3DInMed

New 3D imaging tools for digital surgical microscopy

The significance of digital 3D systems for medical applications, such as surgical microscopy or endoscopy has considerably increased over the last few years. Stereoscopic systems offer entirely new possibilities to extract and to visualize additional information, resulting in significantly enhanced conditions for diagnostics and surgical interventions. Furthermore, digital stereoscopy improves the clinical workflow by reducing duration of the surgical procedure and risks of tissue injuries. Beyond intraoperative benefits, it also provides improved learning curves. For this purpose, Fraunhofer HHI and ARRI Medical have developed real-time capable image-based algorithms facilitating intraoperative decisions during ossiculoplasty and tympanoplasty for ENT surgery.

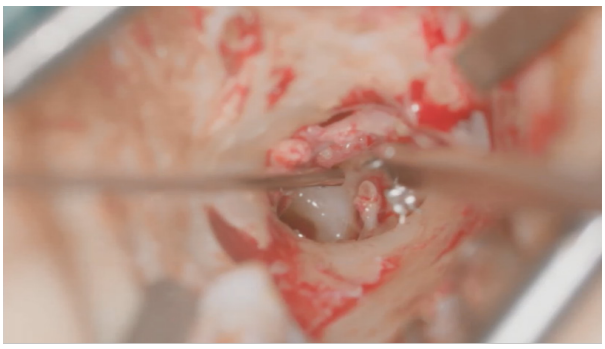
Challenges

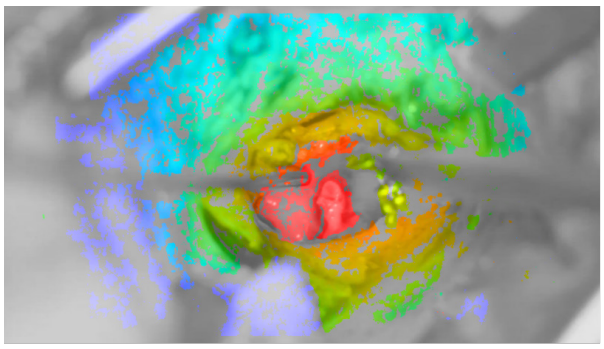
- Real-time capable estimation of enhanced information
  - Distance measurements
  - Contour measurements
  - Instrument tracking
- Precise calibration of system optics (e.g. zoom lens)
- Latency-free high-data rate transmission:
  2x Full-HD with 60fps
- Correct color representation of tissues
- Guarantee highest stereo image quality by avoiding symptoms of visual fatigue
  - Objective stereo characteristics (e.g. geometric alignment of stereo images)
  - Subjective stereo characteristics (e.g. stereoscopic comfort zone, vignetting)
- Retain established workflows

Benefits

- Comfortable tools for image-based distance and contour measurements
- Static 3D measurements and dynamic 3D gauging
- Cost reduction due to increased efficiency (e.g. by reduction of mistaken length of middle ear prosthesis)
- Additional and enhanced AR information to facilitate intraoperative decisions
- Heads-up surgery offering brilliant, high-contrast and crisp images
- Shorter durations of surgical interventions due to uninterrupted workflow
- Seamless integration in established workflows

Digital surgical microscope using a digital binocular and a stereoscopic display for 3D visualization – ARRISCOPE by ARRI Medical





(a) Implant of a stapes prosthesis

(b) Real-time AR overlay of depth information

Technical background

Digital stereoscopic systems introduce a wide variety of new possibilities in medical engineering. However, such systems also require a properly configured setup. Therefore, a streamlined design is mandatory to match the stereoscopic recording unit and stereoscopic display. Real-time detected robust feature point correspondences allow a latency-free correction of geometric misalignments. The algorithm ensures compliance with the so-called stereoscopic comfort zone for video playback. A real-time advanced histogram analysis guarantees colorimetric consistencies.

Calibrated stereoscopic imaging systems allow to perform image-based measurements, to survey risk structures or to specify tumor dimensions with highest metric accuracy. Within ENT surgery, there are two use cases for digital surgical microscopy: First, the proposed method offers intraoperative support to select the correct size of middle ear prosthesis during a partial or total ossiculoplasty procedure (PORP/TORP) or for the selection of the correct stapes prosthesis. Second, it facilitates the cutting process of cartilage to replace the damaged eardrum during tympanoplasty. In this context, surgical instruments are used as tactile measuring devices by using innovative and advanced tracking algorithms. The method for image-based measurement uses a new GPU-based concept for disparity estimation and to calculate depth information. The idea of instrument tracking uses a hybrid approach of color- and depth-based image segmentation. Beyond digital surgical microscopy, stereoscopic endoscopes can use the same technology for surgical decision support or for industrial applications like contactless visual inspection and maintenance processes of inaccessible tubular parts or cavities.

Project background

The described procedures are developed by members of the „3IT – Innovation Center for Immersive Imaging Technologies“ in the project “3DInMed”. The project partners are ARRI Medical, C.R.S. iiMotion GmbH, Fraunhofer HHI, Fraunhofer IIS, SCHÖLLY FIBEROPTIC GmbH, SeeFront GmbH and Solectrix GmbH. The project is funded by the German Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag.

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