



# Optical Navigation in Craniomaxillofacial (CMF) surgery using MITK

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Laura Sanz Díaz(l sanz@hggm.es)

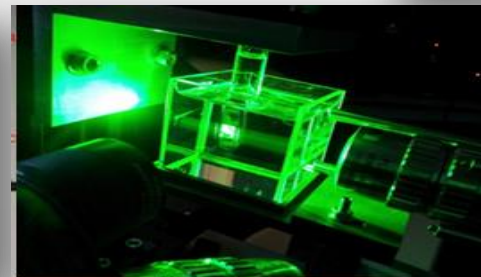
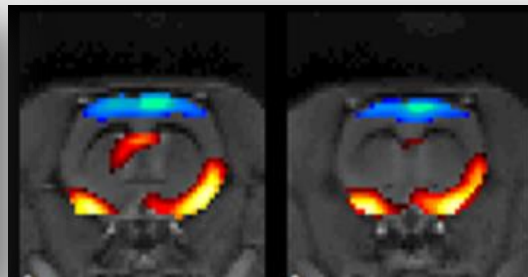
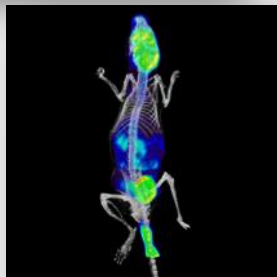
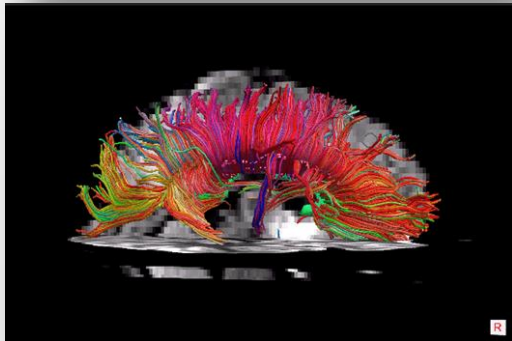
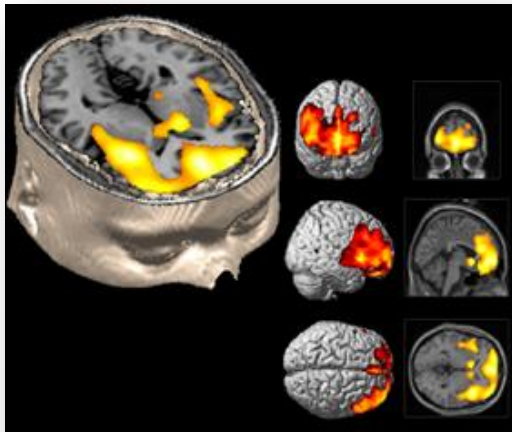
E. Marinetto, V. García, M. Desco, J. Pascau

# Medical Imaging Lab (Hospital Gregorio Marañón-UC3M)

Director: *Manuel Desco*

Research lines:

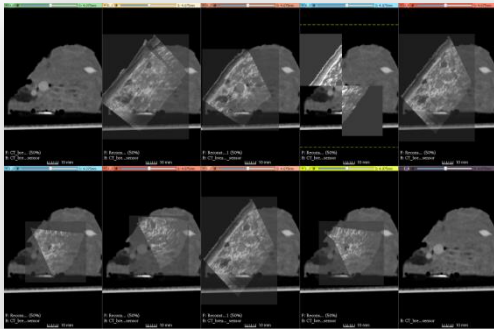
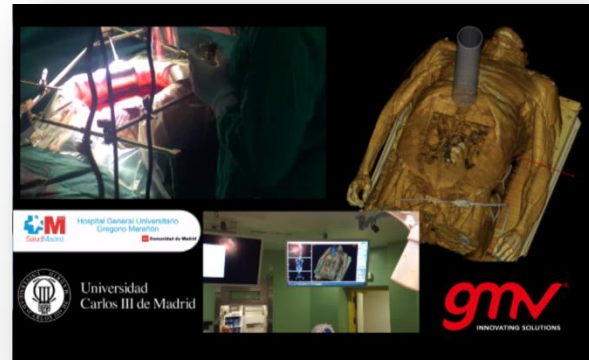
- **Development of medical imaging tools:**
  - Preclinical equipment.
  - Reconstruction algorithms.
  - Post-processing software.
- **Technical support to clinical research:**
  - Radiotherapy.
  - Neuroimaging.
  - Cardio-imaging.
- **Preclinical molecular imaging:**
  - Nuclear.
  - MRI.
  - Optics.
  - Radiopharmacy.



# Image-Guided Surgery projects: PI Javier Pascau

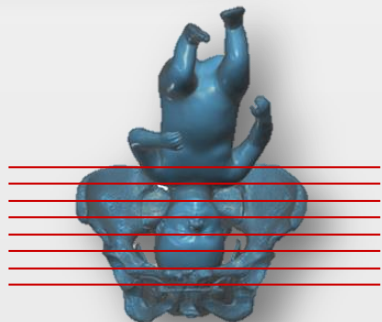
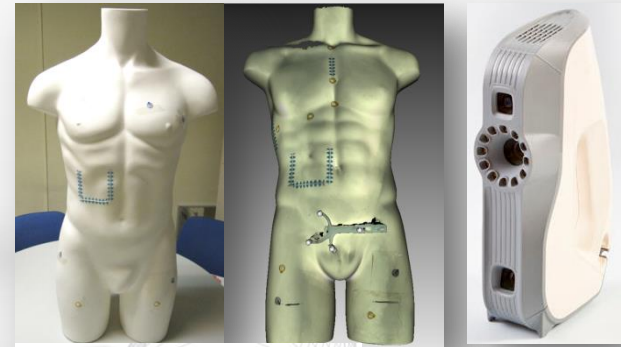
Patented technology:

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

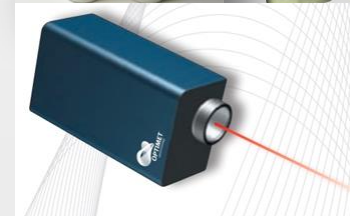


US Navigation  
(Breast cancer)

Surface-scanning  
(IOERT)



EM Navigation  
(Fetal monitoring)



# Image-Guided Maxillofacial Surgery: background

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- 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

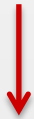
It is performed to correct a wide range of skeletal and dental irregularities, including the misalignment of jaws and teeth.



## 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

# Maxillofacial Cancer Surgery

- Tumor resection : 2 cm margin.



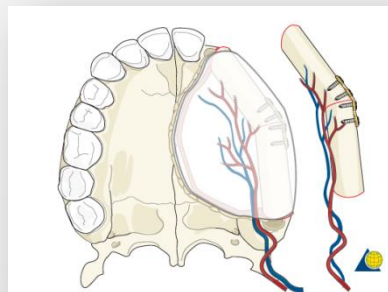
**Motivation** → Preservation of surgical margin around tumor using navigation.

- 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

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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

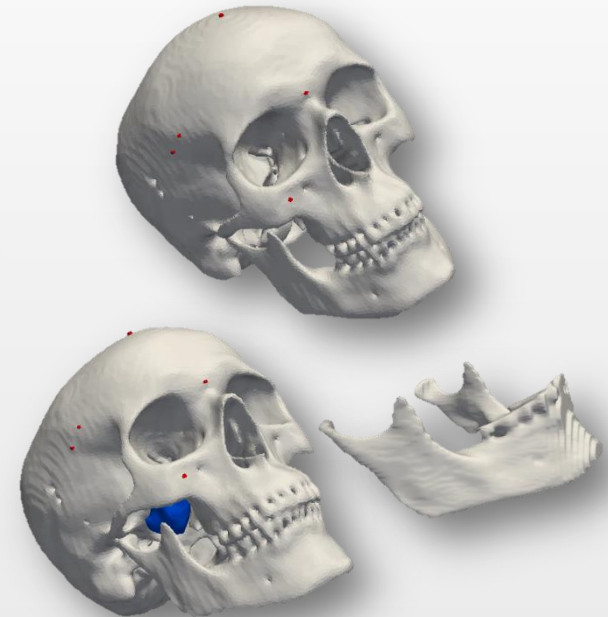
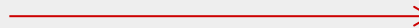
- Trackables, tools or “Rigid bodies”:



- Cranium with radiopaque markers:

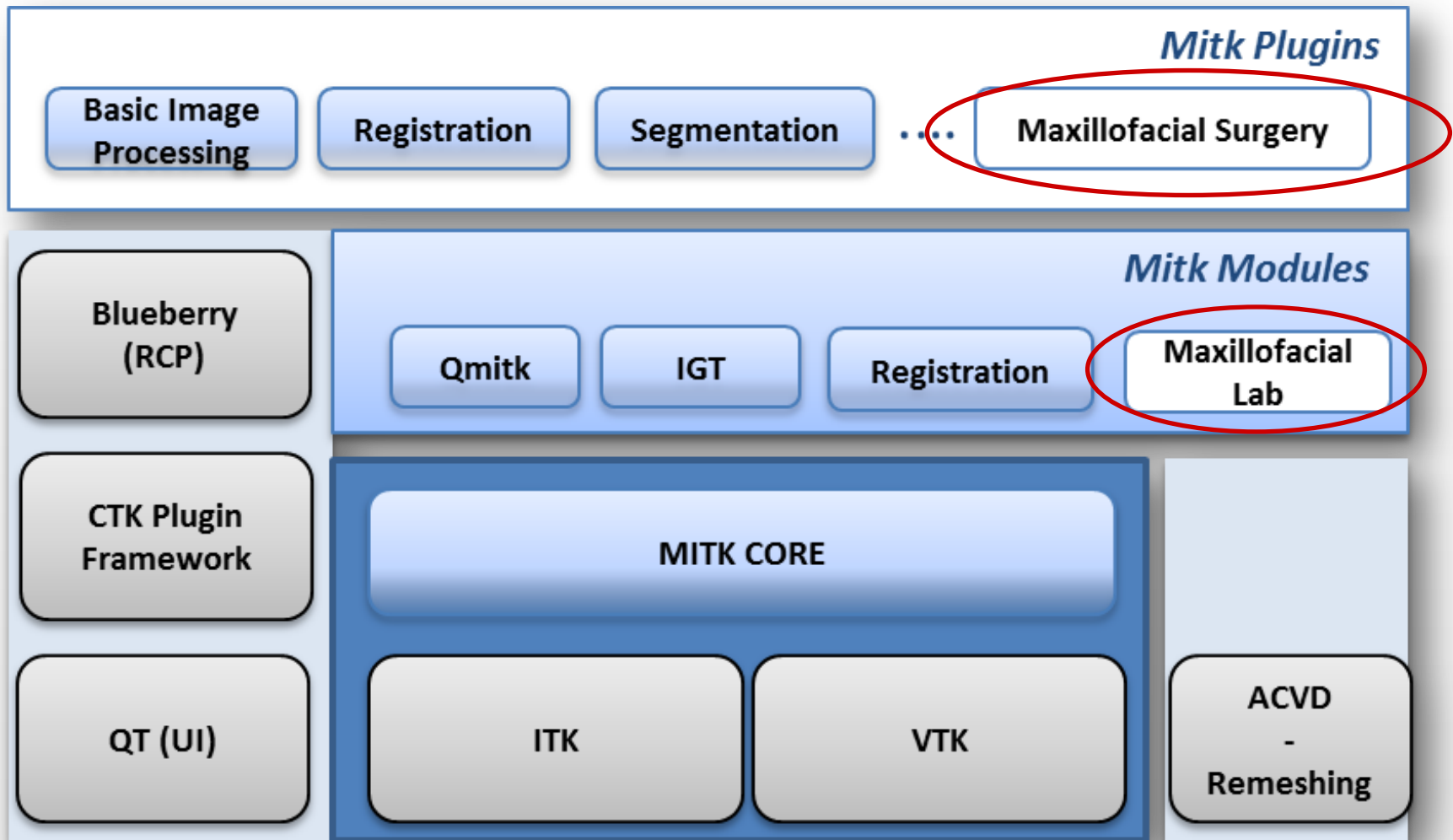


CT Scan





# MITK Application



# MITK Application

Settings

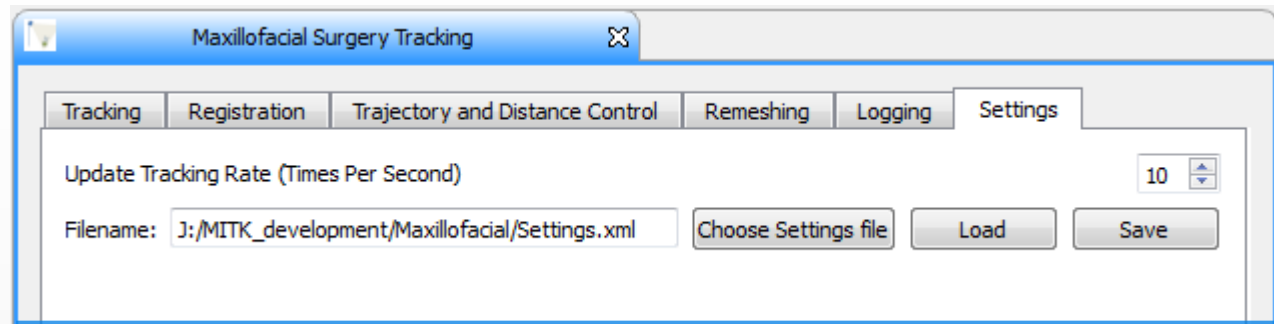
Preloading of tracking device configuration and navigation tool data.

Tracking

Point-Based Registration

Trajectory and distance control

Logging



```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
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<TrackingDevice Type="Optitrack" CalibrationFile="Calibration.cal"/>
<ToolData>
<Tool Name="Pointer" ToolDefinition="PolarisPointer.txt" ToolRepresentation="ndi_polaris_tool.stl"
IsReference="0">
</Tool>
<Tool Name="RigidBody" ToolDefinition="RigidBody.txt" ToolRepresentation="RigidBody.stl"
IsReference="1"/>
</Tool>
<Tool Name="RigidBodyJaw" ToolDefinition="RigidBodyJaw.txt" ToolRepresentation="RigidBodyJaw.stl"
IsReference="0">
/Tool>
</ToolData>
</Data>
```

# MITK Application

Settings

Tracking

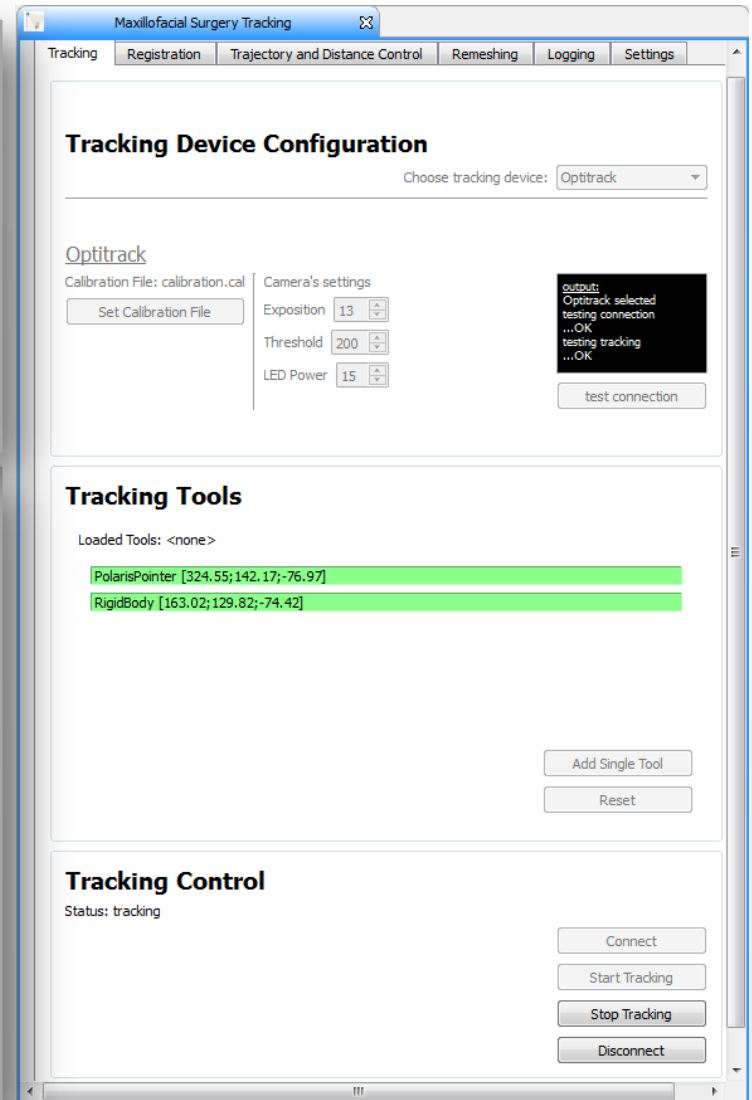
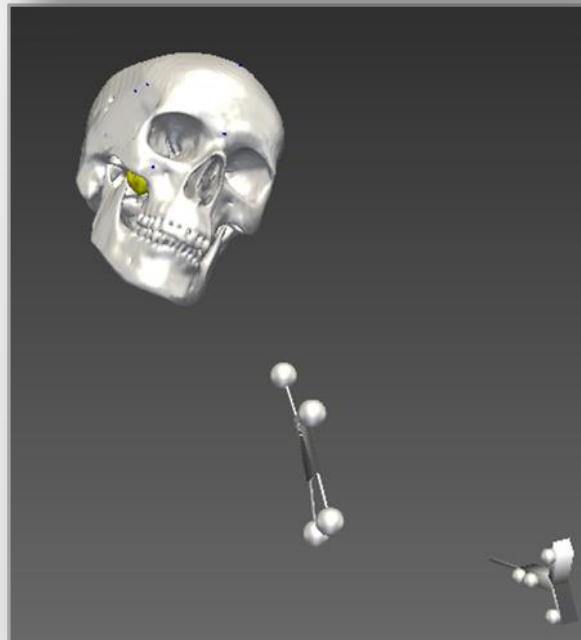
Optitrack:

- The IGT Optitrack support was implemented by Eugenio Marinetto.

Point-Based  
Registration

Trajectory and  
distance control

Logging

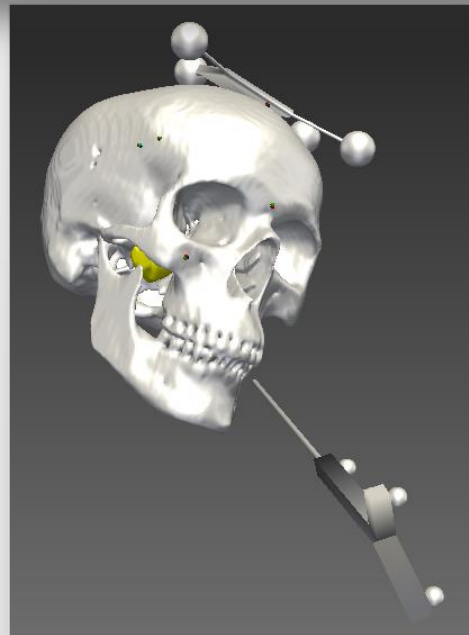
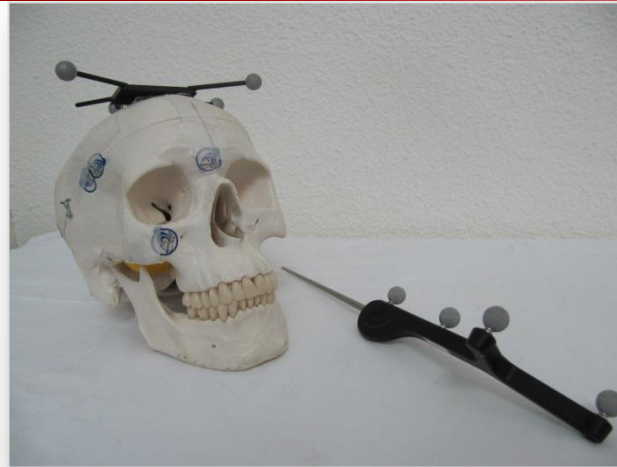


# MITK Application

Settings

Tracking

Point-Based  
Registration



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

Trajectory and  
distance control

Logging

The screenshot shows the 'Maxillofacial Surgery Tracking' application window. It has several tabs: 'Tracking', 'Registration', 'Trajectory and Distance Control', 'Remeshing', 'Logging', and 'Settings'. The 'Registration' tab is active.

**Tool Data**

Tracking device: Optitrack Tracking So

Tools: PolarisPointer, RigidBody

Set tool as reference framework  
 Register with surface:  
RigidBody

Accept

	Tool	Reference framework	Surface	Tool-Surf Reg.	General R
1	PolarisPointer	-	-	-	Registered
2	RigidBody	Reference framework	-	-	Registered
3					

**Point-based Registration**

Positioning tool: PolarisPointer

General registration (applied to every tool)  Tool to surface registration (applied to selected tool)

**Image fiducials**

0:	(-53.616, -51.701, -4.019)
1:	(-34.156, -10.619, -56.034)
2:	(2.538, -92.292, 7.076)
3:	(1.220, -51.814, -48.846)
4:	(11.065, -34.148, -53.061)

**Real world fiducials**

0:	(184.515, 76.181, -9.439)
1:	(248.357, 84.146, 13.652)
2:	(172.559, 133.077, -45.202)
3:	(228.010, 130.491, -5.003)
4:	(247.676, 128.065, -10.482)

Buttons: +, +XYZ, ✎, ↑, ↓, 📁, 📁

Add current instrument position

Status: FRE: 0.997894 mm Calculate registration

Permanent registration

Transform filename: C:\Users\tfg-big\transform.txt Save Registration

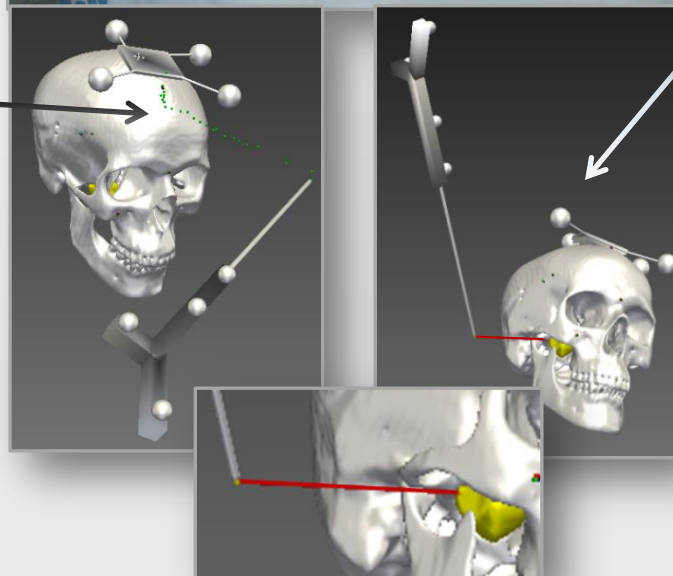
# MITK Application

Settings

Tracking

Point-Based  
Registration

Trajectory and  
distance control



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

Logging

Maxillofacial Surgery Tracking

Tracking Registration Trajectory and Distance Control Remeshing Logging Settings

**Available tools**

Tracking device: Optitrack Tracking Source

Tools: PolarisPointer, RigidBody

**Trajectory** Point Distance [mm]: 1 Show Trajectory

**Point-to-Surface distance**

Surface: Tumor

Distance Control Distance: 125.968

**Point-to-Point distance**

Reference points

Measurement points

+ +xyz [clear] [up] [down] [save] [load]

+ +xyz [clear] [up] [down] [save] [load]

Add reference position Add measurement position

Distance values

Calculate distance values

Save data

**Surface-to-Surface distance**

Control Surface: C:/Laura/Optitrack/Tool\_definition/ndi\_polaris\_toc

Moving Surface: C:/Laura/Optitrack/Tool\_definition/ndi\_polaris\_toc

Calculate disalignment

# MITK Application

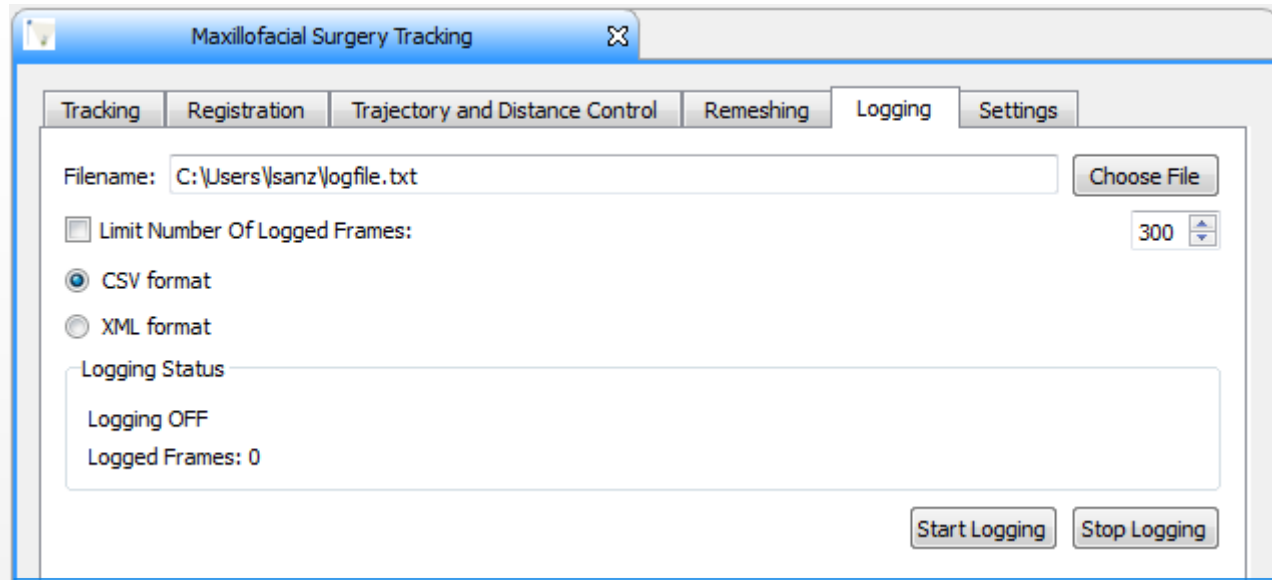
Settings

Tracking

Point-Based  
Registration

Trajectory and  
distance control

Logging



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

# Future work

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- 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”.*

L.K. de Paula, A.C.O. Ruellas, B. Paniagua, M. Styner, T. Turvey, H. Zhu, J. Wang, L.H.S. Cevitanes. Federal University of Rio de Janeiro, Brazil; University of North Carolina, USA.

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

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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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