Optical Navigation in Craniomaxillofacial (CMF) surgery using MITK

Laura Sanz Díaz(lsanz@hggm.es)
E. Marinetto, V. García, M. Desco, J. Pascau
Medical Imaging Lab (Hospital Gregorio Marañón-UC3M)

Director: Manuel Desco

Research lines:

- **Development of medical imaging tools:**
  - Preclinical equipment.
  - Reconstruction algorithms.
  - Post-processing software.

- **Technical support to clinical research:**
  - Radiotherapy.
  - Neuroimaging.
  - Cardio-imaging.

- **Preclinical molecular imaging:**
  - Nuclear.
  - MRI.
  - Optics.
  - Radiopharmacy.
Image-Guided Surgery projects: PI Javier Pascau

Patented technology:
- Dosimetry planning (Radiance)
- First Intraoperative External Radiotherapy (IOERT) operating room with navigation.

US Navigation (Breast cancer)

Surface-scanning (IOERT)

EM Navigation (Fetal monitoring)
Image-Guided Maxillofacial Surgery: background

- Maxillofacial Surgery:
  - Target: facial injuries, facial disproportion, impacted teeth, tumors, etc.
  - Our clinical partners have presented us two types of surgical scenarios:
    - Orthognathic surgery.
    - Cancer surgery.
Orthognathic Surgery

It is performed to correct a wide range of skeletal and dental irregularities, including the misalignment of jaws and teeth.

Steps:

- Cutting the maxillofacial bones (osteotomy);
- Moving the maxillofacial bones to place them in the optimal position.
- Fixation of the bones (osteosynthesis).

Current situation

Validation of bone positioning performed manually.

Motivation

Tracking of surgical landmarks

Motivation

Current situation

Validation of bone positioning performed manually.
Maxillofacial Cancer Surgery

- Tumor resection: 2 cm margin.

Motivation → Preservation of surgical margin around tumor using navigation.

- Reconstruction of the area: use of tissue from the patient's fibula or scapula.

Current situation

Manual selection of fibula’s tissue segments based on anatomical references.

Motivation

Fibula’s tissue harvesting and area reconstruction using navigation.
Objective of the project

Developing a MITK software prototype for Maxillofacial Surgery procedures guided by an Optical Navigation System.

Use scenarios:
- Orthognathic surgery:
  - Tracking of surgical landmarks.
- Cancer surgery:
  - Surgical margin of 2 cm (cancer surgery).
  - Fibula’s tissue harvesting and area reconstruction.

Navigation error: < 2 mm.

Advantages with respect to current limitations:
- Tailored to the particularity of maxillofacial procedures.
- Real-time surgical margin.
- Preoperative planning.
Materials and methods

- Optitrack cameras:
  - Higher FOV.
  - Allows changing number and location of cameras: easy to adapt to any specific surgery procedure.
  - Price

- Trackables, tools or “Rigid bodies”:

- Cranium with radiopaque markers:

CT Scan
MITK Application
Preloading of tracking device configuration and navigation tool data.

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MITK Application

Optitrack:

- The IGT Optitrack support was implemented by Eugenio Marinetto.

Settings

Tracking

Point-Based Registration

Trajectory and distance control

Logging

Tracking Device Configuration

Choose tracking device: Optitrack

Optitrack
- Calibration File: calibration.cal
- Set Calibration File
- Camera's settings:
  - Exposition: 13 [1]
  - Threshold: 200 [2]
  - LED Power: 15 [2]

Tracking Tools

Loaded Tools: <none>
- RigidPoint $[224.38; 42.17; -76.97]$
- RigidBody $[283.02; 129.62; -74.42]$

Tracking Control

Status: tracking

Add Single Tool
Reset
Connect
Start Tracking
Stop Tracking
Disconnect
MITK Application

- Permanent alignment of a surgical piece (i.e. jaw) with a tracking tool.

Settings

Tracking

Point-Based Registration

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MITK Application

- Tool’s trajectory.
- Tool distance to surface of interest.
- Use of 3D models with different mesh qualities.
- Point-to-point distance.
MITK Application

- Storage of the trajectory of a selected tracking navigation tool.
- Storage of distance information.
- Reporting and review of the procedure.
Future work

• Experimental setup for validating the error.

• Orthognathic surgery: tests with cranium phantom and brackets.

• Cancer surgery: tests with a cranium phantom including a tumor analog.

• Animal studies at HGGM.

• Integration and assessment of other navigation systems:

  April 2011
  “Accuracy assessment for navigated maxillofacial surgery using an electromagnetic tracking device”.  
  Robin Seeberger, , Gavin Kane, Juergen Hoffmann, Georg Eggers. Department of Oral and Maxillofacial Surgery, University Hospital Heidelberg, Germany.

  February 2013
  “One-year assessment of surgical outcomes in Class III patients using cone beam computed tomography”.  

  September 2014
  Kitware announces Development of Real-Time Image Guidance to improve Orthognathic Surgery.  
  “Kitware is collaborating with Dr. Tung Nguyen, Director of the Dentofacial Deformities Clinic, and Dr. Beatriz Paniagua, Research Assistant professor at the University of North Carolina School of Dentistry”.

• Usability / workflow.
Conclusions and feedback

Easy to customize.

Easy to integrate new functionalities based on VTK/ITK.

Maxillofacial surgery: high number of pieces-> high number of tools or trackables:

• Reference tool.
• Load settings with whole project.
• Save complete configuration.

Interface with OpenIGTLink.
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