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Multi-modal image registration of CT and Optical Coherence Tomography (OCT) images

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Overview

- Introduction to OCT and comparison to other imaging technologies

- Research project at the IMES (Leibniz University of Hannover)

- Multi-modal image registration

Optical Coherence Tomography (OCT)

Features of OCT

- Interferometric measurement principle

- Non invasive, non contact 3D imaging

- Resolution: 2-15 μm

- Imaging depth depends on light penetration depth in tissue (~ 1 mm – 3 mm)

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Overview of imaging procedures
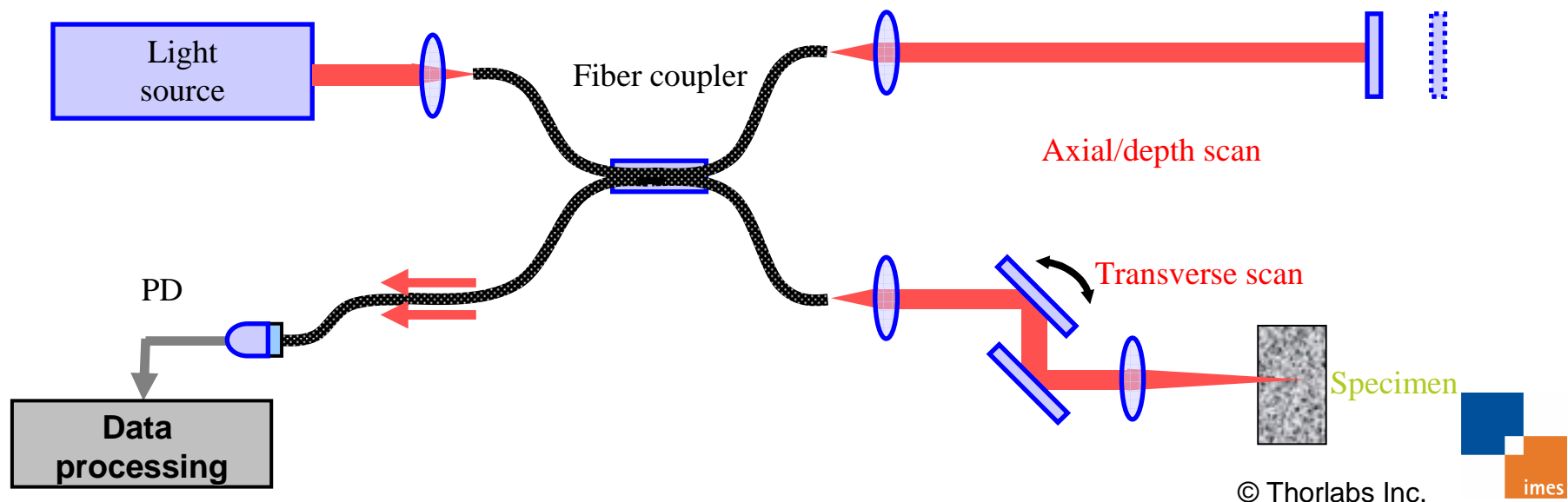
Overview of imaging technologies

Imaging Technology	Typical resolution (µm)	Imaging Depth (mm)	System Cost	Speed	Features
Microscopy	1	0.3	Low	Video rate	Non-Invasive
OCT	2-15	1.5	Low	Video rate	Non-Invasive
Ultrasound	150	150	Low	Video rate	Contact
MRI	500	-	High	50ms	Non-Invasive
CT	500	-	High	50ms	Non-Invasive, Radiation

→ Approach: Combination of two different imaging technologies

Cochlea Implant (CI)

- Insertion of an electrode array into the cochlea for electrical stimulation of the auditory nerve

- State-of-the art: Exposition of functional important structures ensuring their safety by resecting big parts of the lateral skull. Opening of the cochlea by drilling a hole with a diameter of 0.5-1.0mm

Research project at the imes
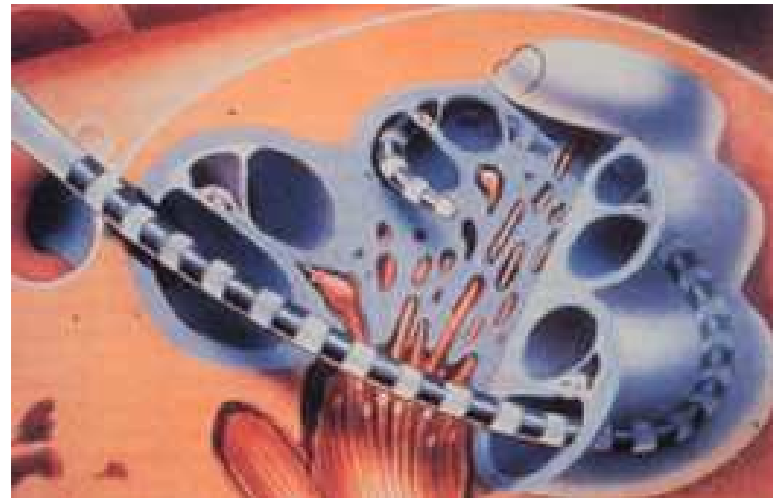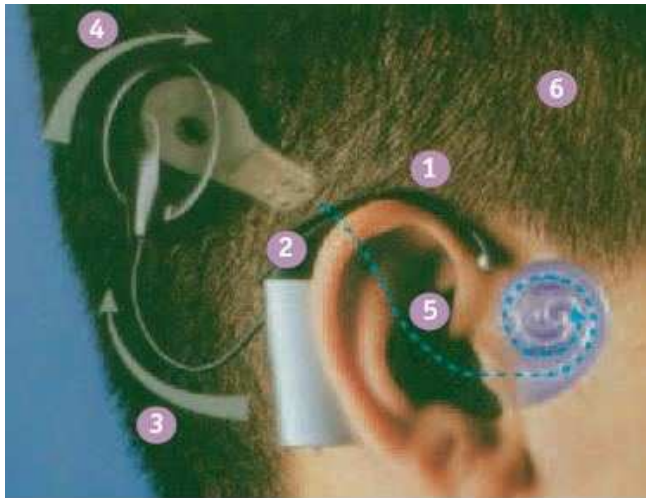
Minimal Invasive Cochlea Implant

- High-accurate preoperative positioning of the drilling device for a **direct access** to the cochlea
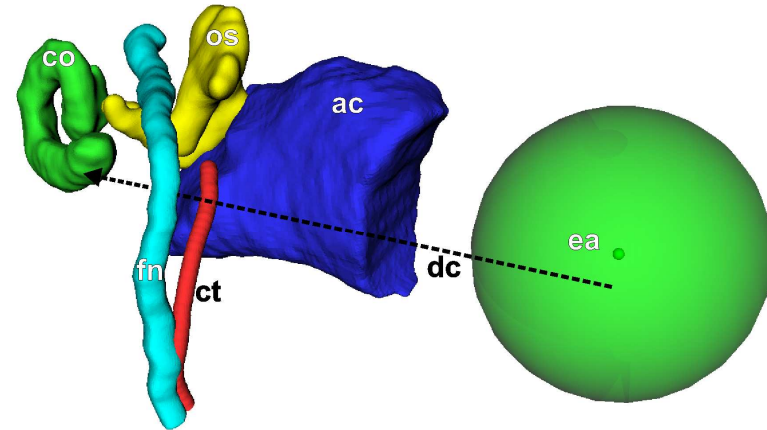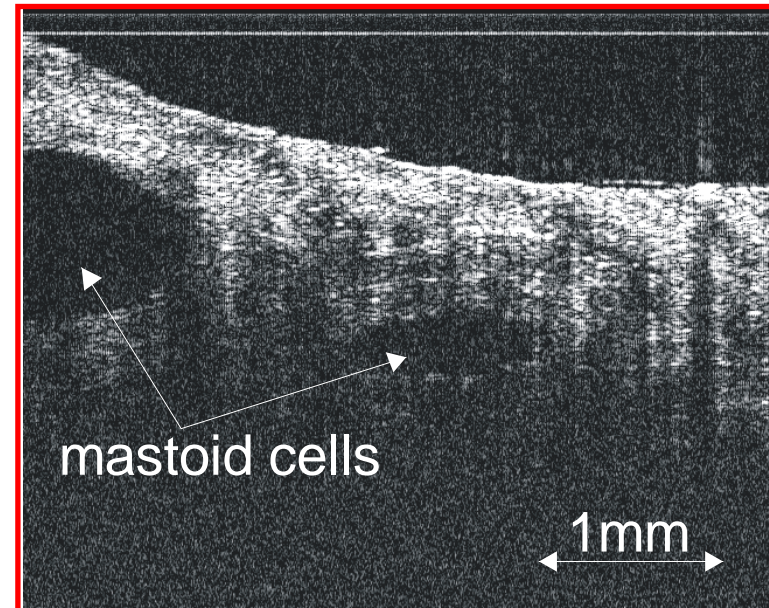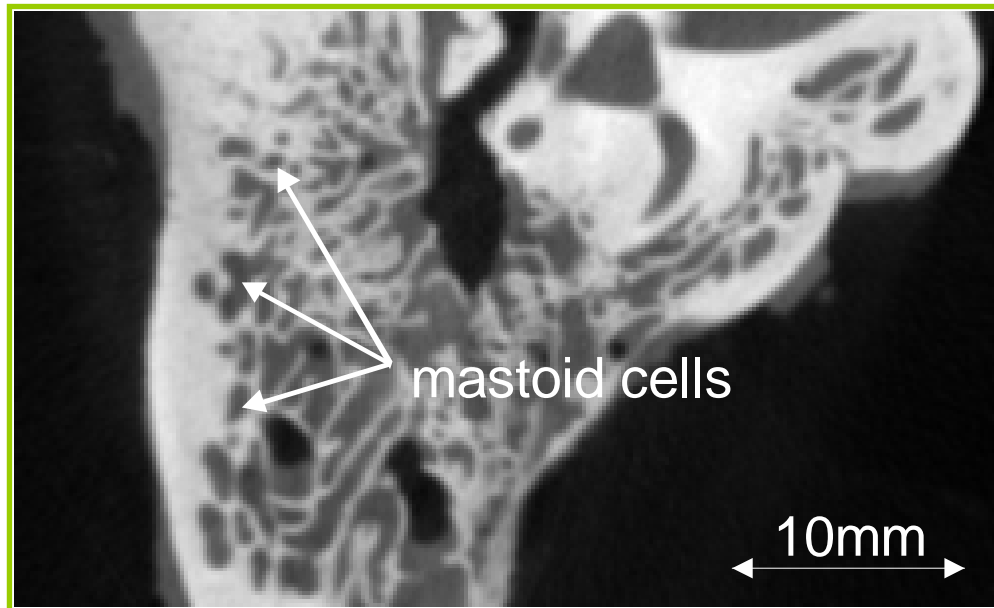

Our approach for navigation

- Surgical navigation based on landmarks, different imaging technologies and robotics

- Two scale approach using CT and OCT images

  → Registration of CT and OCT images

Comparison of CT and OCT images

Images from a temporal bone specimen…

mastoid cells

10mm

mastoid cells

1mm

- Flat panel volumetric computerized tomography (used for surgical planning)

- Resolution: 0.148mm (isotropic)

- Optical coherence tomography (used for intra-operative guidance)

- Resolution: $8.3 \times 6.3 \times 5\ \mu m^3$

Registration of CT and OCT images

- Stereo optical localizer for an initial pose estimation of the OCT scan volume within the CT data

- Image registration of OCT and CT in order to calculate a corrective transformation T

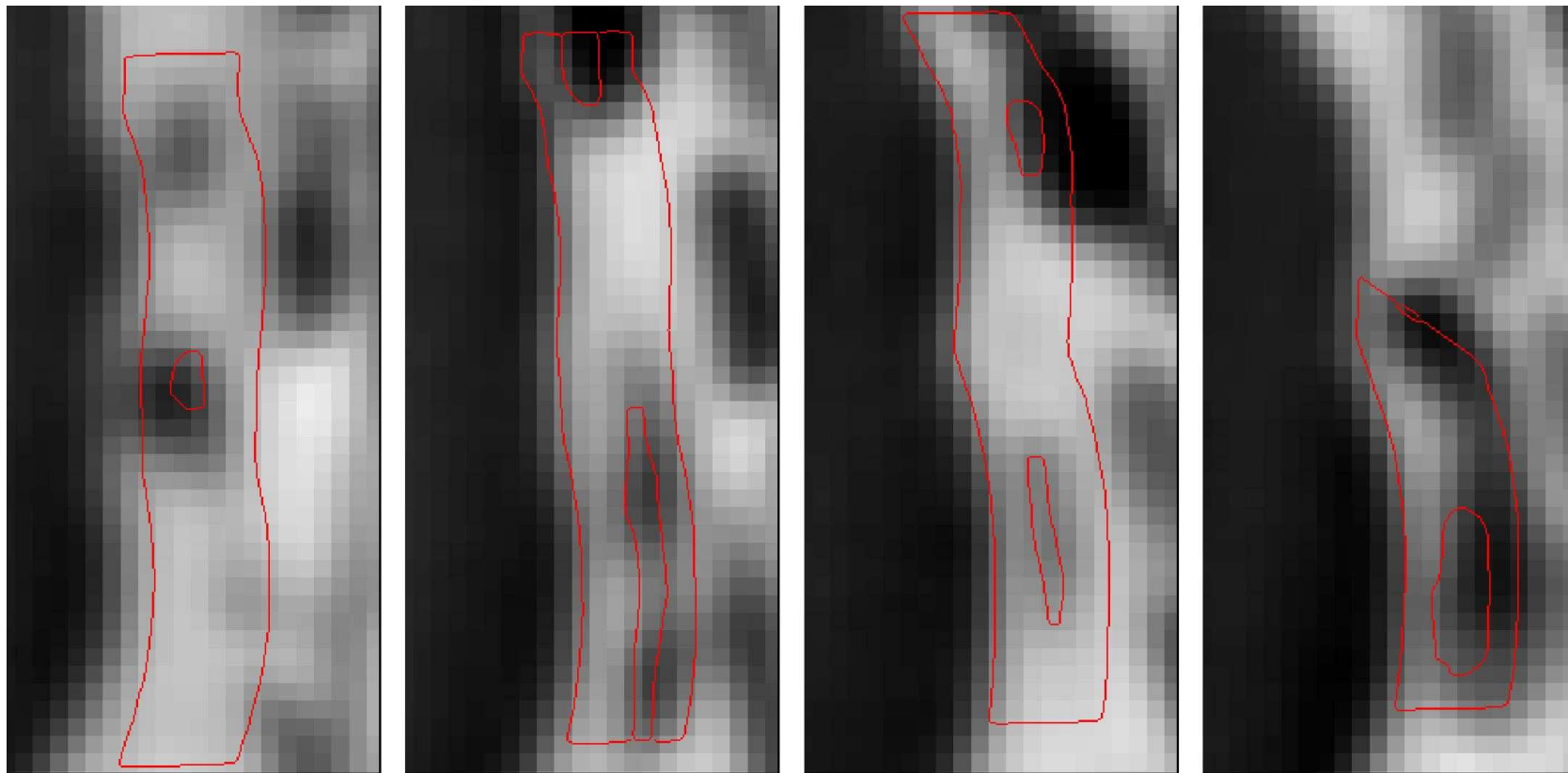- Apply T to the robot's endeffector guiding the surgical instrument

Results
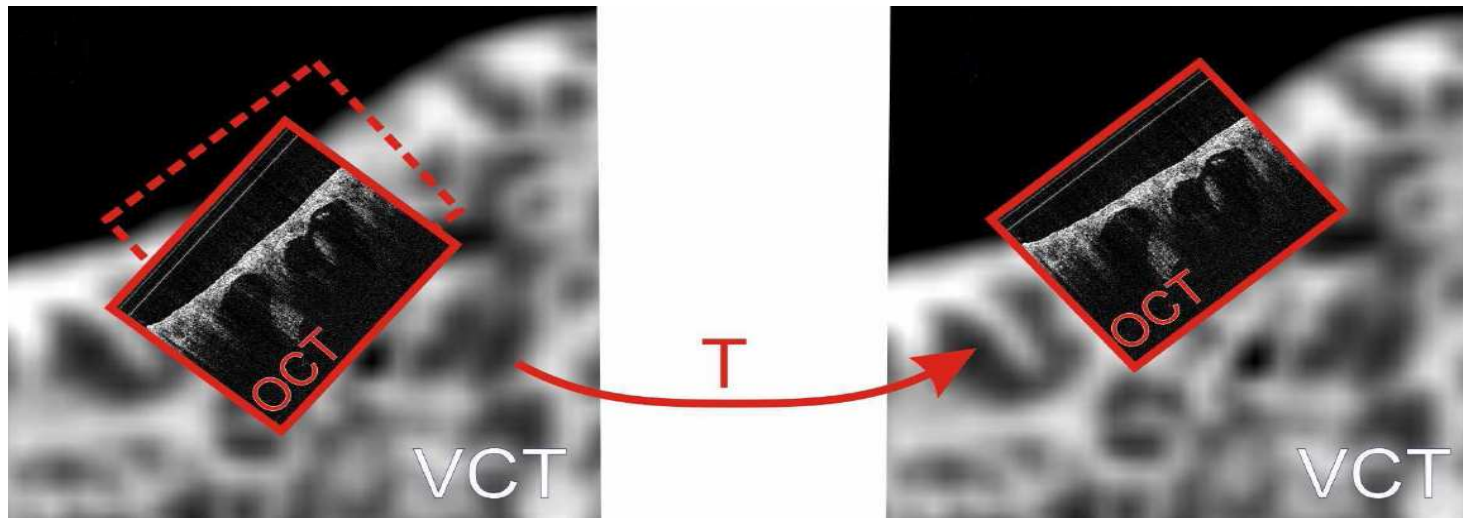
Before image registration

- Edges of the segmented OCT data (red) plotted into the correspondent VCT image; 4 exemplary slides

Results
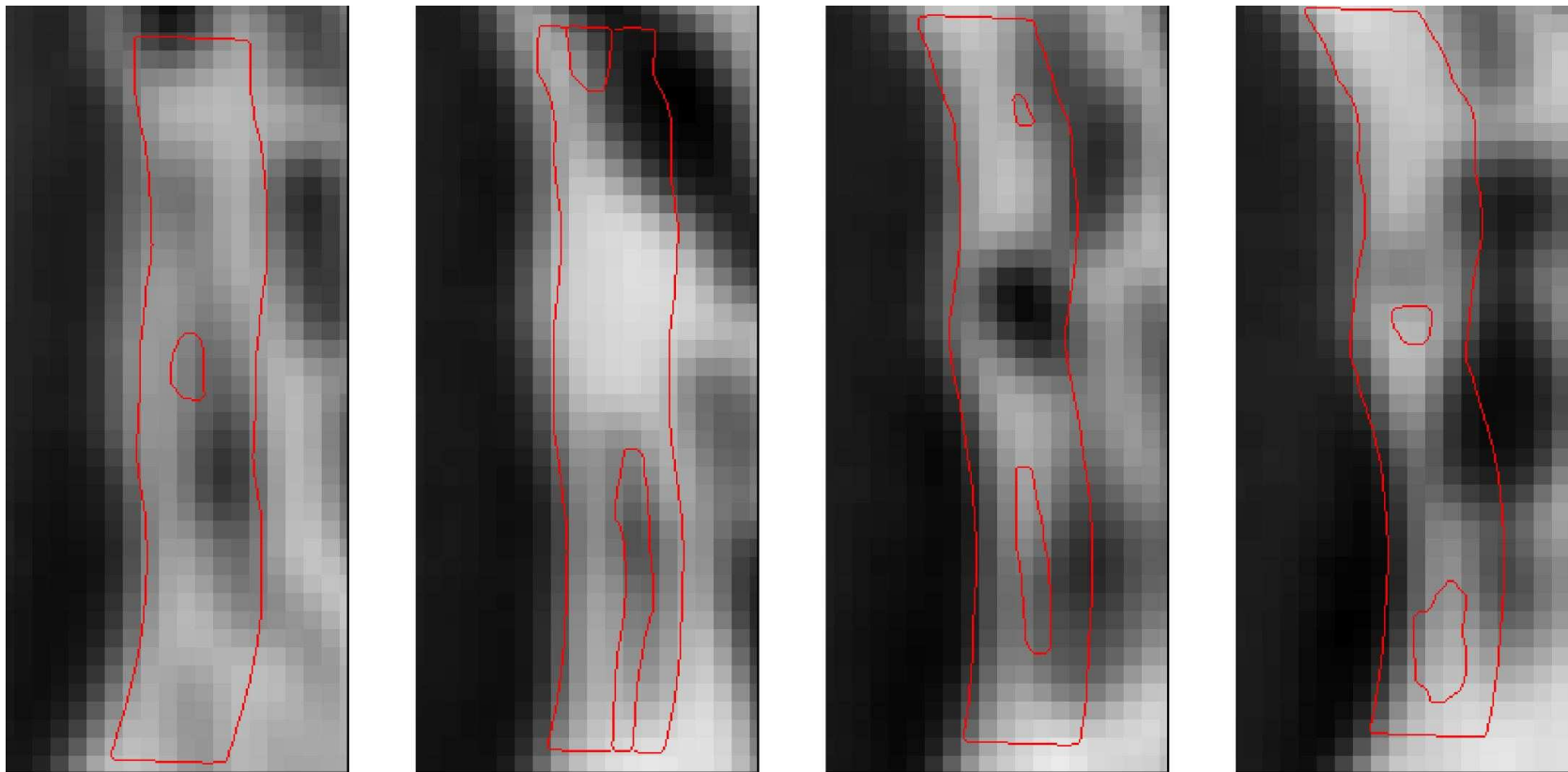
After image registration

- Edges of the segmented OCT data (red) plotted into the correspondent VCT image; 4 exemplary slides

Outlook

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- Improvement of the registration methods due to model-based approaches

- Robustness of registration due to changes in measurement and optimization methods

- Determination of the registration accuracy using highly accurate calibration objects

Gottfried Wilhelm Leibniz Universität Hannover

Thank you for your attention!