroid Plexus generates CSF
- CSF circulated in brain
- Absorption by Arachnoid granulations in brain
- Re-production of CSF in Choroid Plexus

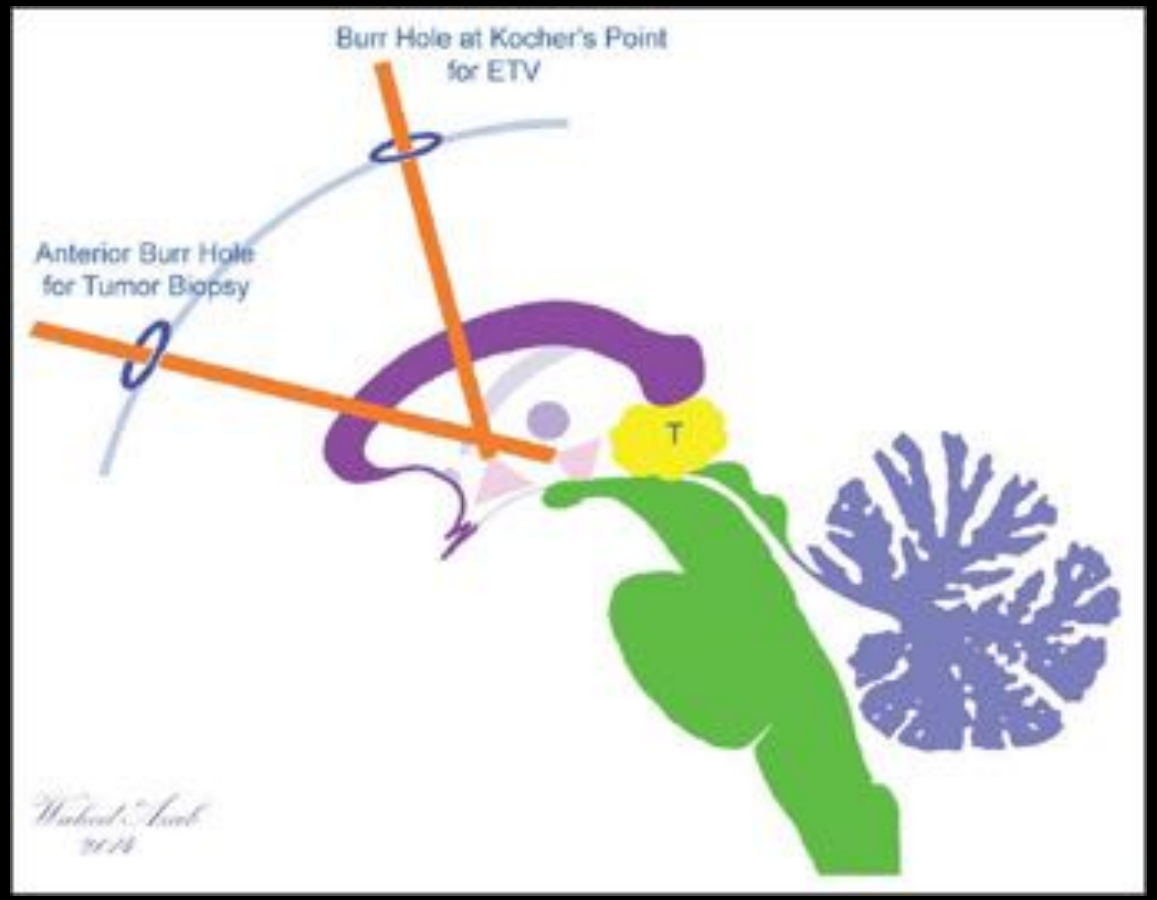


Installing Libraries & Getting the System Ready

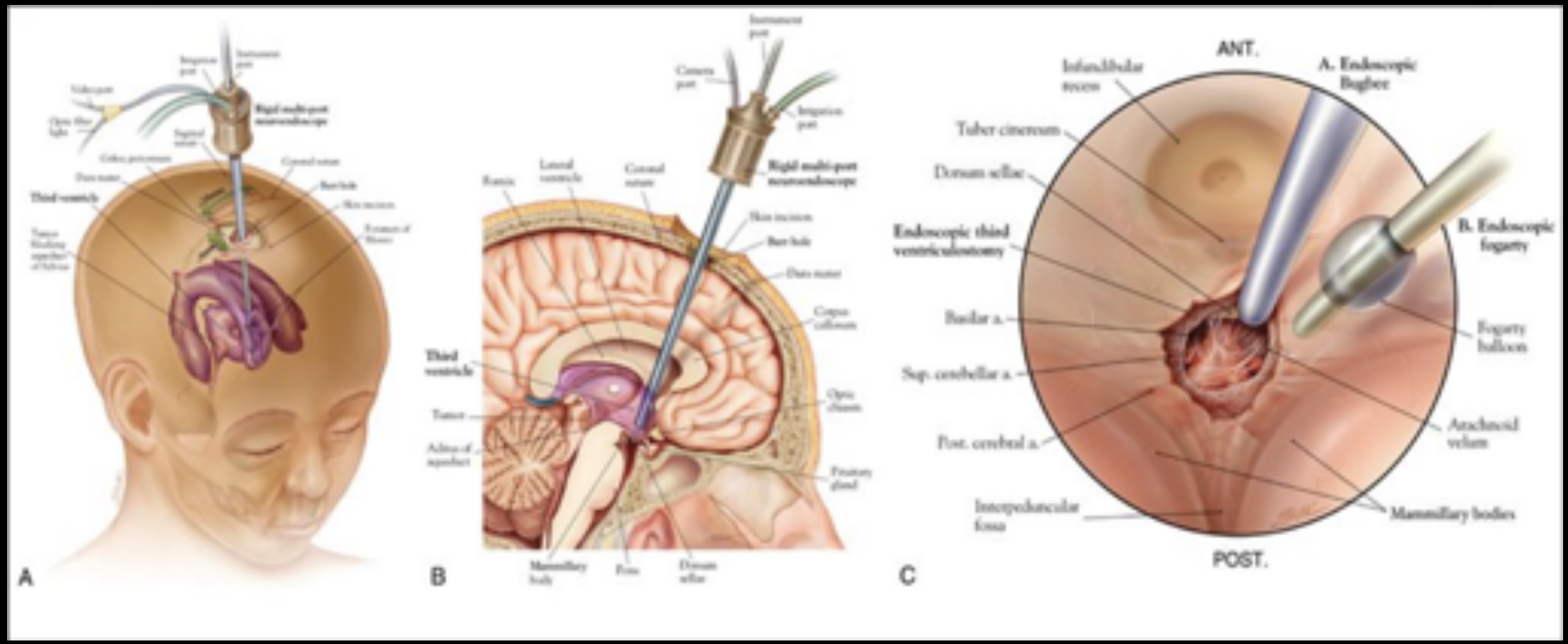
- Received System in early February
- Installed libraries for Chai3D, OpenGL ..
- Tested that the inherited code executes

Understanding the Procedure

- Create a **burrhole** at a suitable location.
- Ideally straight line path without disturbing sensitive arteries & veins.
- Rigid Pivoting of endoscope at the point of burrhole.
- Jelly like nature of gyri in brain
- Can be pierced, rejoins when endoscope removed

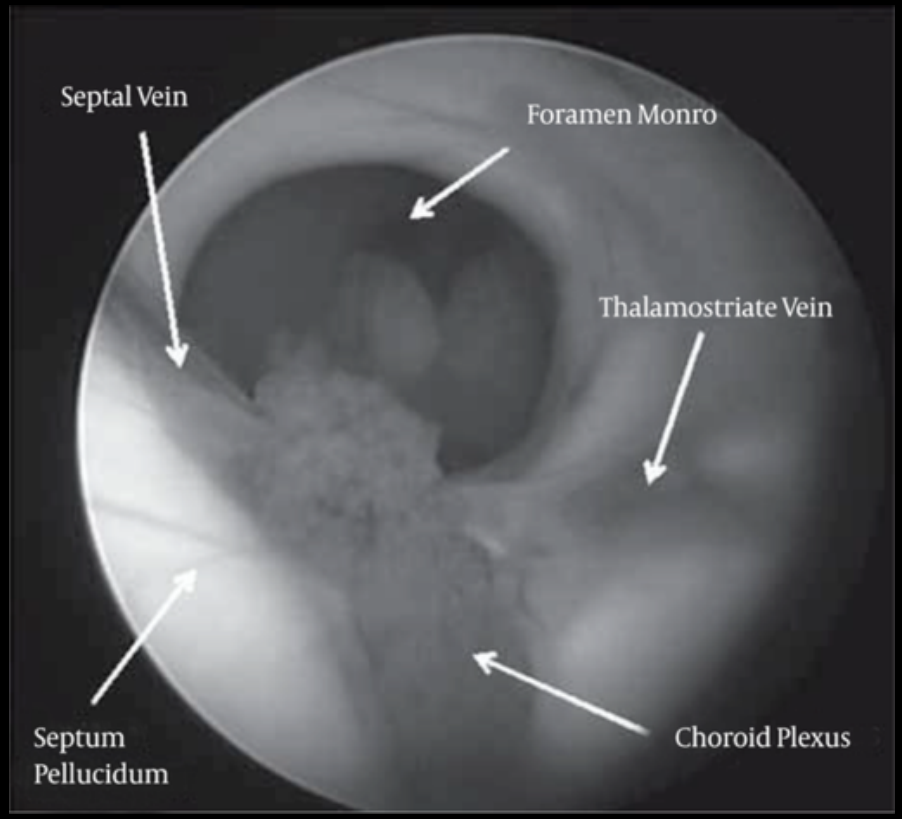


Understanding the Procedure



Understanding the Procedure

- **Navigate** the endoscope
- Following the Choroid Plexus (red in colour)
- Special care for Fornix – leads to memory loss
- Perforate through the Foramen of Monro



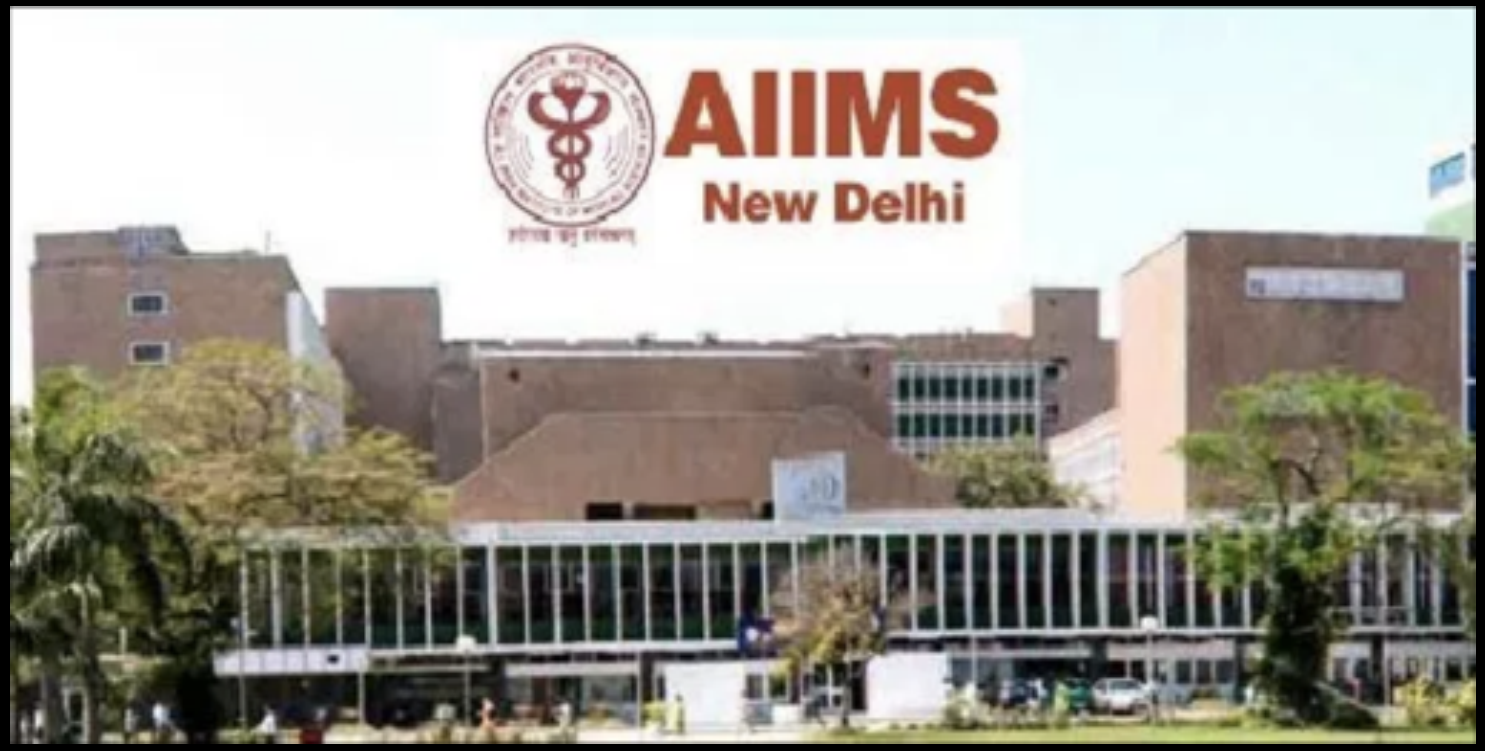
Understanding the Procedure

Complications involved

1. Fornix should not be damaged
2. Basilary Artery should not be touched – Locates at the base of the third ventricle
3. Vital nerves should not be hit during navigation– may lead to loose of senses/ death

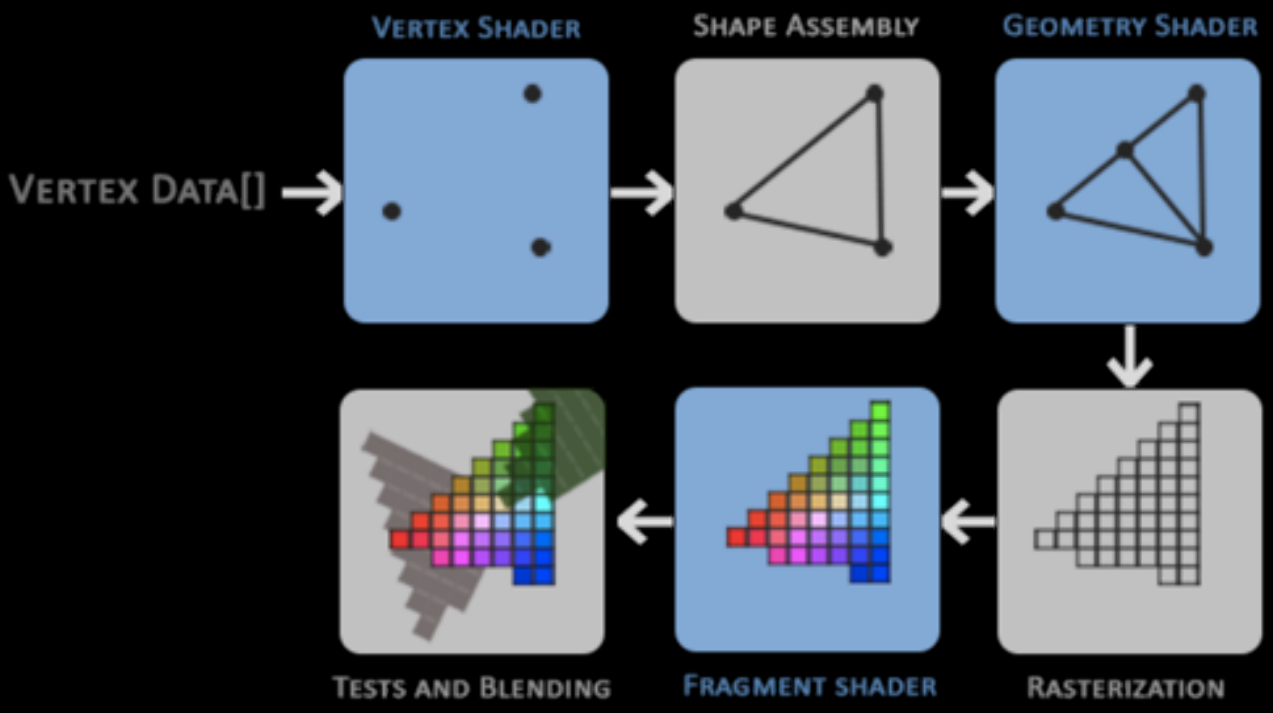
Understanding the Procedure

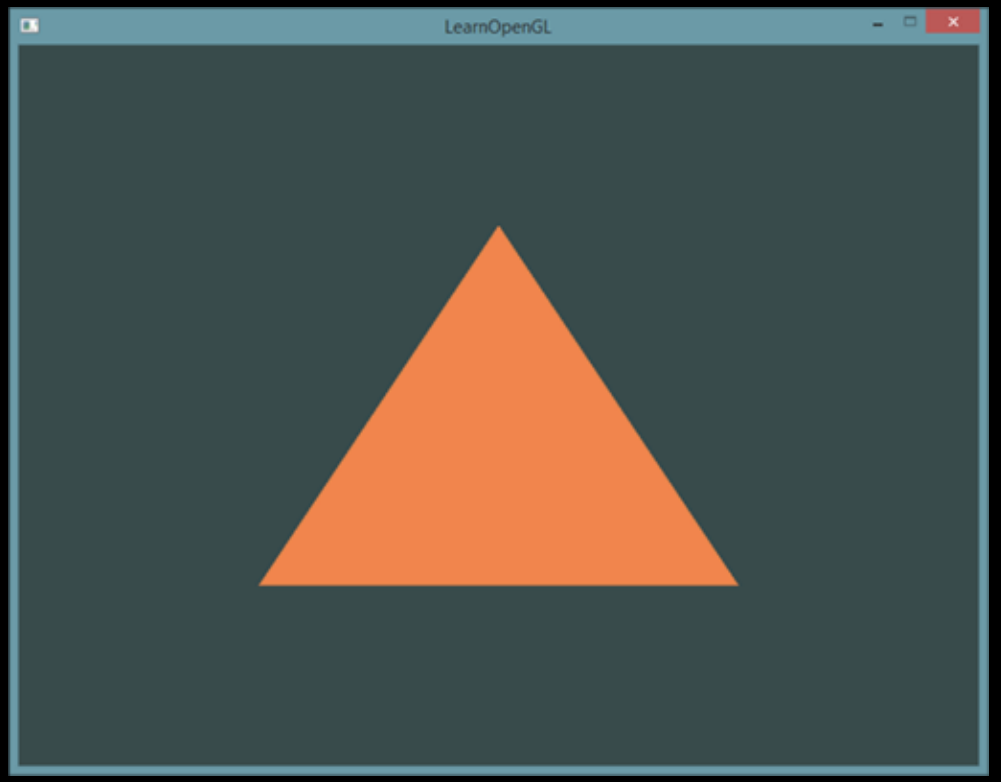
- Visit to AIIMS for understanding the problem



Learning Basics of OpenGL

- Understanding Basics of OpenGL
- Shaders, Transformations, Homogenous Coordinate System



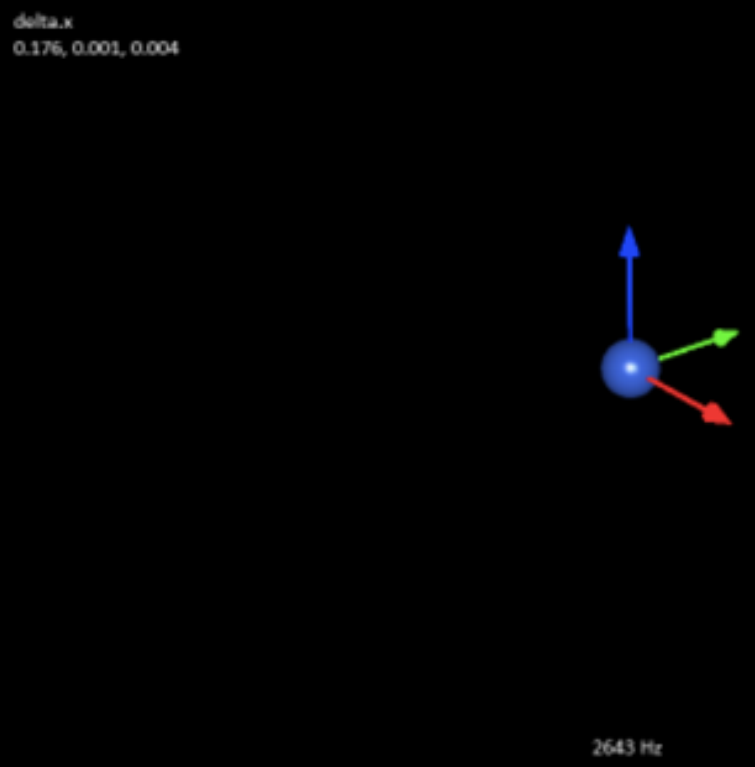


Practice Codes / Tutorials OpenGL

- GLFW, GLUI libraries
- Opening windows
- Drawing triangles
- Basic Shading
- Input Output
- Put up on Git repository

Working with Chai3D and Haptics

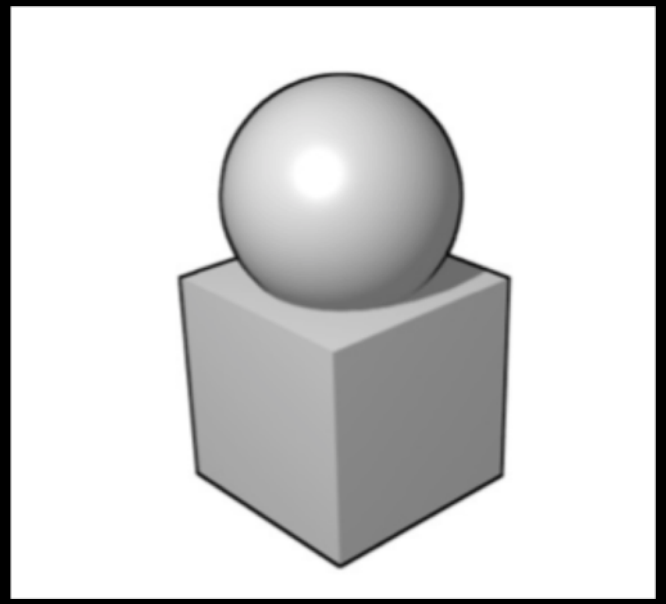
Over 30 Example Chai3D Programs with use of Mesh, Force, Haptic Endoscope, Field effects etc.



Working with Chai3D and Haptics

Stanford CS277: Course on Experimental Haptics

- **Part I - Shapes Using Force Fields**
- **Part II - Inverting the Force Fields**
- **Part III - Animating the Objects**



Good Introduction to Libraries

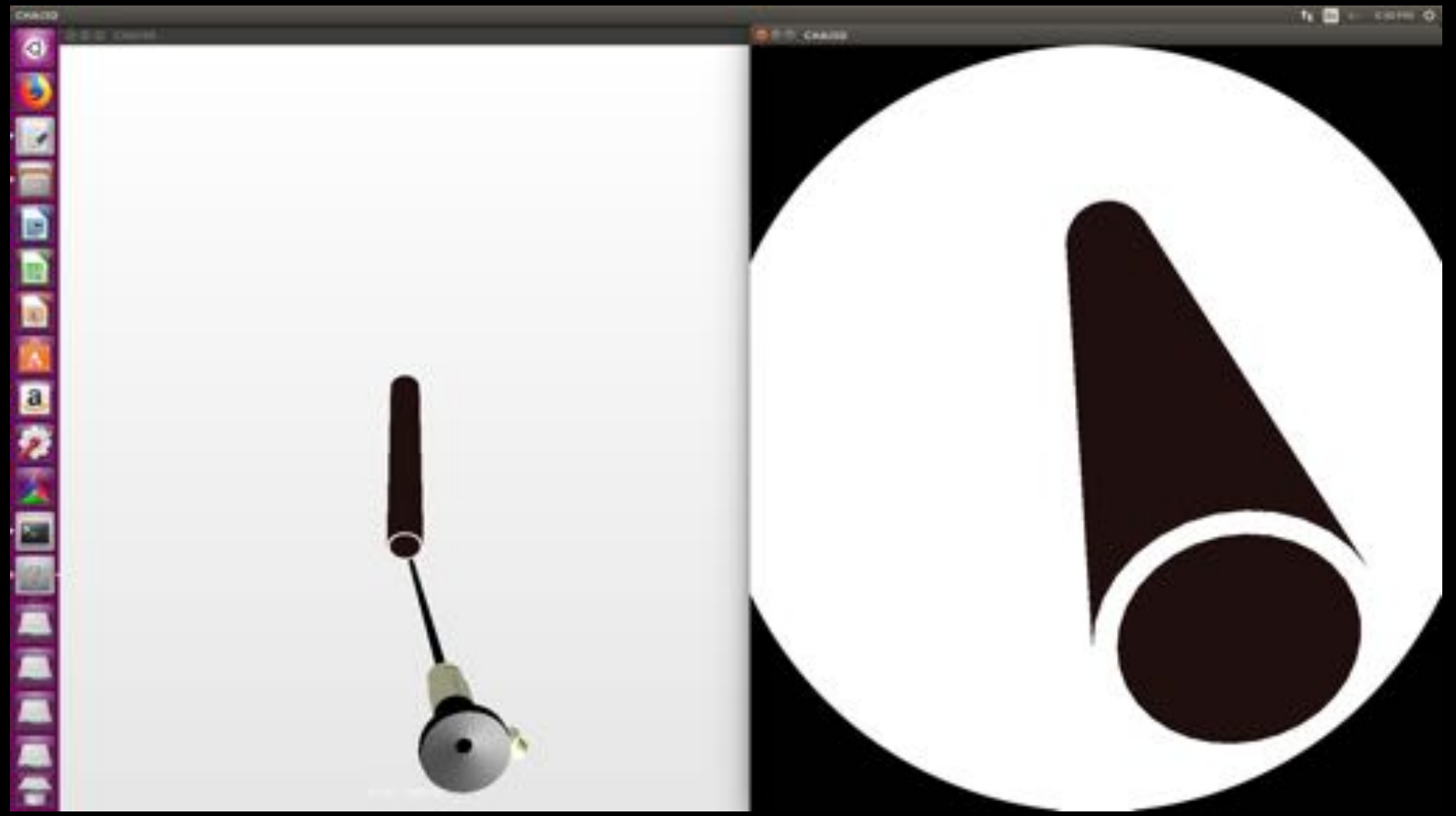
Make Small tweaks in the code and run it

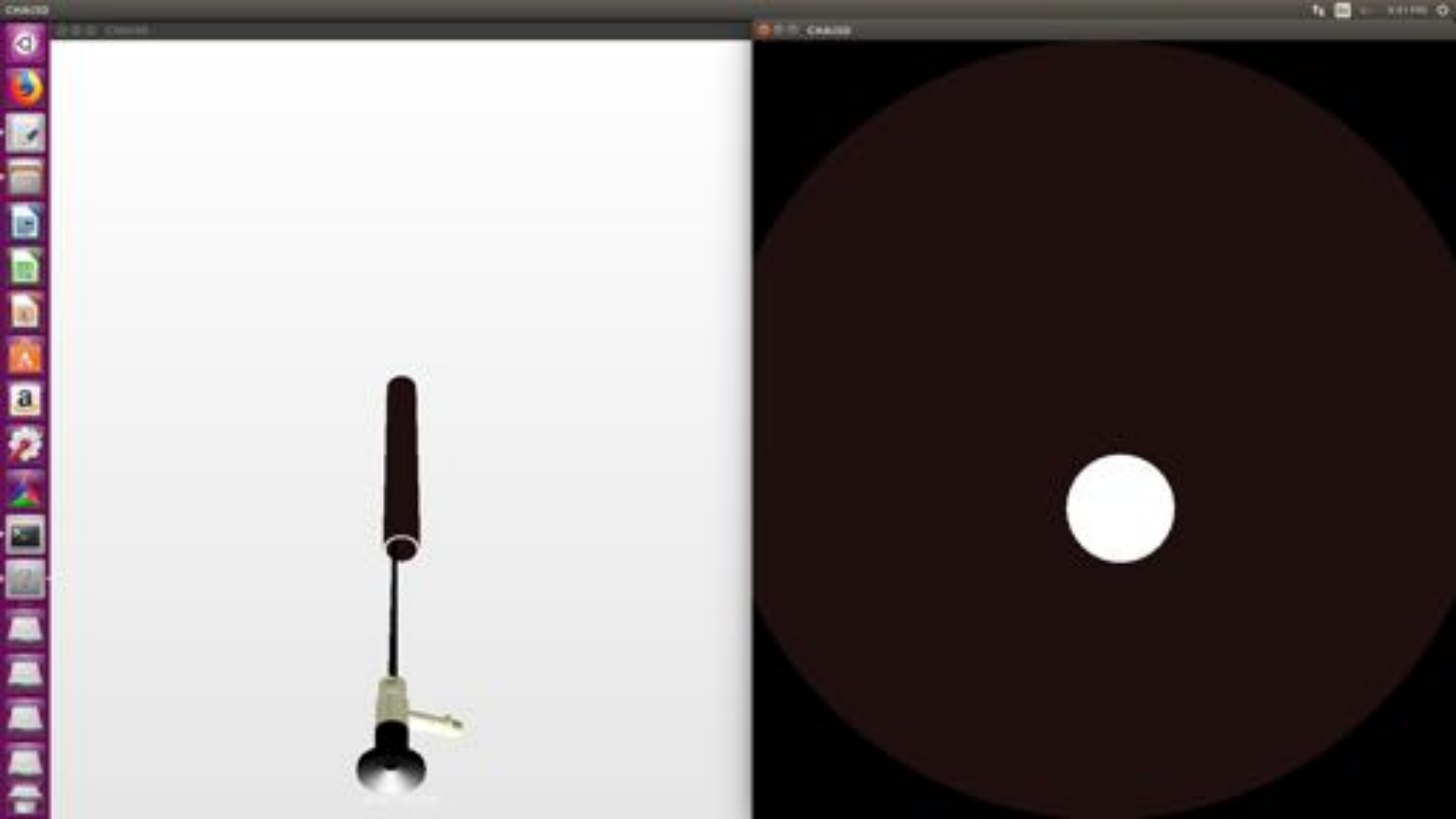
- Working on Modularized Code
- Adding I/O operations to introduce more readability.

Mid Semester Break

Coordinated Movement on Cylinder

- Getting Navigation to work on Cylinder proto-type





Intuitive Navigation

- What is intuitive for us might not be how an endoscope works?
- Physical Translation → Virtual Translation ? YES
- Physical Rotation → Virtual Rotation ? YES & … NO

Adjusting Camera View

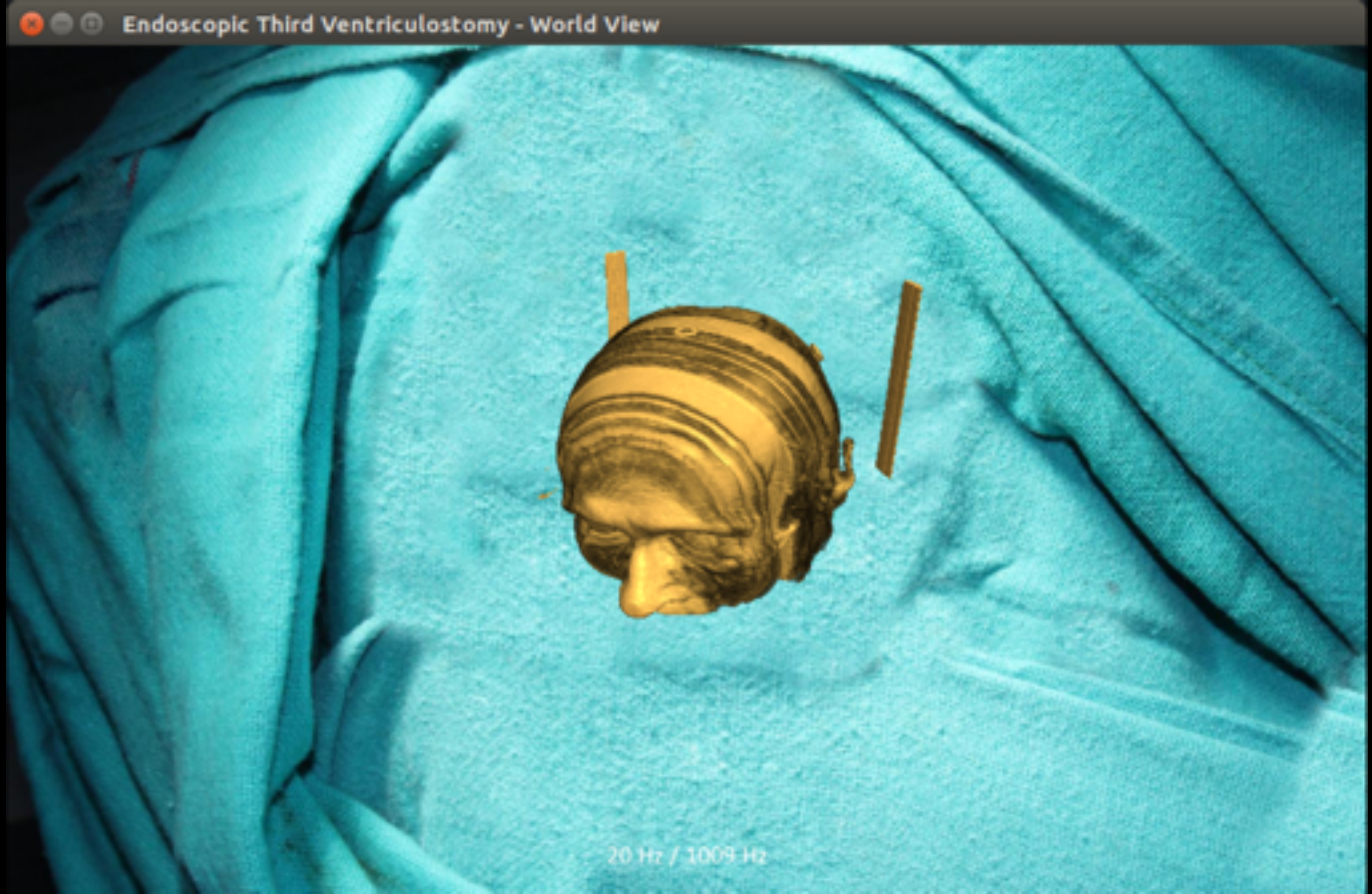
- Two Choices – Rotation Allowed / Static Viewing Angle
- Static Viewing Angle during translation
- Rotation during halts

Get Phantom Model 3D Printed

- Printed in IIT Delhi
- Markings on the skull for calibration
- STL file for printing not compliant with VoxelFile for Virtual Diagram

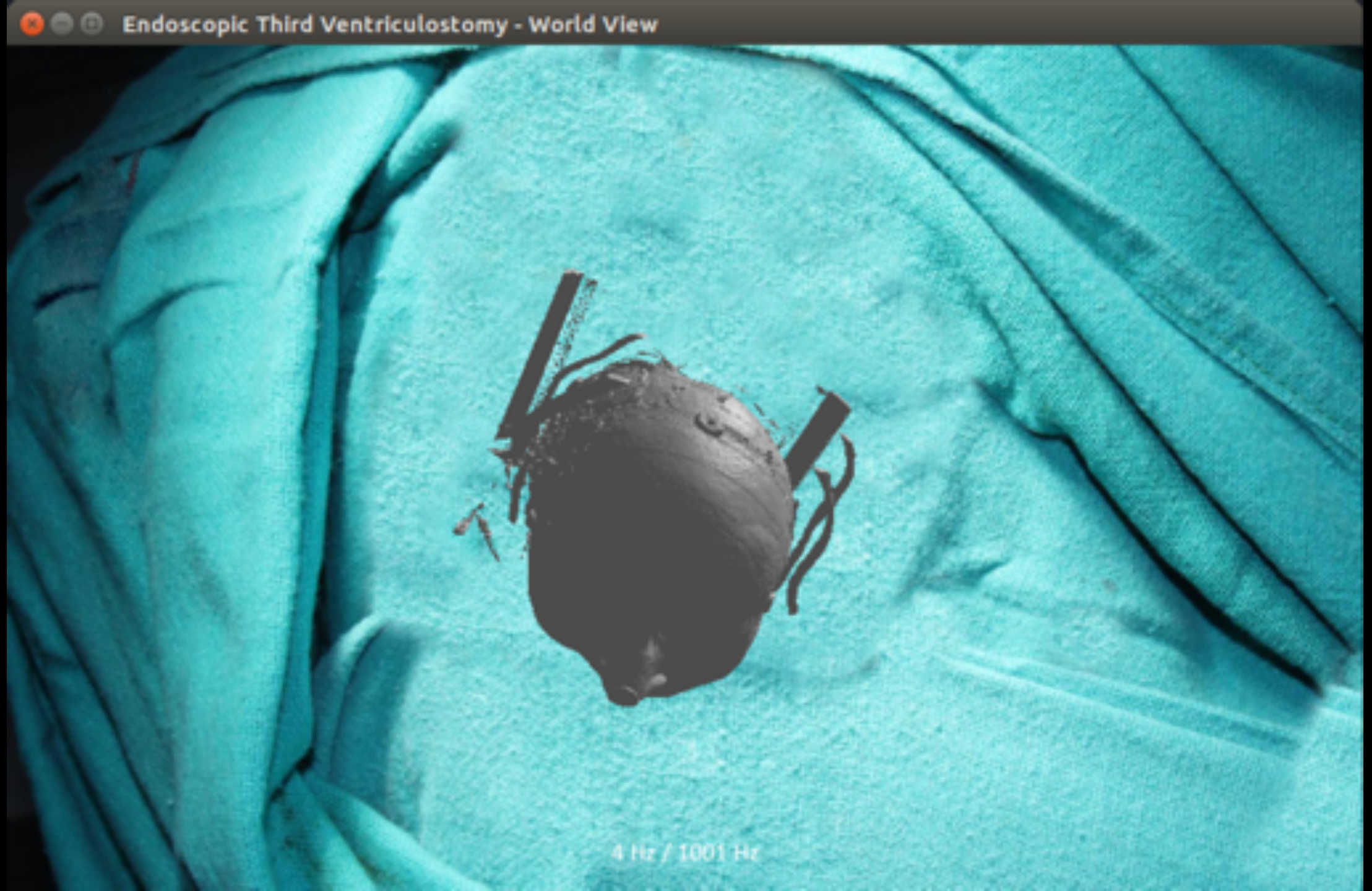
New Virtual Copy Created

- DCM to PNG Conversion
- Reconstructed a new 3D Virtual Model in Compliance with the 3D Printed Physical Model
- PNG to Voxel Conversion


Endoscopic Third Ventriculostomy - World View
20 Hz / 1009 Hz

Calibration of haptic device with Phantom Model

- Voxel to Multi-Mesh Conversion
- Polygonisation Approach


Endoscopic Third Ventriculostomy - World View
4 Hz / 1001 Hz

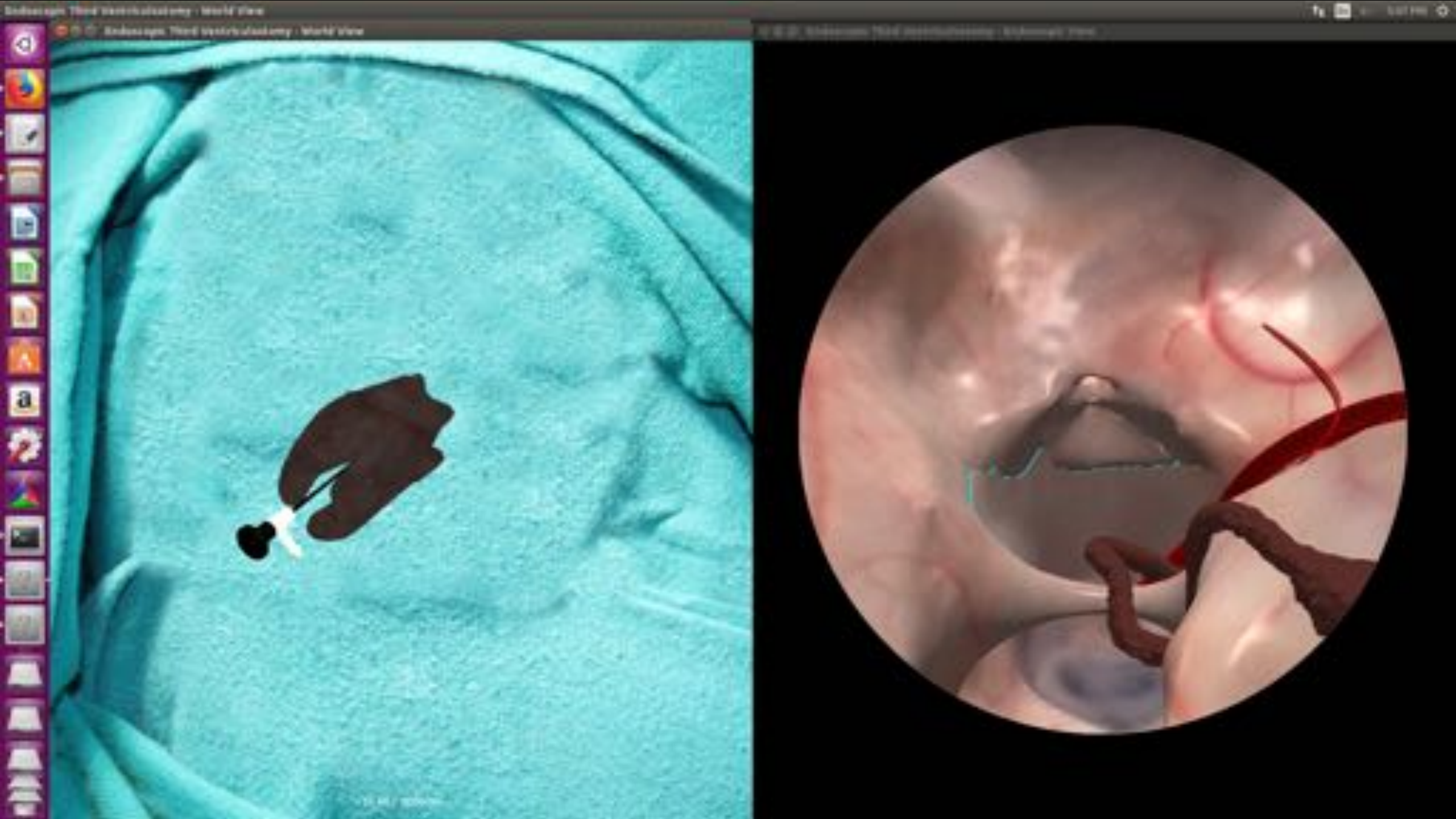
Calibration of haptic device with Phantom Model

- Local 3 points algorithm developed for coordinate calibration.
- Rigid ICP / MeshLab not a feasible option
- Accuracy v/s Feasibility Trade-off
- Static followed by Dynamic Calibration

Calibration Algorithm

- Step1: Scaling
- Step2:Rotating to align normal vectors
- Step3:Translating to match one point of virtual space and its corresponding real point
- Step4:Rotating to match all points

Navigating through the 3D Model



Thank You