



CI-WIZARD

Intervention Planning and Anatomical Training for Cochlear Implants

The Challenge

A cochlear implant (CI) is an electronic hearing aid, which is surgically implanted into the human inner ear (the cochlear) in order to restore the hearing capabilities. As the surgical field contains high-risk structures such as the facial nerve and the tympanic chord and is furthermore characterized by a limited intra-operative visibility, CT (Computed Tomography) scans depicting all anatomical structures are routinely made before each intervention. These scans provide detailed overview information of the middle and inner ear and are used by the surgeons to plan their access strategy to the anatomy of a specific patient.

The Solution

In order to support surgeons to plan the individual intervention based on the available CT data, the CI-Wizard has been implemented. The CI-Wizard is a novel software-tool for the interactive assessment of CT scans of the human ear. With a tight user guidance and clear instructions in the CI-Wizard, a physician can segment multiple structures of the ear in approximately 15 minutes. During the process the user is guided through the patient's anatomy and provided with a deeper understanding of the individual patient's anatomy. The orthogonal slice views of the CT datasets used for planning have been enriched by an intuitive segmentation process as well as various 3D views of the anatomical structures.

The CI-Wizard easily guides medical experts without technical background through a segmentation of different ear structures for cochlear implant planning. Segmentation is encapsulated in an easy-to-use software, resulting in an efficient workflow for cochlear implant planning.

Fraunhofer Institute for Integrated Circuits IIS

Director
Prof. Dr.-Ing. Albert Heuberger

Am Wolfsmantel 33
91058 Erlangen, Germany

Department of Image Processing
and Medical Engineering BMT
Dipl.-Inf. Christian Weigand

Contact
PD Dr. Thomas Wittenberg
Phone +49 9131 776-7330
Fax +49 9131 776-7309
thomas.wittenberg@
iis.fraunhofer.de

www.iis.fraunhofer.de/med

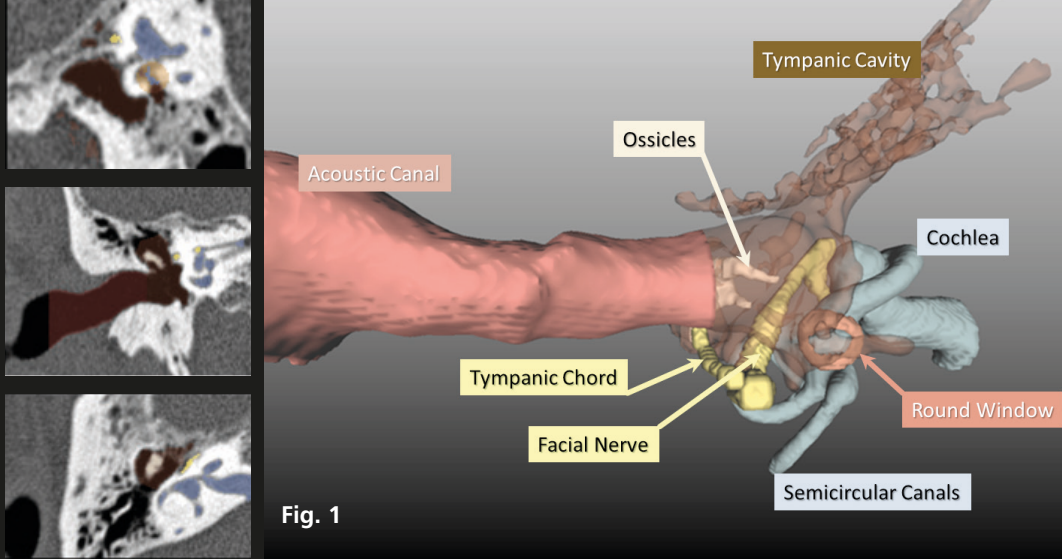


Fig. 1

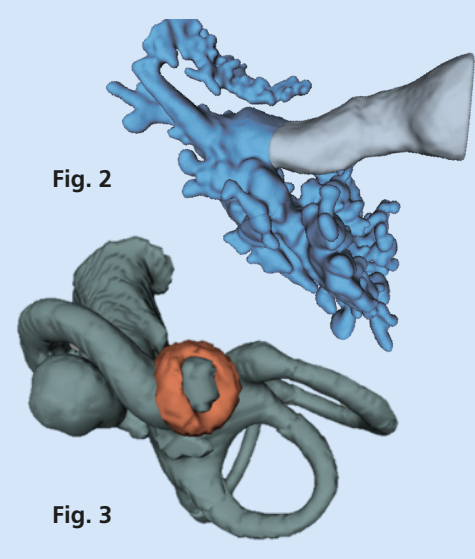


Fig. 2

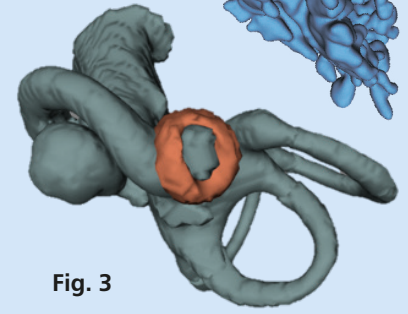


Fig. 3

The Process

The CI-Wizard encapsulates complex image processing methods in efficient segmentation corrections, formulated in medical language. Most anatomical structures in the inner and middle ear are embedded in bony tissue. Therefore, inter-patient variations in shape, relative position and volume of structures are limited. This knowledge is used in the CI-Wizard to restrict the search space for segmentation parameters and speed up the segmentation process. The CI-Wizard deals with the anatomical structures step by step and segments the following structures:

- **Acoustic Canal:** Overview Structure, also boundary to anterior. Risk structure, as the bony boundary to the acoustic canal needs to be preserved
- **Ossicles:** Incus and Malleus are segmented together as the ossicles. In most cases the stapes is not displayed in the data. Short crus of malleus directs to the facial nerve
- **Tympanic Cavity:** Overview structure
- **Facial Nerve:** Main risk structure, hurting it leads to facial paralysis

- **Tympanic chord (of facial nerve):** Risk structure, hurting it leads to loss of taste. Together with the facial nerve, forms the chorda facial angle, which restricts access and insertion angle of the cochlear implant
- **Round window:** Target structure, through a small incision the CI is inserted into the cochlea. From the tympanic cavity the tympanic sinus leads to the round window, it is surrounded by bony tissue that is removed during surgery.
- **Cochlea:** Target structure which determines the insertion angle of the CI (angle of first coil of the cochlea)
- **Semicircular canals:** Overview structures that enhance orientation due to their distinctive shape

The Benefits

- CI-Wizard standardizes intervention planning for cochlear implantations
- CI-Wizard prepares surgeons for the patient specific anatomy and patient specific risks, in order to reduce time in the operation room and to reduce risks during CI intervention.
- CI-Wizard trains medical personnel on ear anatomy in CT images.

Fig. 1: Last page of the CI-Wizard, a complete view of the patient specific anatomy, the interventions aim and risk structures.

Fig. 2: 3D-Model of the acoustic canal and the tympanic cavity

Fig. 3: 3D-Model of the cochlea and the bony area around the round window

Literature

Franz D, Hofer M, Pfeifle M, Pirlich M, Stamminger M, Wittenberg T. A Wizard-based Segmentation Approach for Cochlear Implant Planning. In: Deserno TM, Handels H, Meinzer HP, Tolxdorff T, editors. Proc BVM. Berlin: Springer Verlag; 2014. p. 258–263.

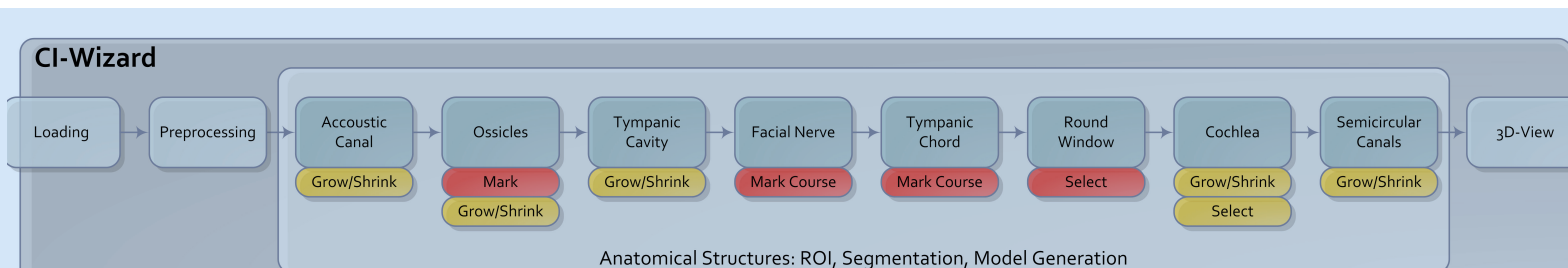


Fig. 4: Workflow in the CI-Wizard