

OTOVIRT: An image-guided workflow for individualized surgical planning and multiphysics simulation in cochlear implant patients

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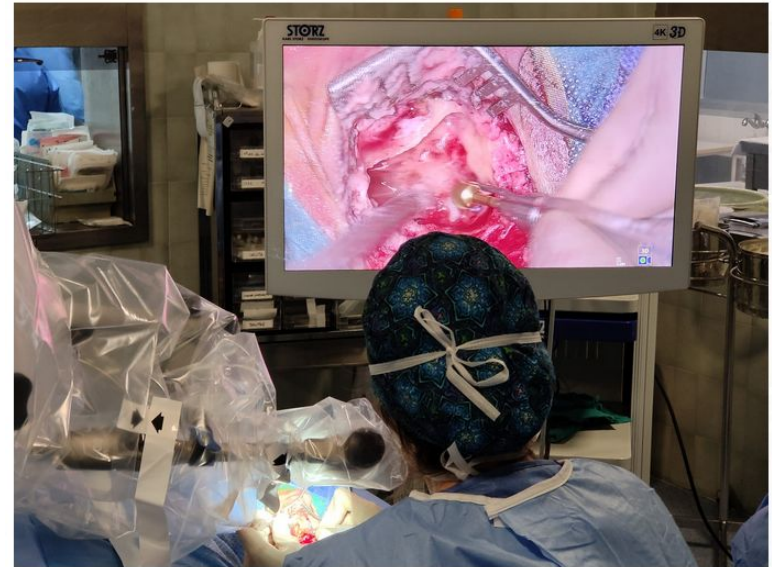
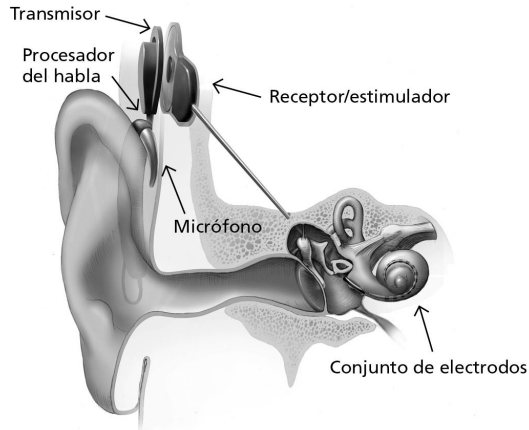
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1. Introduction
2. Objectives
3. Materials and methods
4. Results
5. Conclusions
6. Future lines of action

1. The problem: surgical inner-ear interventions present a big challenge as there is a high anatomical complexity
 - a. Training time
 - b. Resources
 - c. Technological complexity: Cochlear Implants (CI)

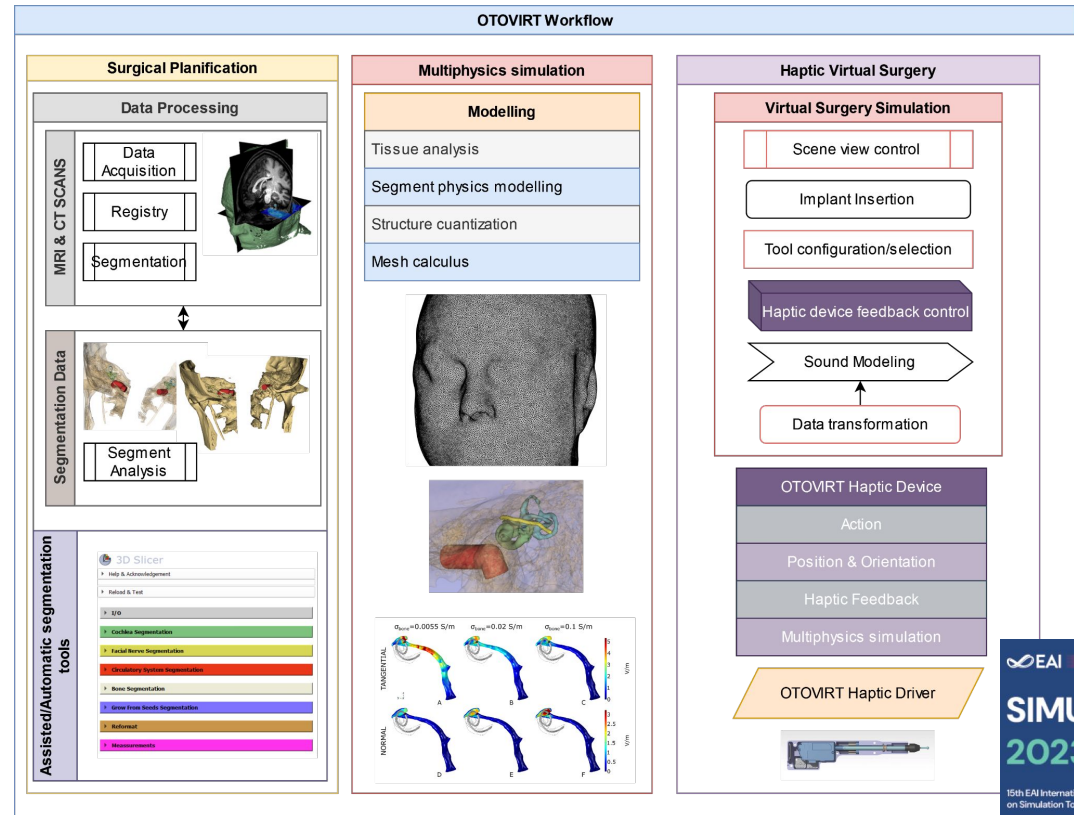


Deep NL, Dowling EM, Jethanamest D. "Cochlear Implantation: An Overview." *Journal of Neurological Surgery. Part B, Skull Base, U.S. National Library of Medicine*. 2019;80(2):169-177. doi:[10.1055/s-0038-1669411](https://doi.org/10.1055/s-0038-1669411)

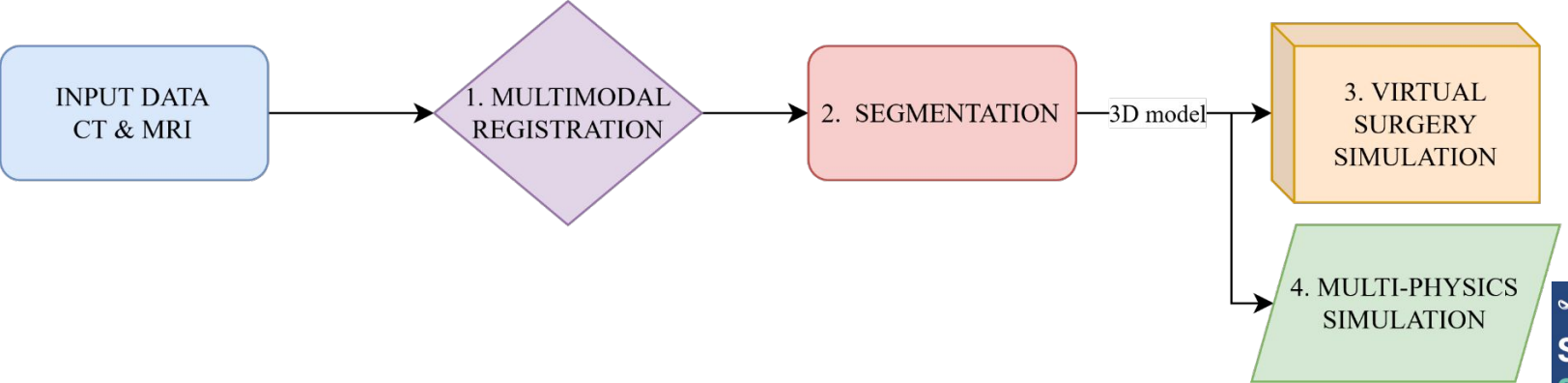
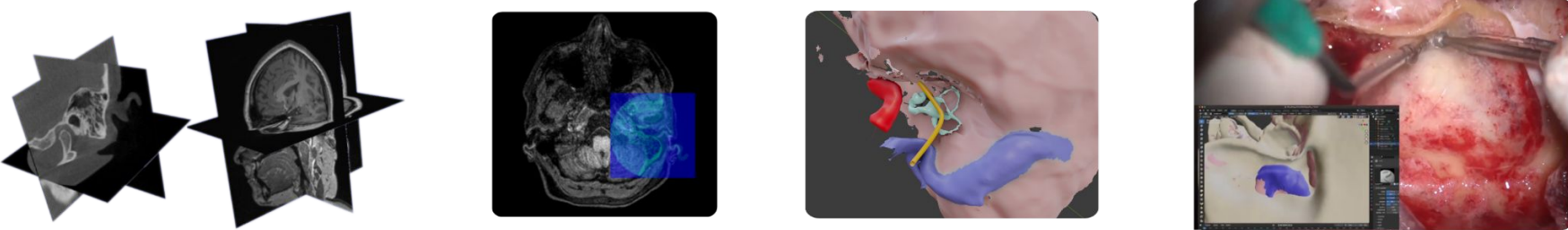
Wiet, Gregory J et al. "Otolologic Skills Training." *Otolaryngologic clinics of North America*. 2017; vol. 50,5: 933-945. doi:<https://doi.org/10.1016/j.otc.2017.05.005>

1. Main goal: to introduce a workflow for the surgical simulation of inner-ear interventions in order to solve the mentioned needs
2. Secondary objectives:
 - a. Design and conceptualization: design requirements, modularity, applications, etc.
 - b. Anatomical model acquisition from real patients
 - c. Results validation

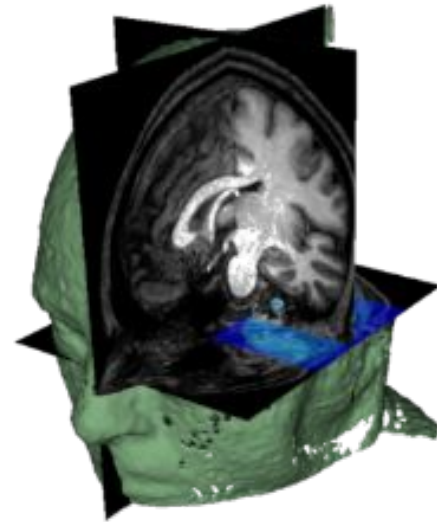
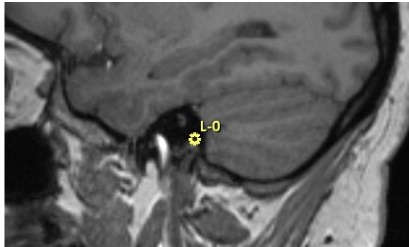
1. Input images
2. Open source software: 3D-Slicer, Blender, etc..
3. Tool and devices integration
4. Semi-Automatic processes
5. Precision and validation of the models



Results: Pipeline OTOVIRT



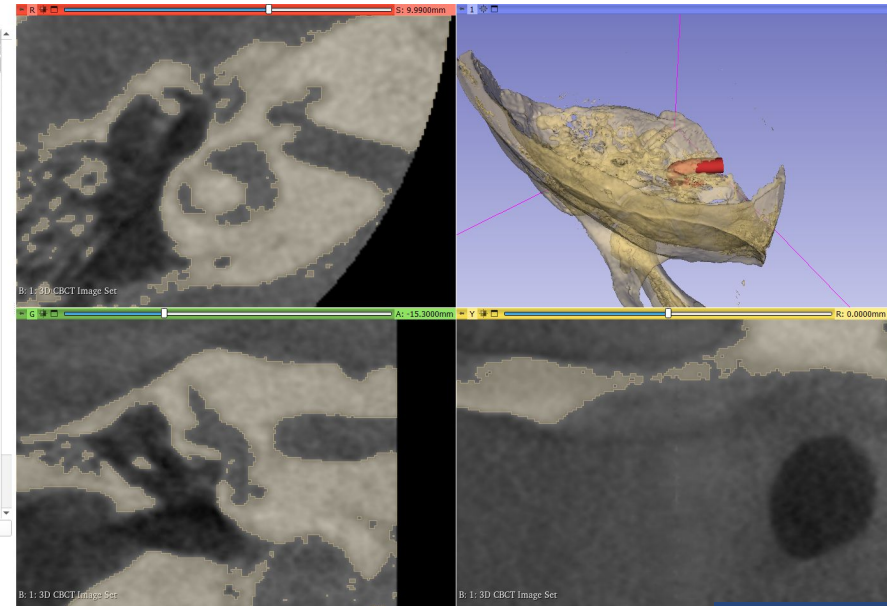
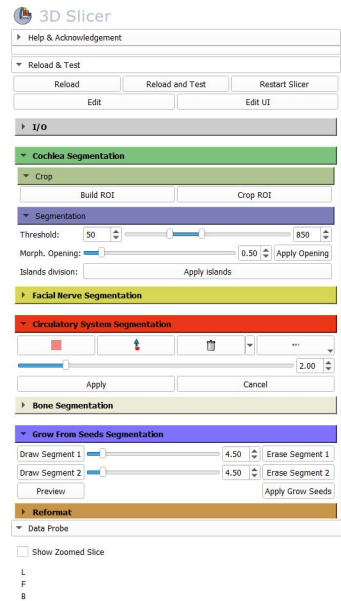
- Available images: CT and MRI
- A first step that is key: models presented in the same anatomic space of coordinates
 - Manual registration based in the localization of key reference points
 - Important anatomic points: present in CT and MRI

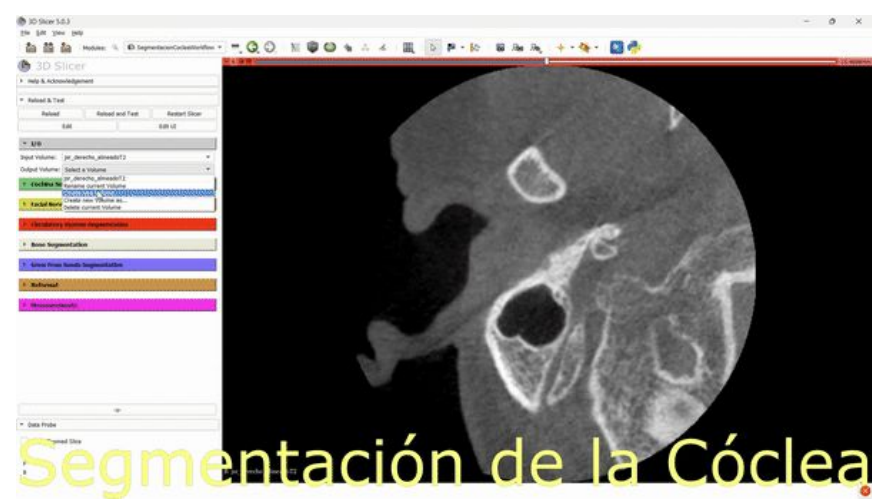


Results: 3D Slicer segmentation extension

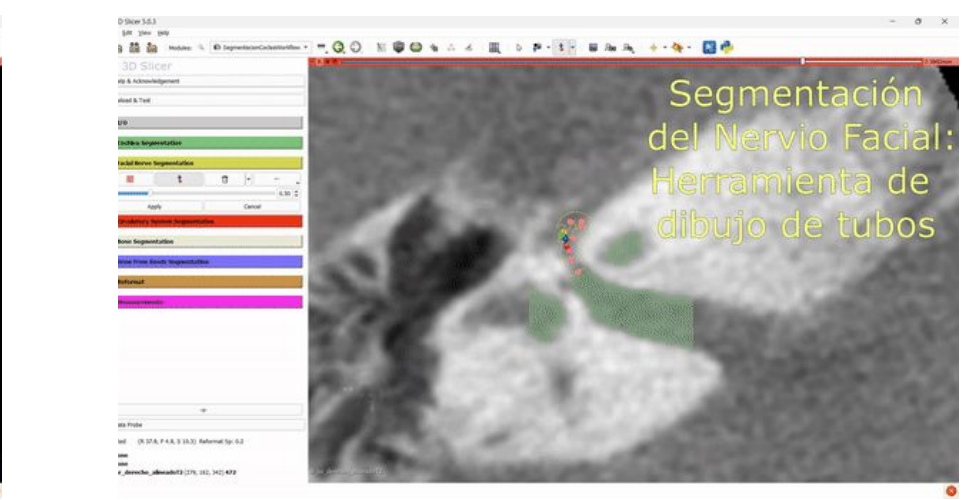
A 3D Slicer extension is developed for the segmentation of relevant structures. Includes the following sections:

- Cochlea segmentation
- Facial nerve segmentation
- Internal carotid segmentation
- Temporal bone segmentation
- Region Growing segmentation
- Transformations
- Measurements and guided sections

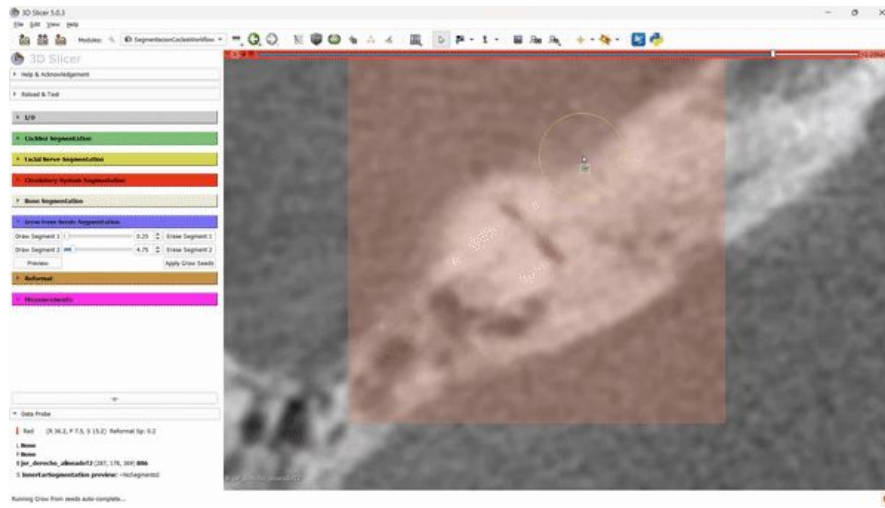




Segmentación de la Cóclea



Segmentación del Nervio Facial: Herramienta de dibujo de tubos

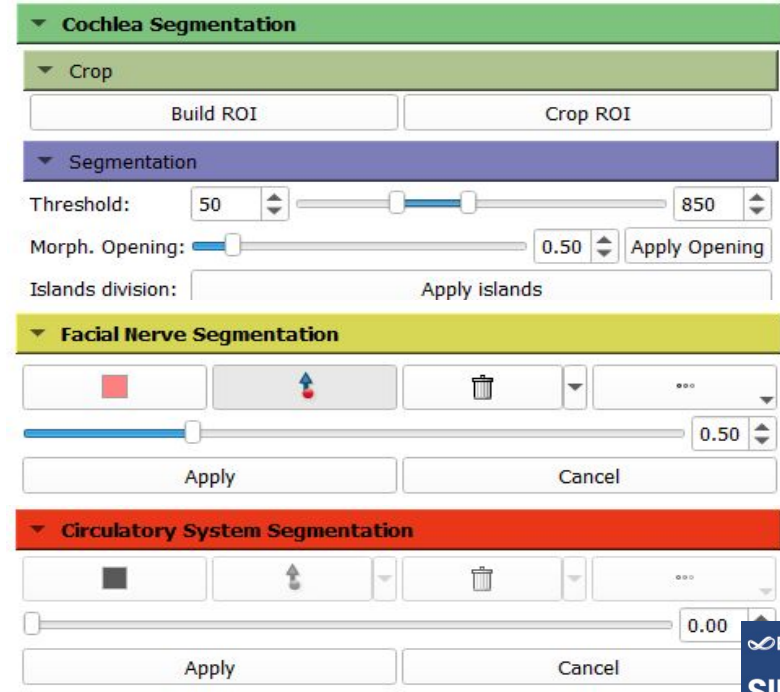


Extensión de 3D Slicer para la segmentación de las estructuras del oído interno

ORL-HUVM

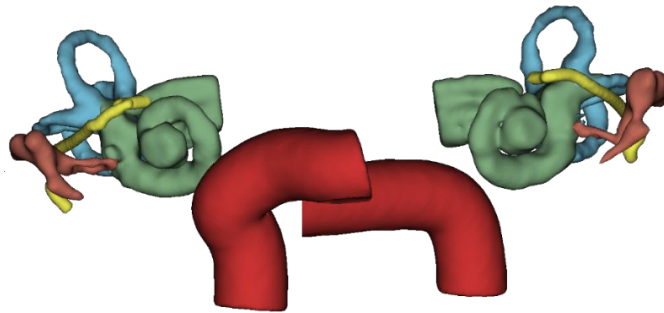
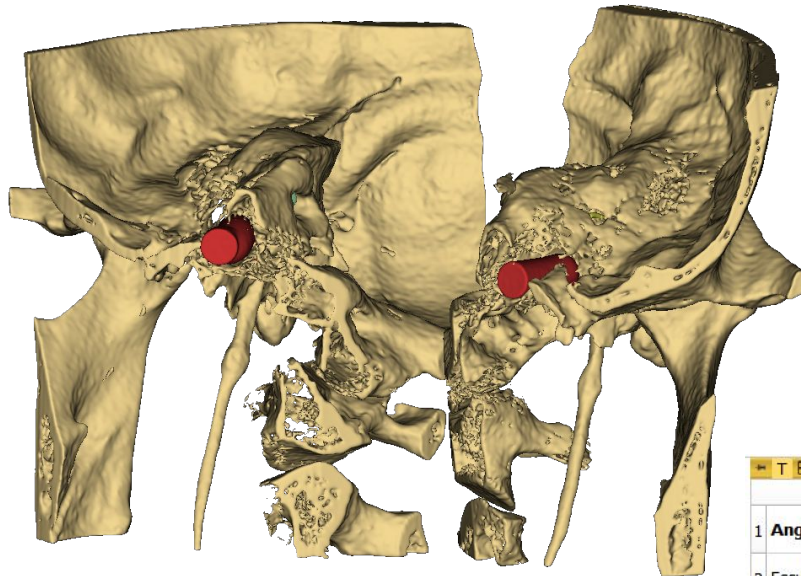
Features of some of the sections:

- Cochlea Segmentation:
 - Crop subsection:
 - Buttons to generate a ROI and capture the intersection with the CT Scan
 - Segmentation subsection:
 - Thresholding
 - Morphological opening (erode+dilate)
 - Connectivity filtering
- Facial Nerve and carotid sections:
 - Buttons to place fiducials
 - Interpolation between fiducial points to generate a tubular structure



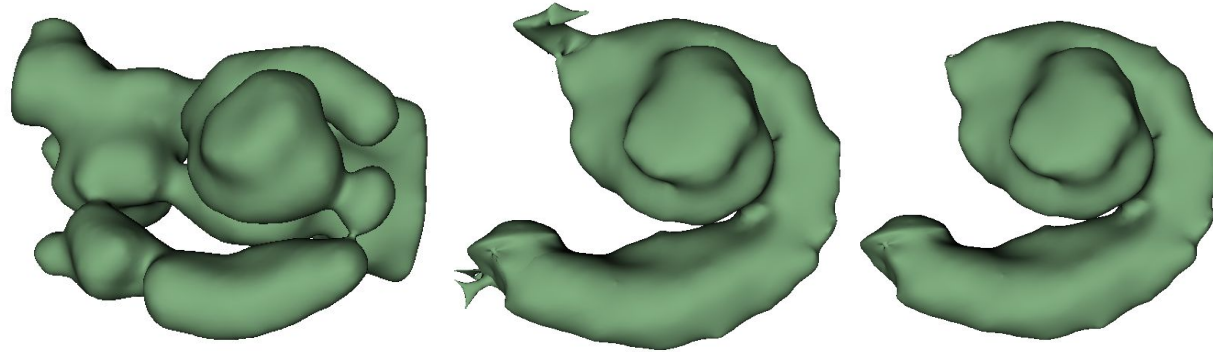
Results: 3D models generated from six patients

OTOVIRT workflow is tested in a clinical environment with images from real patients. It is possible to obtain realistic anatomical models and multiple data and measures.



	A	B	C	D	E	F
1 Angle of insertion	0	14	28	42	56	
2 Escude estimated Length	0.0	1.2650372120246722	2.4608571963071824	3.5946431381621626	4.672514987741	

- Obtained models are validated by experts
- An open repository is used to assess the functioning of the tools

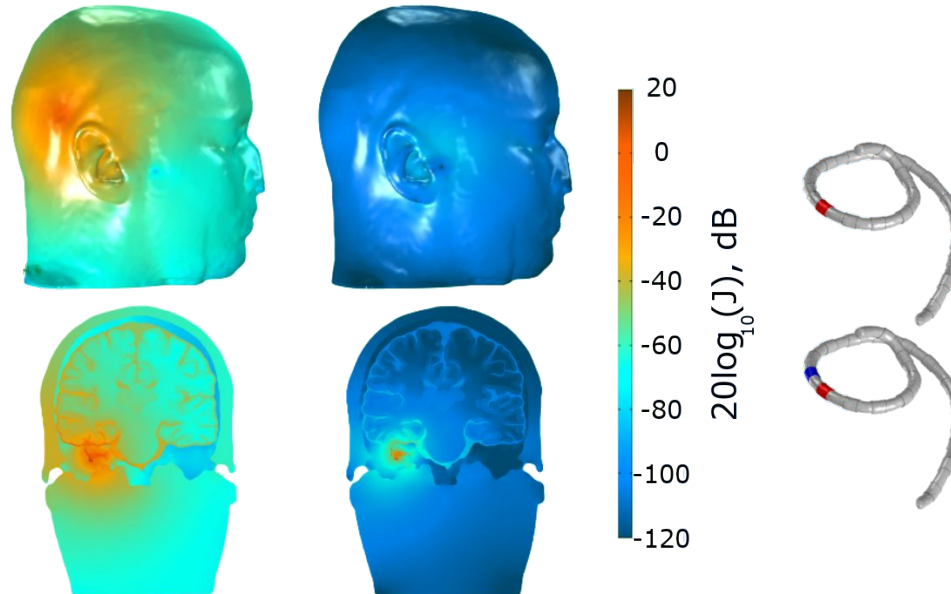


	Cochleo-Vestibular System	Facial Nerve	Cadena osicular
Subject 1	0,88	0,71	0,82
Subject 2	0,81	0,77	0,82

Sieber, D *et al.* “Data descriptor: The openEar library of 3D models of the human temporal bone based on computed tomography and micro-slicing”. *Scientific Data*. 2019;6. <https://doi.org/10.1038/sdata.2018.297>

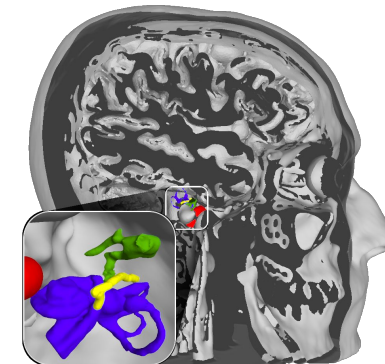
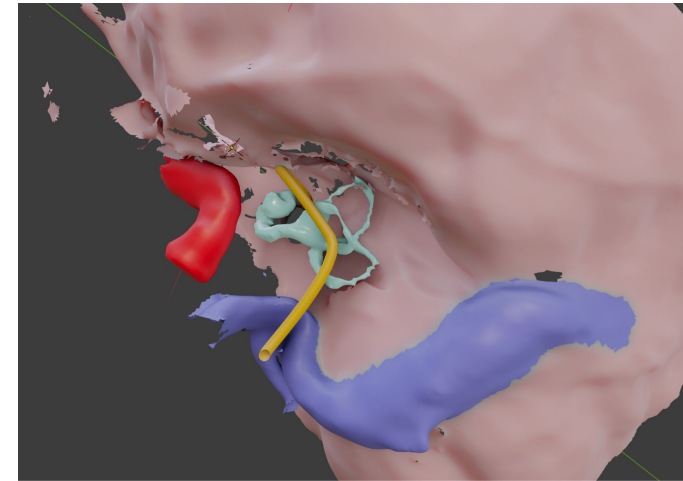
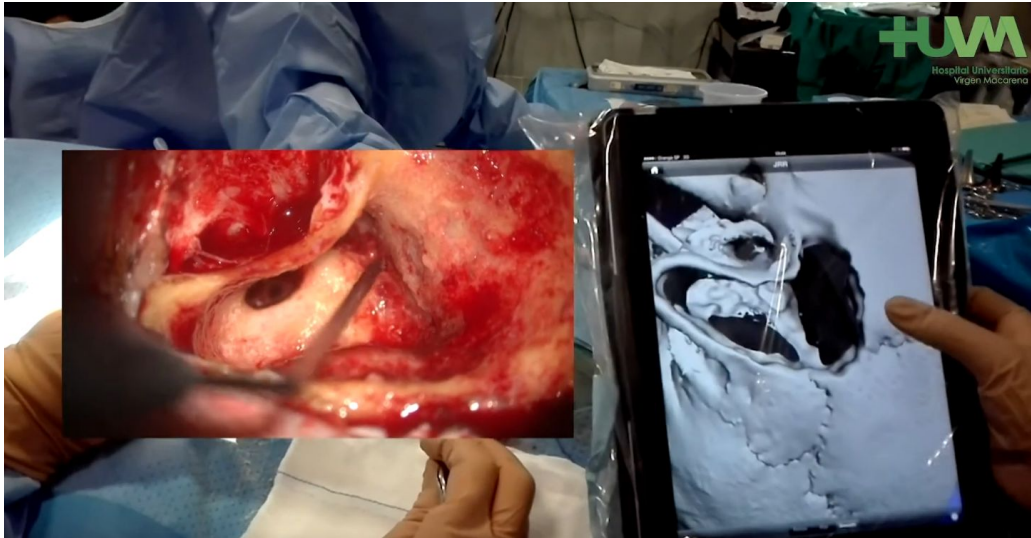
Bag S., Kumar SK., Tiwari MK., “An efficient recommendation generation using relevant Jaccard similarity”. *Information Sciences*. 2019; vol 483 pp-53-46. doi: <https://doi.org/10.1016/j.ins.2019.01.023>

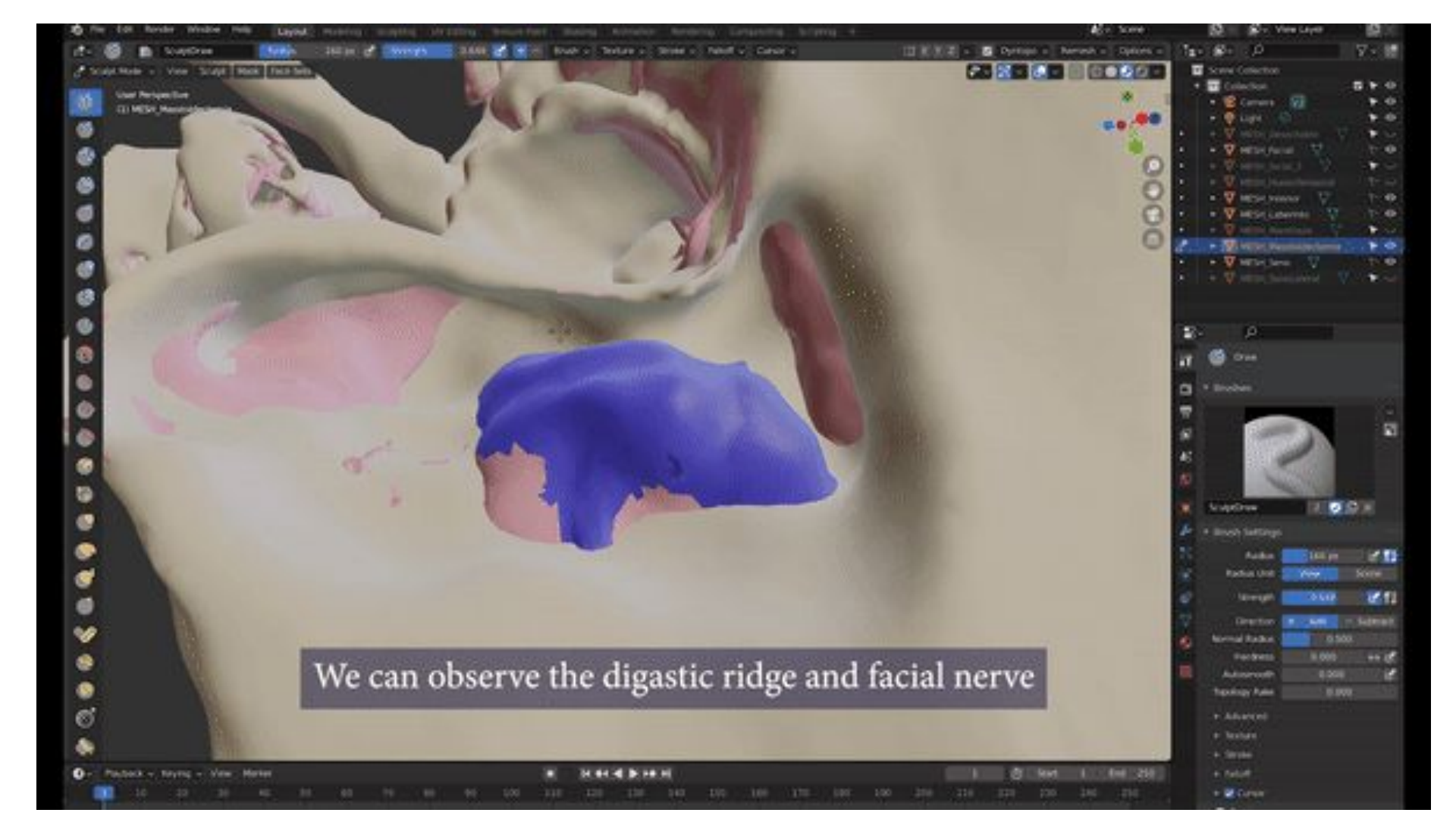
- With the obtained models it is possible to analyze the best stimulation procedure



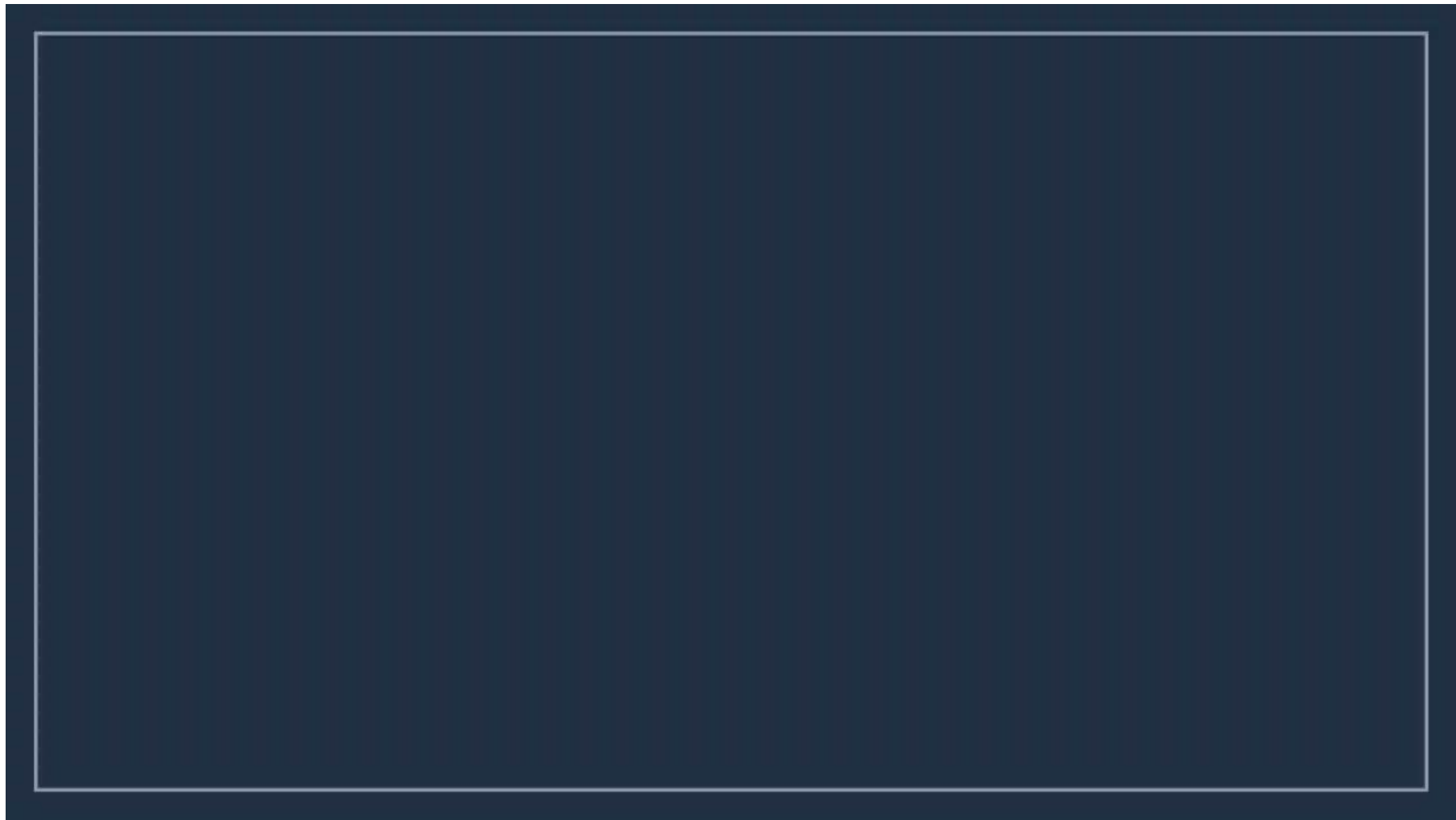
Results: *Virtual surgical simulation*

- The virtual surgical simulation is performed successfully with the use of the previously obtained models



A screenshot of the Blender 2.80.0 software interface. The central 3D viewport shows a detailed anatomical model of a human face, viewed from a slightly elevated perspective. Several anatomical features are highlighted with semi-transparent colors: a pinkish-red area on the left side of the face, a prominent blue area on the right side, and a dark red, elongated structure extending downwards from the right side of the face. The interface includes a top menu bar with options like File, Edit, Render, Window, Help, and various tool modes (Sculpt, Mesh, etc.). On the right side, there is a 'Scene' panel with a 'Scene Collection' list and a 'Brush' panel with settings for Radius, Strength, Direction, Normal Radius, Hardness, AutoSmooth, and Topology Rule. At the bottom, there is a timeline and a status bar.

We can observe the digastic ridge and facial nerve



- The pipeline provides a base workflow that will be developed in a systematic methodology for the surgical planning
- The work is based in open-source software. This eases the access for the community and allows for future improvements
- Support systems can reduce patient's risk and ease the planification, improve understanding and surgical efficiency
- Simulation of procedures proves efficient and capable. The use of these tools during training also has huge potential

Demo ext. Slicer



Demo simulation



Clinical case of use:
example



1. Improve pre-processing
2. Release of an image repository with 3D models for the community
3. Improvements in the 3D Slicer extension for its future publication
4. Development of a 3D Slicer extension for the segmentation of the cochlear implant
5. Use of AI for the image processing: segmentation and registration could be automatized

Demo ext. Slicer



Demo simulation



Clinical case of use:
example



Thank you very much!

Team contacts:

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Other resources:

- [Programa de implantes cocleares: generalidades y red de implantes cocleares](#)
- [Implantes cocleares: vía clínica.](#)
- [Flujo de pacientes](#)

Demo ext. Slicer



Demo simulation



Clinical case of use:
example

