Developing a human-machine interface for surgical planning for deep brain stimulation.

But for real, what does it mean?

Deep brain stimulation (DBS) is a surgical procedure for treating **motor-related neurological disorders**. Its clinical efficacy depends on precise surgical planning and accurate **electrode placement**, which in turn call upon several image processing and visualization tasks, such as image registration, image segmentation, image fusion, and 3D visualization.[1]

This kind of intervention is called **stereotactic surgery**, it's a minimally invasive form of surgical intervention that makes use of a three-dimensional coordinate system to locate small targets inside the body and to perform on them some medical action such as biopsy, injection...

The STIM team at CENIR, the ICM's imaging platform, helps the surgeon to find the two **basal ganglia**. It's located in a very small area in the center of the brain, and is associated with a variety of functions, including control of voluntary motor movements, procedural learning, eye mouvement... So that is the part which needs to be stimulated by the electrodes the surgeon puts on the brain!

At ICM, almost 2 people suffering from parkinson disease undergo this kind of surgery per week!

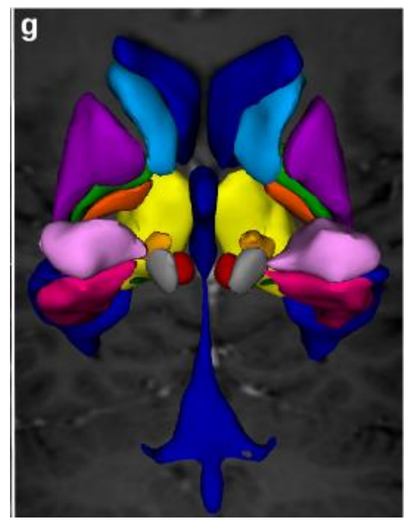

Fig 1: Atlas-based segmentation of brain ventricles (blue) and basal ganglia. [1]

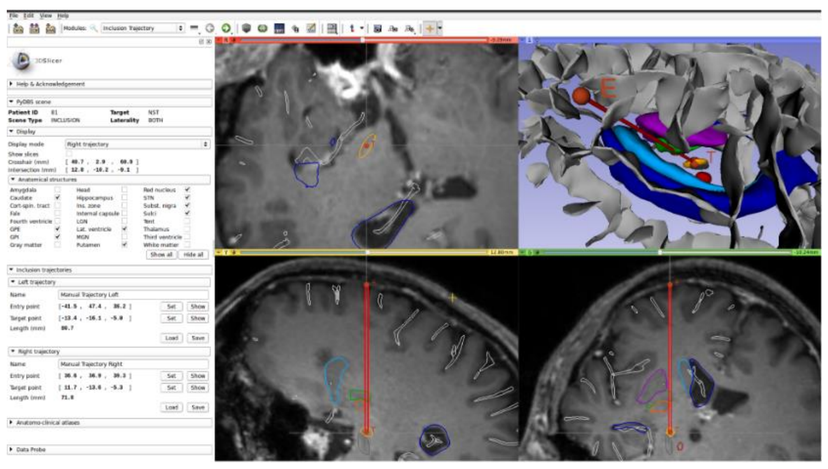

Fig 2 : View of a surgical planning for DBS using 3DSlicer. [1]

How do we make a way through?

3D Slicer is a free, open source and multi-platform software package widely used for medical, biomedical, and related imaging research. It's both a desktop software to compute advanced medical images and a development platform to quickly design solutions. [2]
At ICM, this soft is used with PyDBS, an automated image processing workflow for DBS surgery, to help the surgeon with interactive trajectory planning.

3D Slicer shows images of various format such as CT or MRI, and has a special **window for 3D models** of the patient brain. This part is the one I'm interested in.

Improving vizualisation

Navigating into the brain or in any objects is always harder when we see it only in 2 dimensions. Even thought it is not impossible to get a good trajectory this way, it is always better to see in 3D to get a good view of the whiter matter and blood vessel for example. Hence the use of the 3D model, and of the human-machine interface we talked about earlier, composed of a **zSpace screen** and 3D Slicer.

ZSpace is an All In One computer displaying in a **3D** holographic-like environment, (something like virtual reality) thanks to the **Crystal Eyes** (QuadBuffer) technology.

Fig 3 : zSpace AIO 300.

How 3D works :
Our two eyes to see slightly different perspectives of the world thanks to what is called interpupillary distance. Our brain compares these left and right eye differences in order to understand the spatial complexities of the view in front of us.[3]

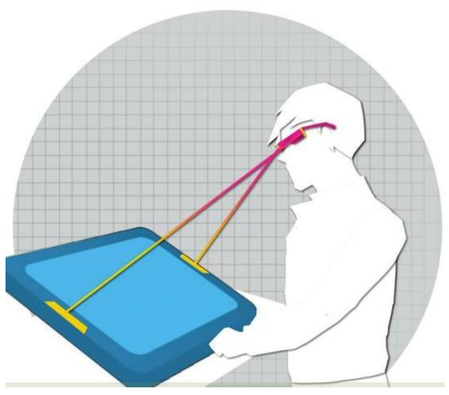

Fig 4 : How the zSpace knows where we are. [3]

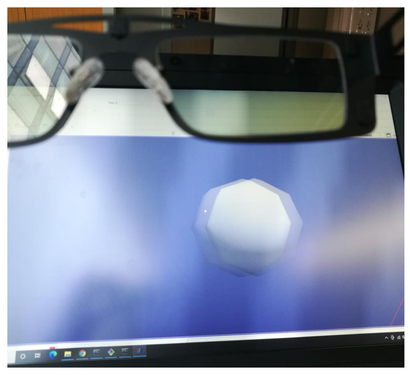

Fig 4 : QuadBuffered images.

The 3D glasses perform the traditional 3D role of distributing the left and right stereoscopic views to the viewer's eyes using circular polarization.[3] But the particularity of these glasses is that they **follow the movements of the head** using with reflectors and two IR "tracking camera" on the left and right side of the screen.

What is QuadBuffer mode?
The stereoscopic version of double buffering. In this mode, both the front" and "back" buffers are stereoscopic images. Stereoscopic vision is the ability to perceive a single image in three dimensions.

Perspective

For now, VR using headsets is the most widespread, as there are more choices over headsets, rather than 3D screens. For example, Slicer lastest version already has a plugin which supports rendering in VR very well.
Both have advantages and can be used for different use cases. Where the headset allows us turn around our environnement, it is easier to show something to someone else using the zSpace. Hence, this new display mode could be used in the futur to teach surgeon.

With Paraview, another vizualisation software based on the same librairy as Slicer, arriving on zSpace devices, one must hope 3D devices are becoming more democratic.

Fig 5 : Astract representation of what one sees using the zSpace. [3]

References:

[1] D'Albis T, Haegelen C, Essert C, Fernández-Vidal S, Lalys F, Jannin P. **PyDBS: an automated image processing workflow for deep brain stimulation surgery.** Int J Comput Assist Radiol Surg. 2015 Feb;10(2):117-28. doi: 10.1007/s11548-014-1007-y. Epub 2014 May 6. PMID: 24799270.
[2] Main page, https://www.slicer.org/, visited 15/06/2021
[3] Best practices, https://developer.zspace.com/docs/bp-mixed-reality-essentials, visited 15/06/2021

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DBS***, movements disorders*** , virtual reality, neurosurgical planning, a lot of code.

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