

# HIGH PERFORMANCE OPTICAL TRACKING FOR MEDICAL APPLICATIONS

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FRAMOS Imaging Systems

# AGENDA



## 1. FRAMOS

- a. Company & Department
- b. Medical Partners

## 2. Tracking

- a. Explanation & Motivation
- b. Systems & Solutions

## 3. Medical Applications

- a. Diagnostic Sonography
- b. Nuclear Medicine
- c. Assistive Movement Therapy

## 4. Conclusion



# FRAMOS KEY FACTS

- Imaging Experts for over 30 years
- Offices across Europe & North America. Asian partners
- 90 employees
- Vision hardware & software for medical applications
- 4 EU research projects, national research
- Close relationships to university hospital



# FRAMOS BUSINESS UNITS



## SENSOR +

Full Range Portfolio of Image Sensors and Peripheral Components (Sony, OnSemi)

- Sensor sockets
- Peripheral components
- Sensor evaluation boards
- Lenses, mounts & filters
- Embedded Camera Interfaces
- Data & I/O connectors

## CAMERA +

Extensive Portfolio of Industrial Cameras, Optics, Filters, Cables, Illumination and Image Acquisition Components (Datalogic, Smartek)

- Industrial cameras
- Lenses, mounts & filters
- Lightings & LED controllers
- Image acquisition
- Data & I/O connectors
- Software & Tools

## IMAGING SYSTEMS

Holistic systems and technology platforms for logistics and medical applications. Specific product development and project planning

## ENGINEERING

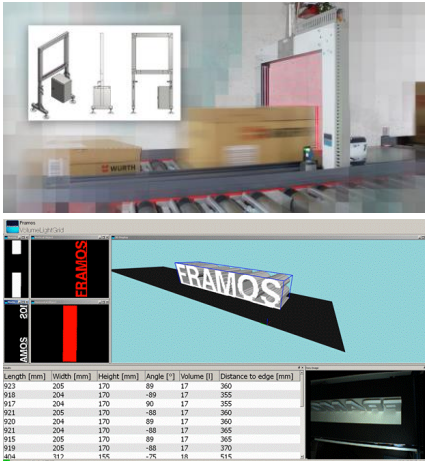
Design support, hardware and software development (evaluation & support, FPGA programming and camera development)

# FRAMOS IMAGING SYSTEMS



## Focus

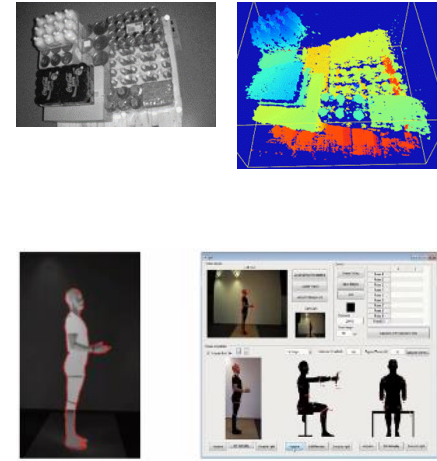
### Logistics



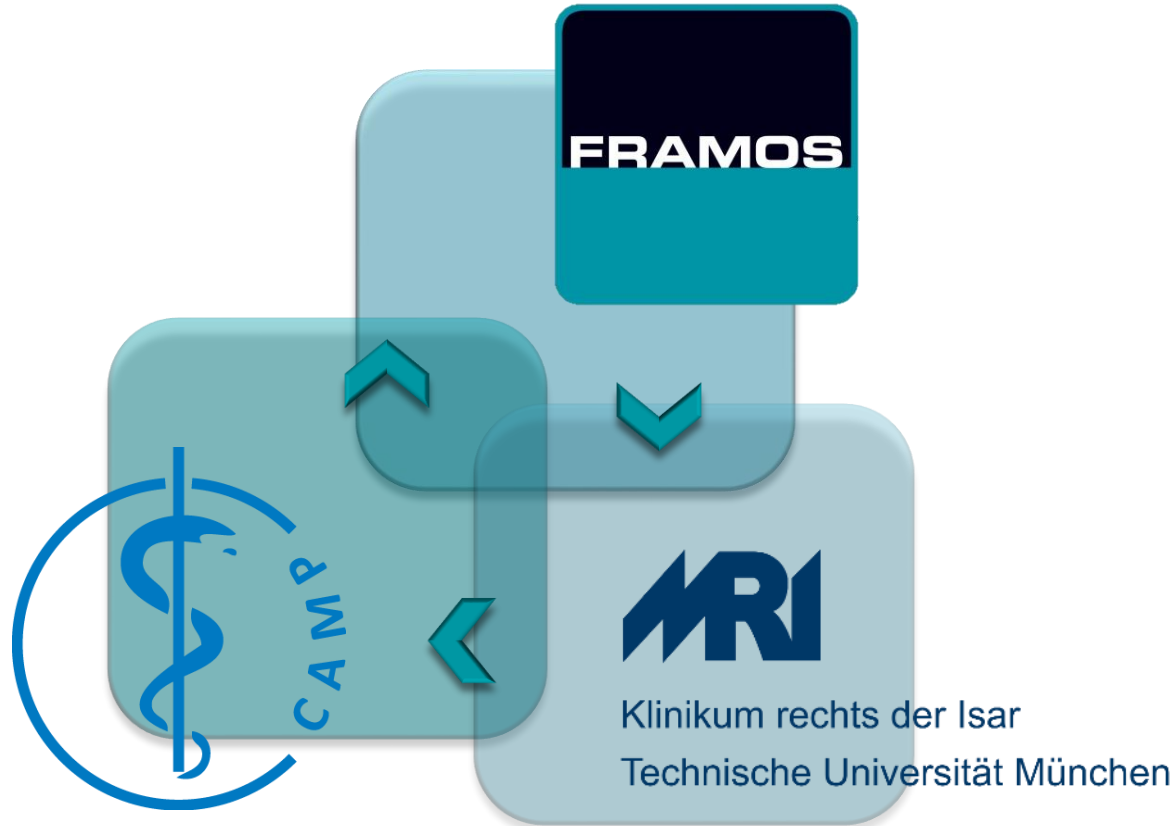
### Medical



### Research & Development



# FRAMOS COOPERATION PARTNERS



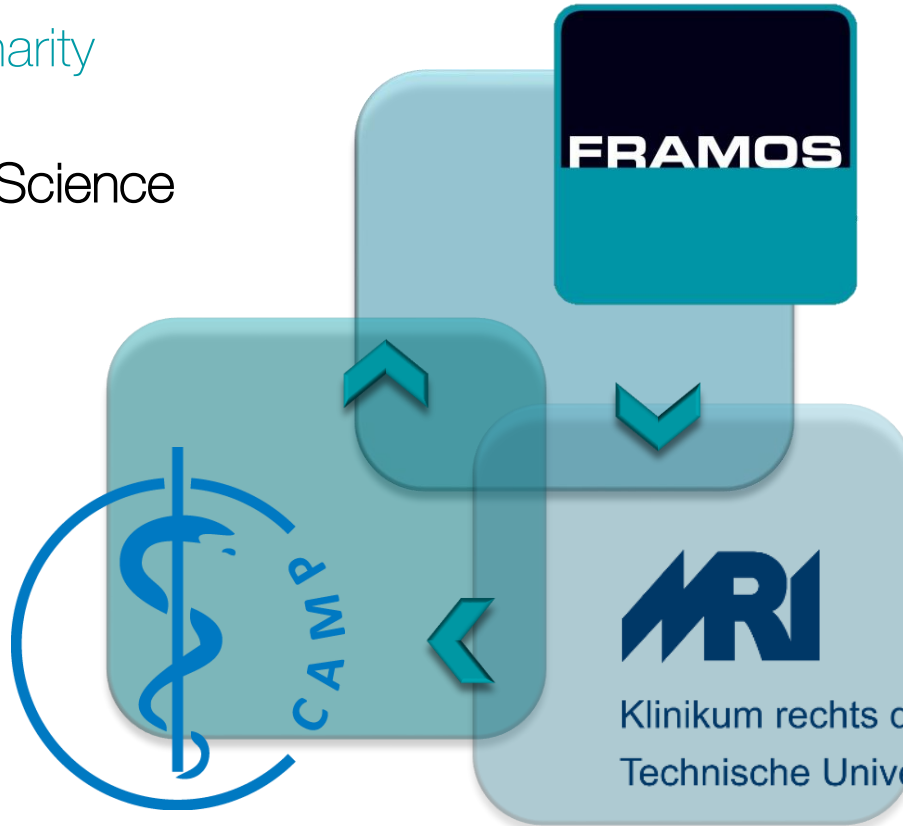


# FRAMOS COOPERATION PARTNERS



## Interdisciplinarity

- Computer Science
- Biomedical
- Robotics
- Physics



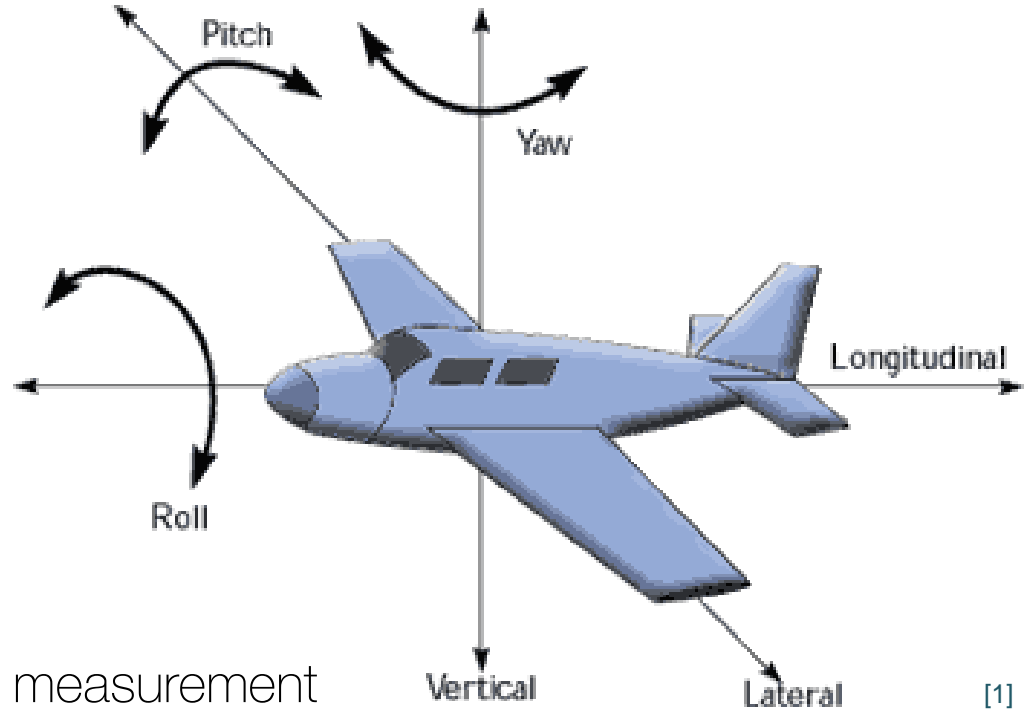
- Mathematics
- Engineering
- Medical
- Economics

# TRACKING



## In a nutshell

- Arbitrary motion = 6 DOFs
  - Position
    - Distance (x,y,z)
  - Rotation
    - Angles (a,b,c)
  - Pose = Position + Rotation
- Tracking = Continuous pose measurement



[1]

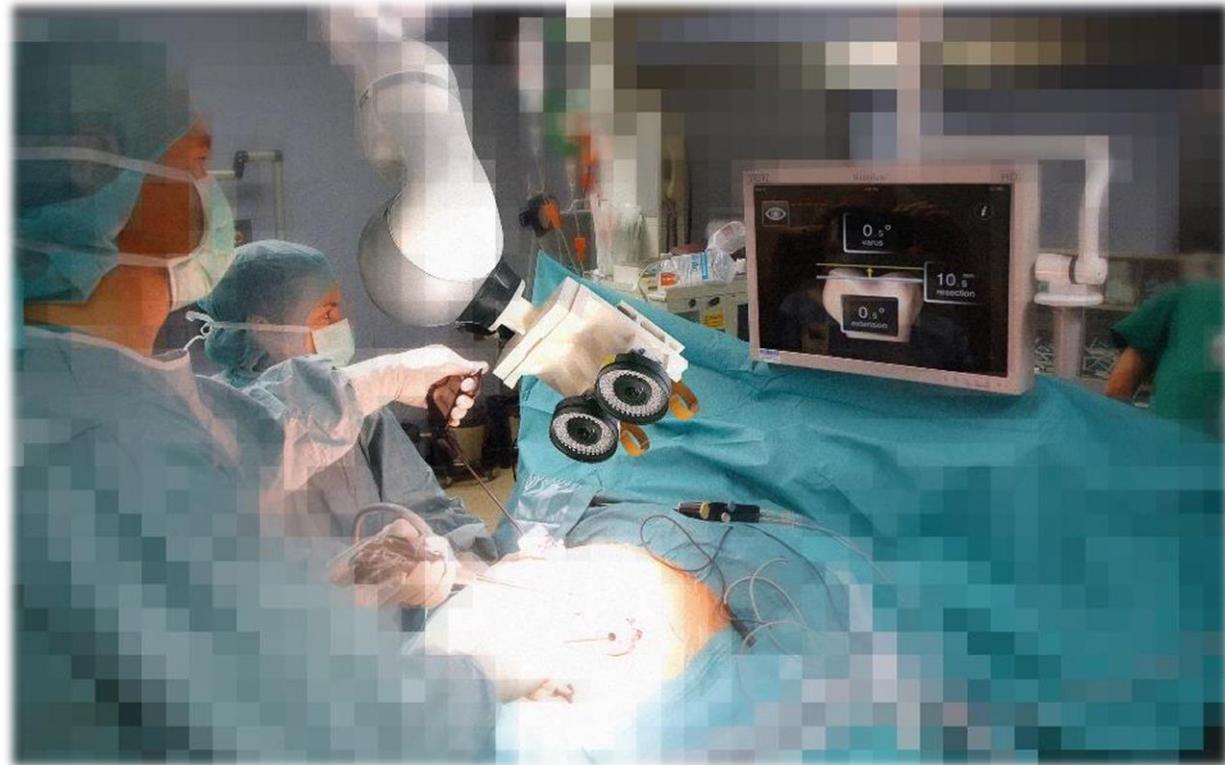


# TRACKING



## Requirements for medical applications

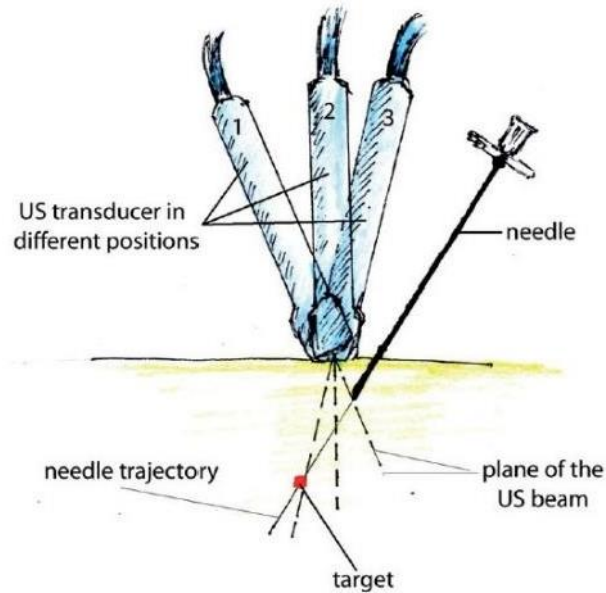
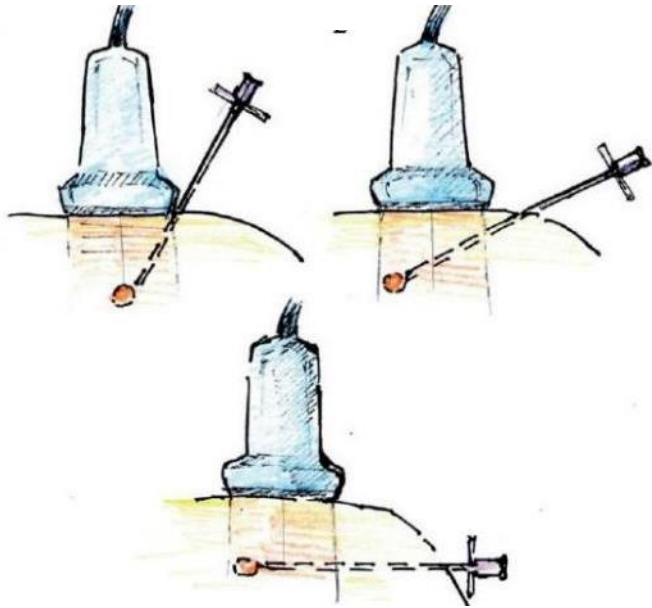
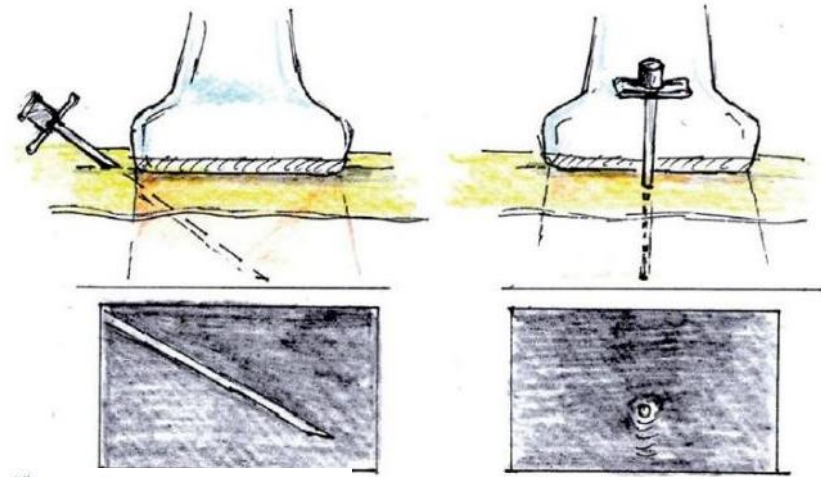
- Arbitrary motion
- High-precision
- Real-time
- Robust recognition
- Intuitive handling
- Individual objects
- Online teaching
- Communication



# A MEDICAL MOTIVATION

## Needle Tip Tracking

- Needle placement difficult with 2D ultrasound (US)

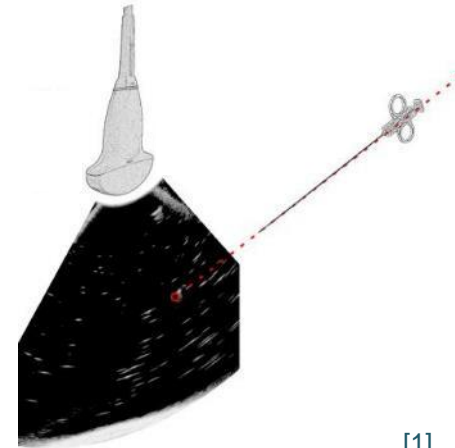
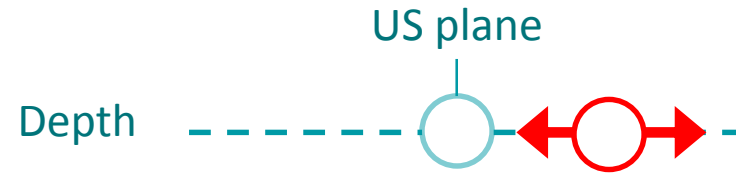


[1] B. Ihnatsenka et al. IJSS 2010

# MEDICAL EXAMPLE

## Needle Tip Tracking

- Show needle position on ultrasound image

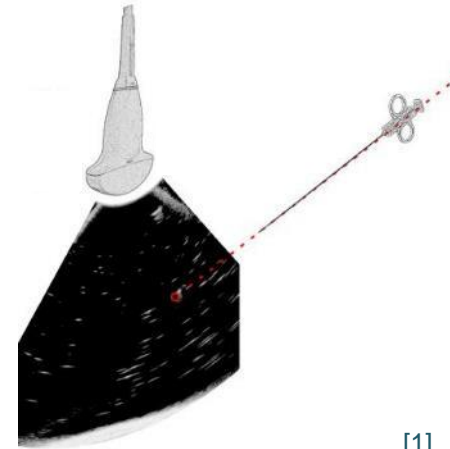
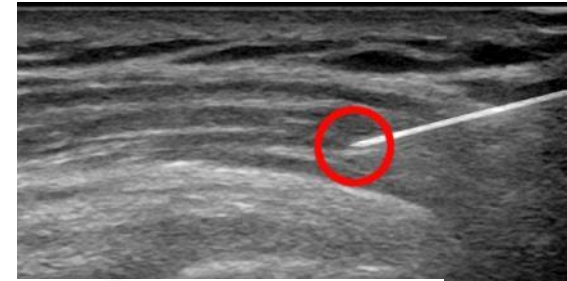
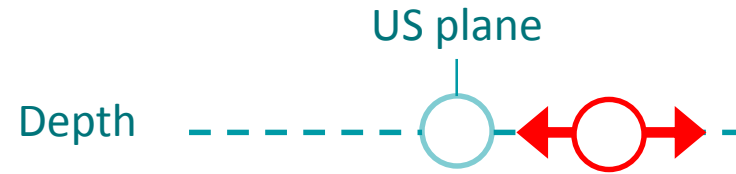


[1]

# MEDICAL EXAMPLE

## Needle Tip Tracking

- Show needle position on ultrasound image

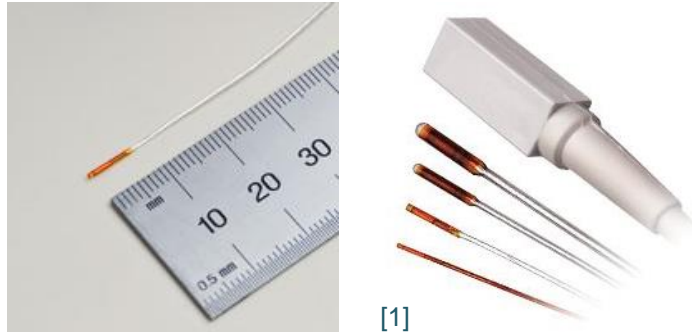


[1]

# AVAILABLE SOLUTIONS

## Electromagnetic Tracking

- Pros
  - No line of sight restrictions



- Cons
  - Limited accuracy [mm]
  - Small working volume
    - [66 cm away from transmitter]
  - Wiring: sensor power supply
  - Complex sensors
  - Lack of reliability
    - Unintuitive error source analysis [e.g. metal]
  - Electromagnetic interference
    - Pacemakers ...



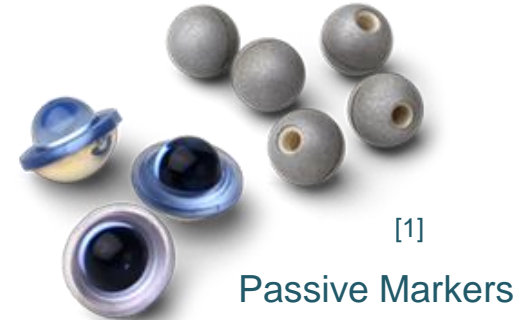
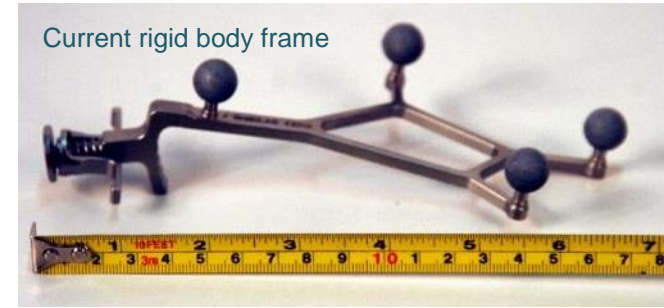
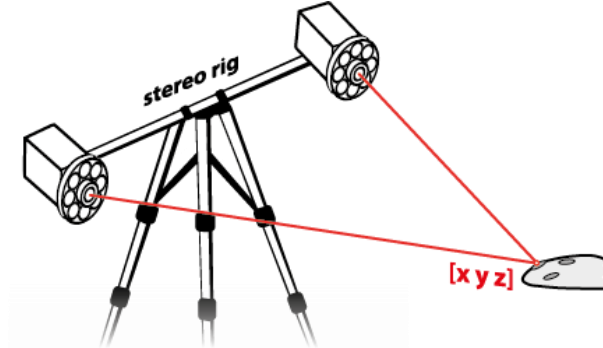


# AVAILABLE SOLUTIONS

## Optical Tracking

### ■ Pros

- High accuracy [ $\sim 0.3$  mm]
- Markers: passive / active / disposable
- Reliability
  - Intuitive error analysis
- No interference
- Large working volume
  - [up to 3 m in depth]



### ■ Cons

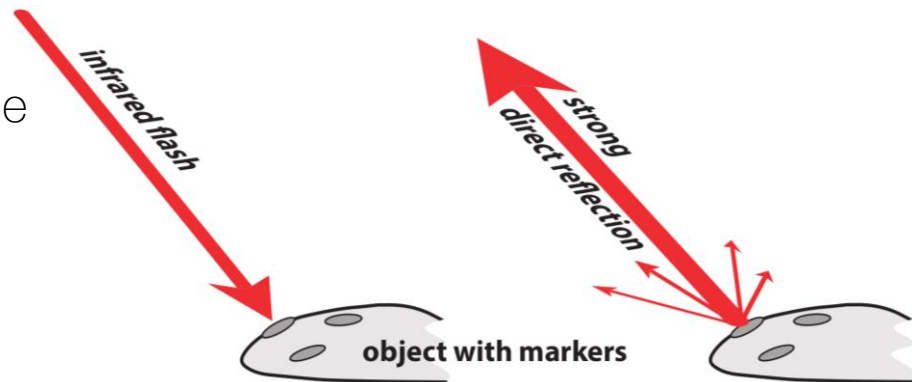
- Often: Strong line of sight restrictions
- Often: Bulky rigid mounts
- Often: Fixed marker geometry

# AVAILABLE SOLUTIONS

## FRAMOS High Performance Optical Tracking Systems

### ■ Pros

- Very high accuracy [10-90  $\mu\text{m}$ ]
- Markers: passive + active + disposable
- Reliability
- No interference
- Very large working volume
- Robust recognition
- Individual marker set-up
- Independent of object geometry
  - Intuitive handling
- Scalable to custom requirements
- Outside-in & inside-out solutions



### ■ Cons

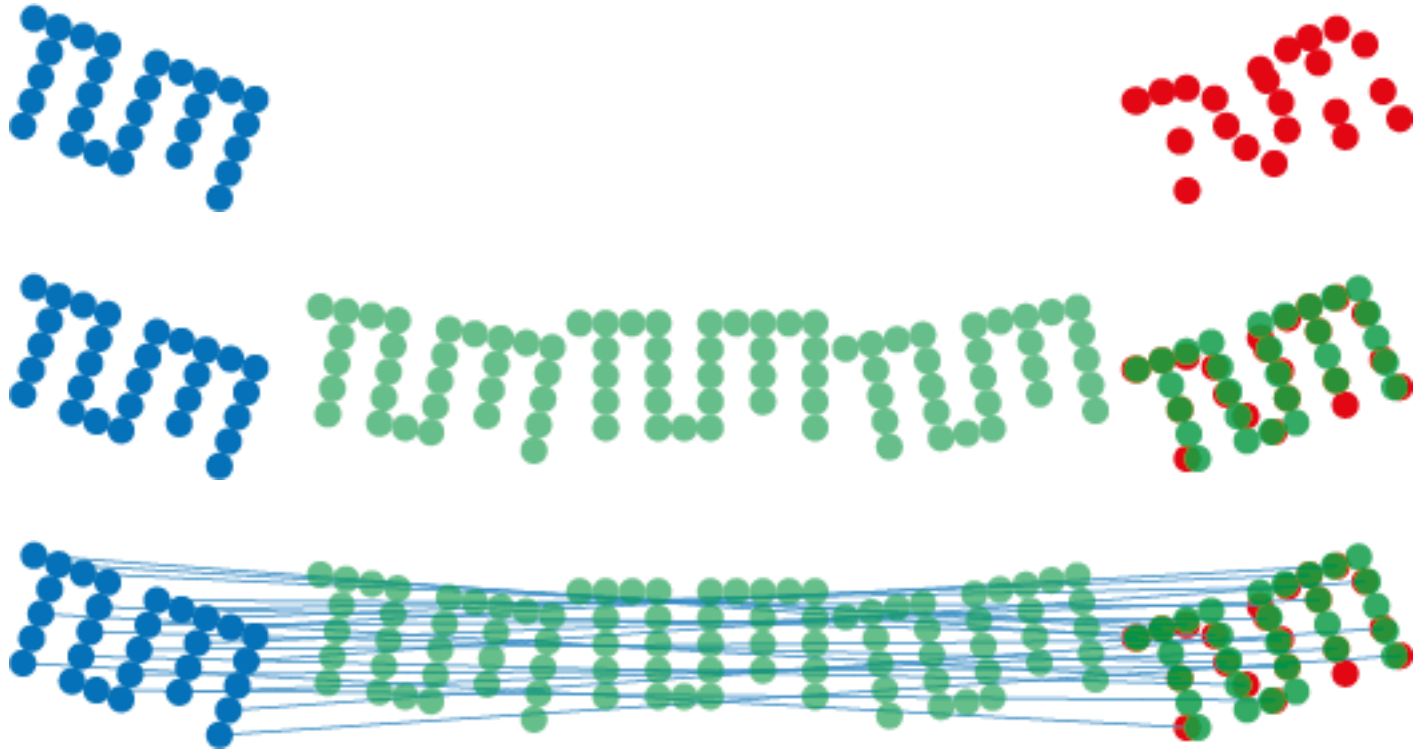
- ~~Partial~~ line of sight restrictions
- ~~Often: Bulky rigid mounts~~
- ~~Often: Fixed marker geometry~~



# 3D POSE MEASUREMENT



Algorithm & idea awarded 2015 by  
European Machine Vision Association

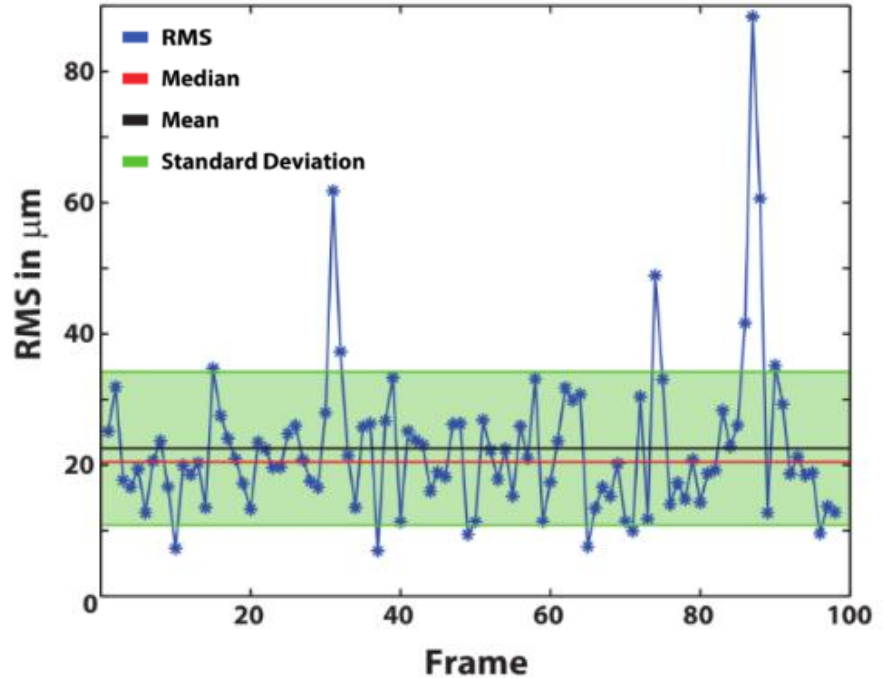
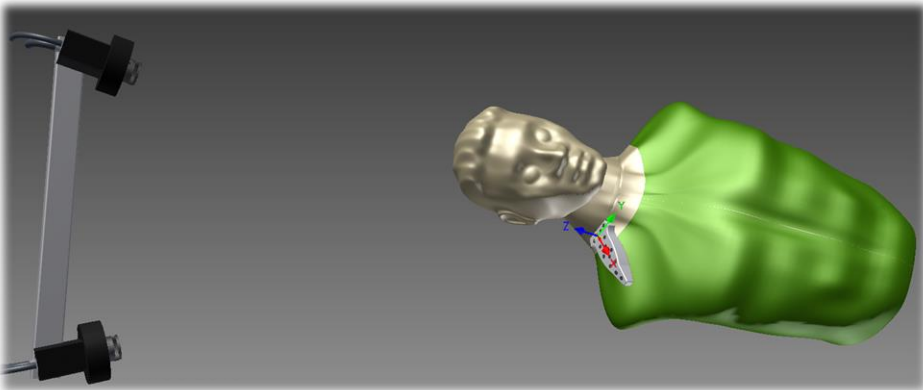


# FRAMOS OTS



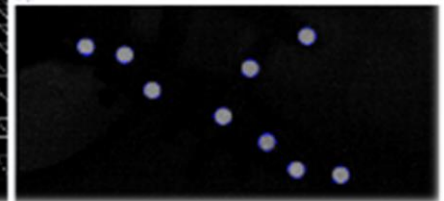
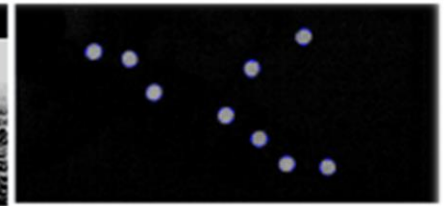
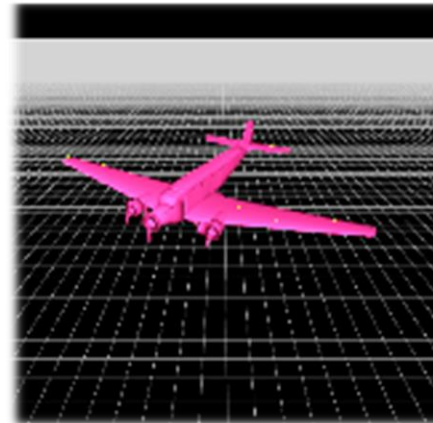
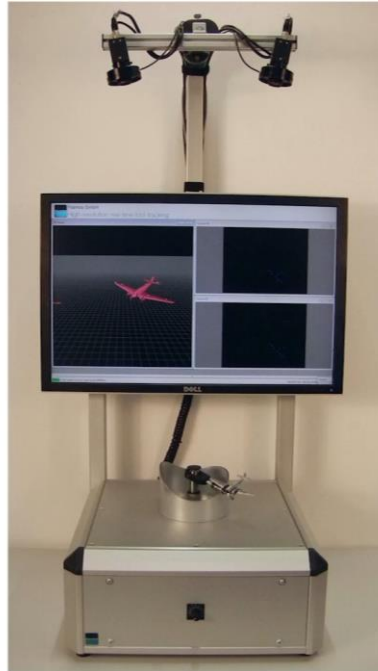
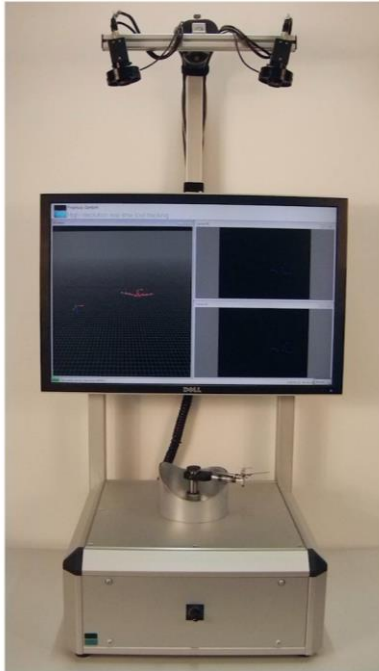
## Hardware & Accuracy

- Cost-efficient passive markers
- Self-adhesive, retro reflective
- Individual stereo camera setup



# FRAMOS OTS

## Software & Application



# APPLICATION FIELDS

## Medical Tracking Solutions for

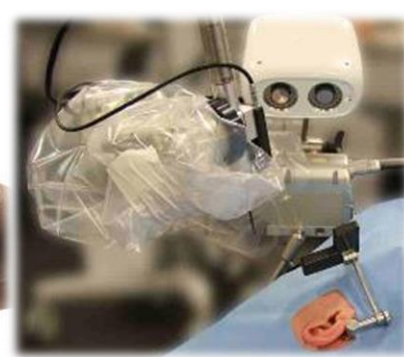
- Robot-guidance
- Surgical tool-navigation
- 3D measurements
- Augmented Reality / Virtual Reality
- Head Mounted Displays
- Motion Capture



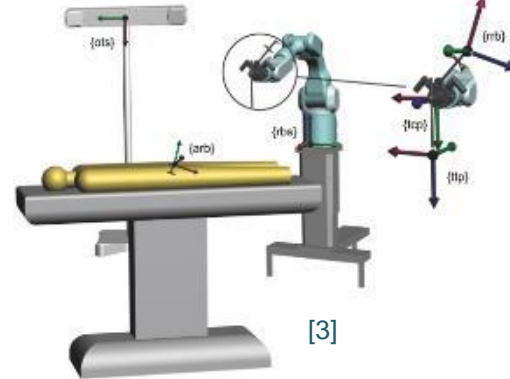
[5]



[1]



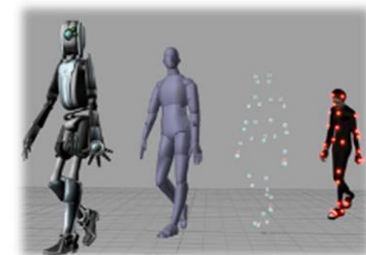
[2]



[3]



[4]



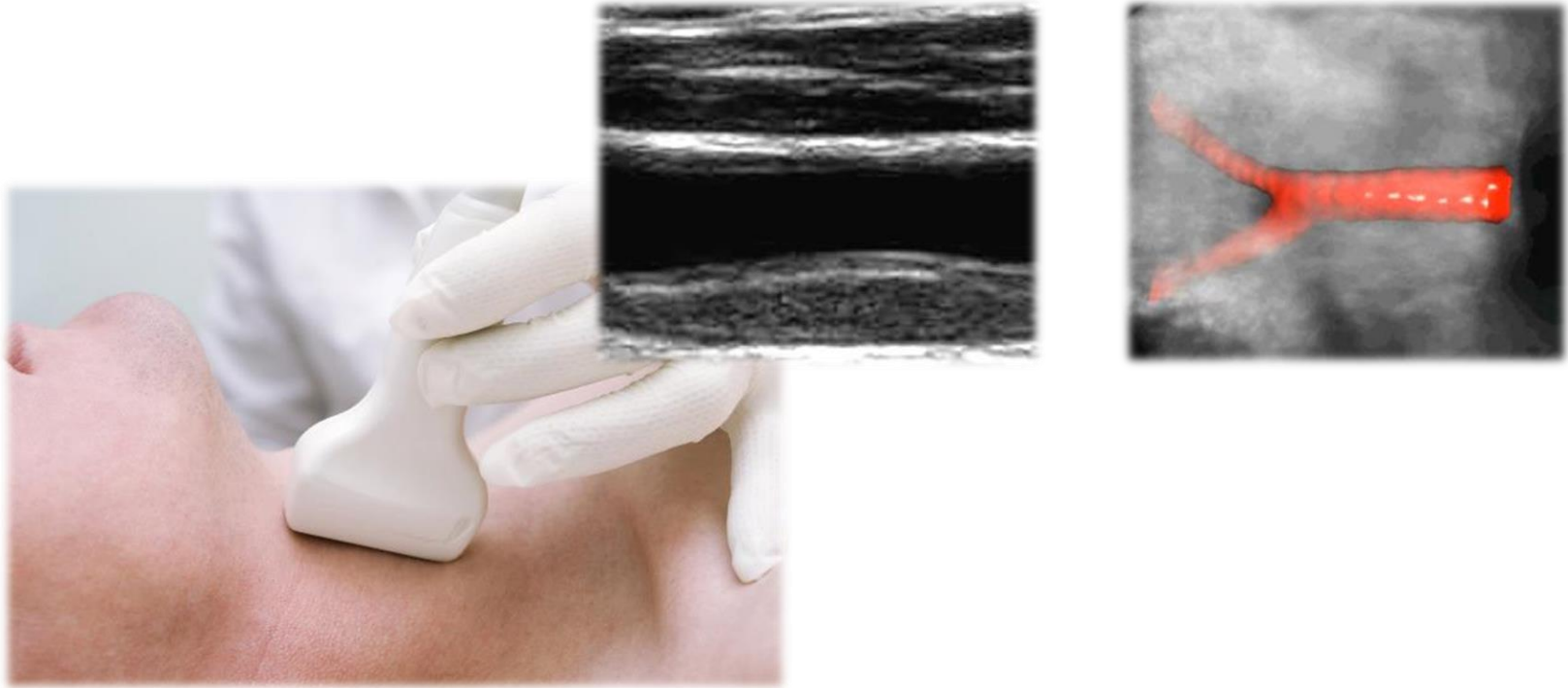
[1] : R-Design Studio. GOM. 2015-06-08

[2] : Surgical Robot System. University of Bern. 2015-06-08

[3] : H.-C. Schneider e al. Robot Surgery 2010

[4] : Augmented Reality in Medicine. CAMP. 2010 [5] : P. Fallavollita. CAMP. 2014

# 3D ULTRASOUND FROM 2D IMAGES



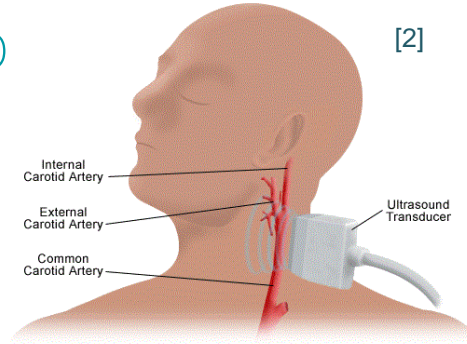
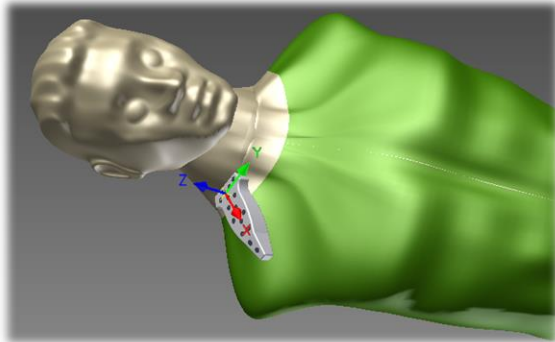
[1]



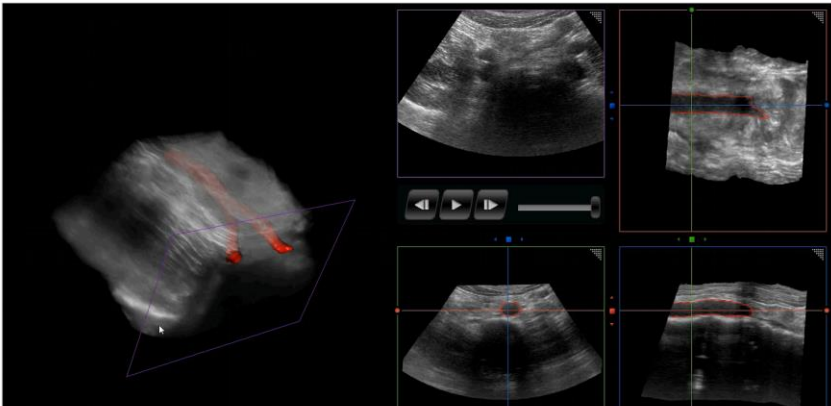
# OTS - 3D ULTRASOUND



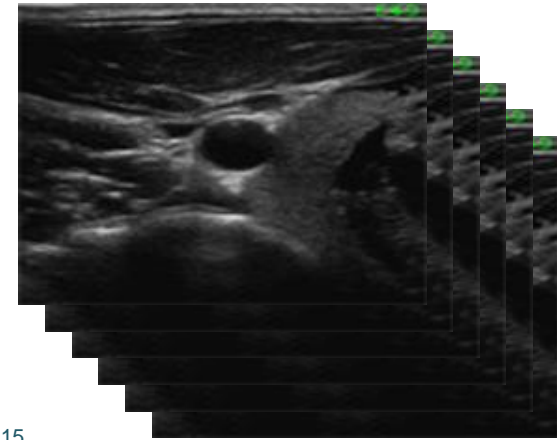
Upgrade conventional ultrasound to 3D



[1]



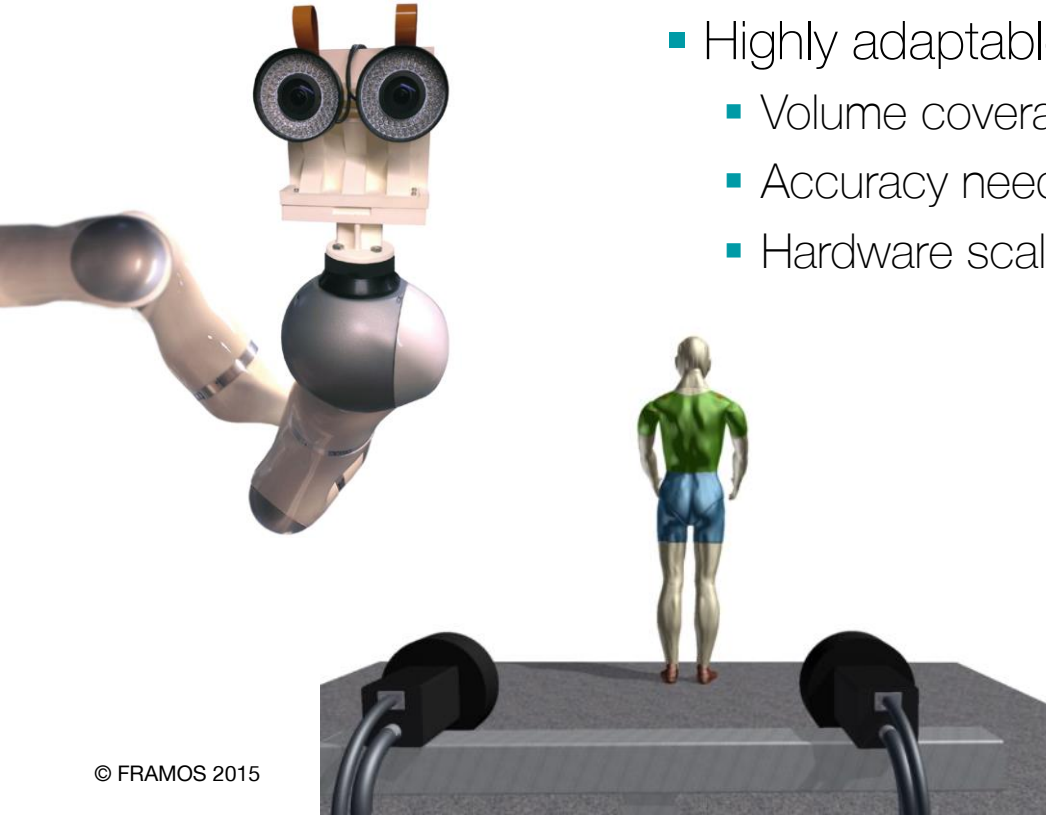
3D poses



[1] Curefab CS, CUREFAB, 2015

[2] Carotid Artery Duplex Scan, J. H. Medicine, 2015

# OUTSIDE-IN & INSIDE-OUT TRACKING

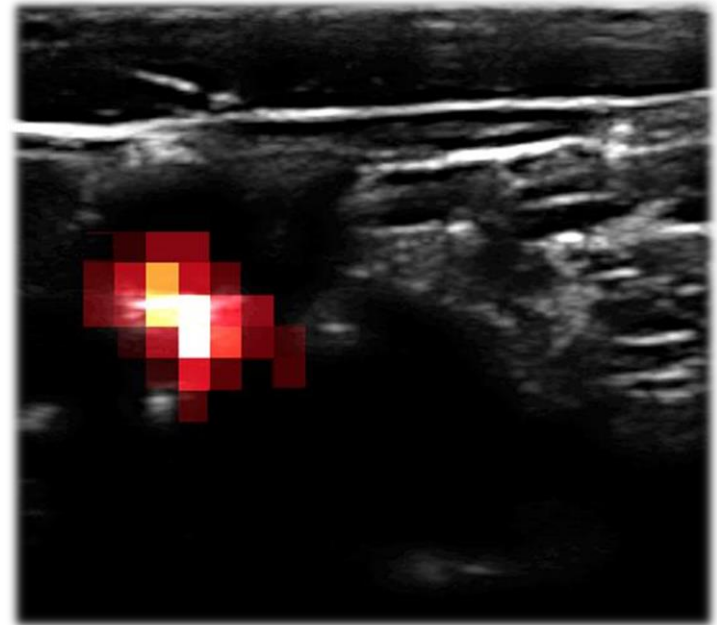
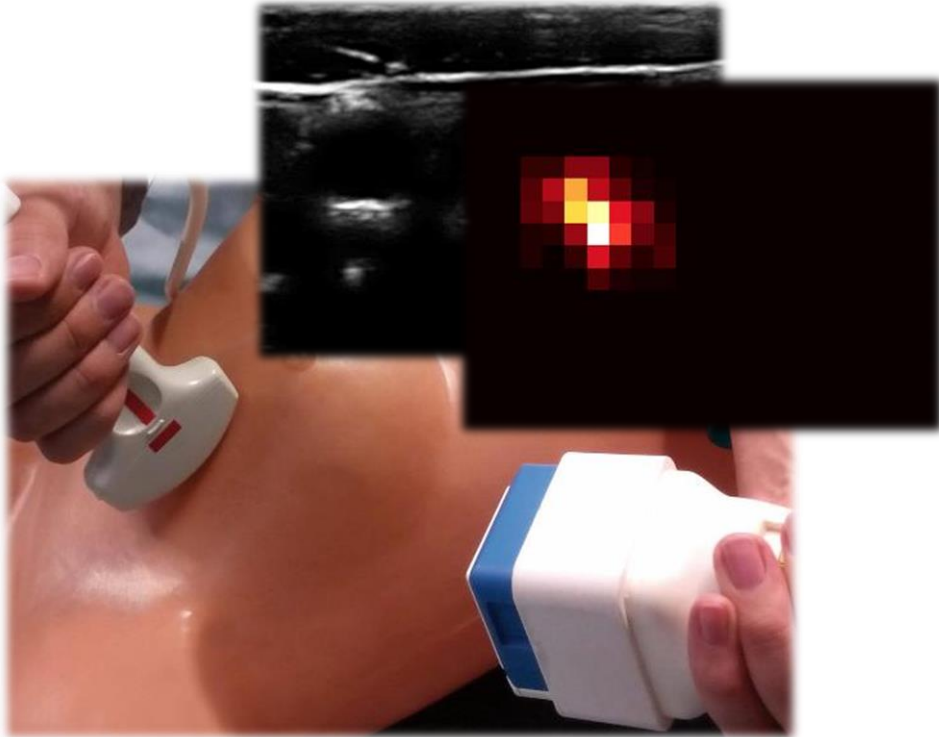


- Highly adaptable
  - Volume coverage
  - Accuracy needs
  - Hardware scale





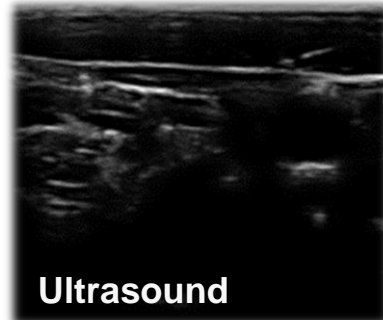
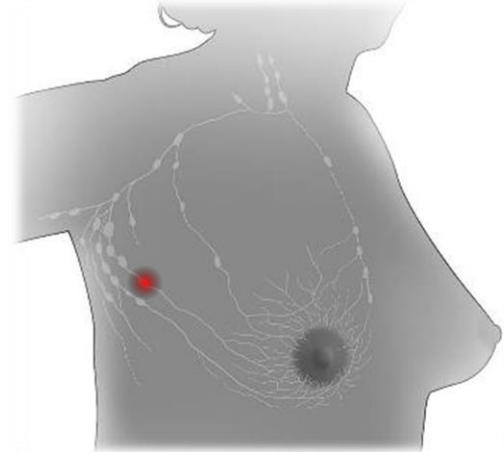
# SENSOR FUSION - GAMMA & US



# OTS - SENSOR FUSION



## Sentinel Lymph Node Biopsy

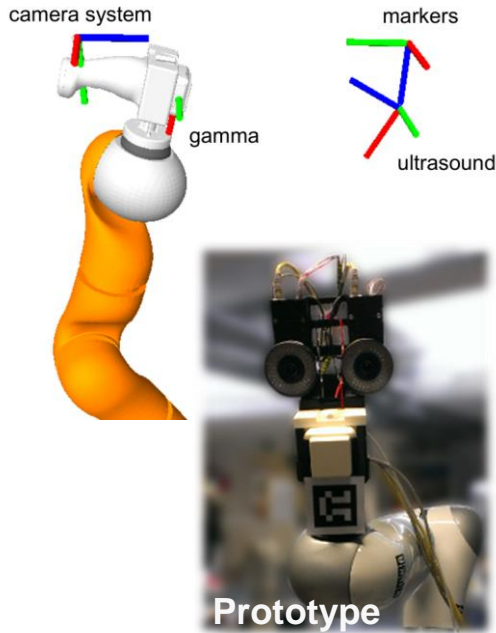


- Current Workflow
  - Handling of 2 devices
  - Two independent images
  - Biopsy with ultrasound

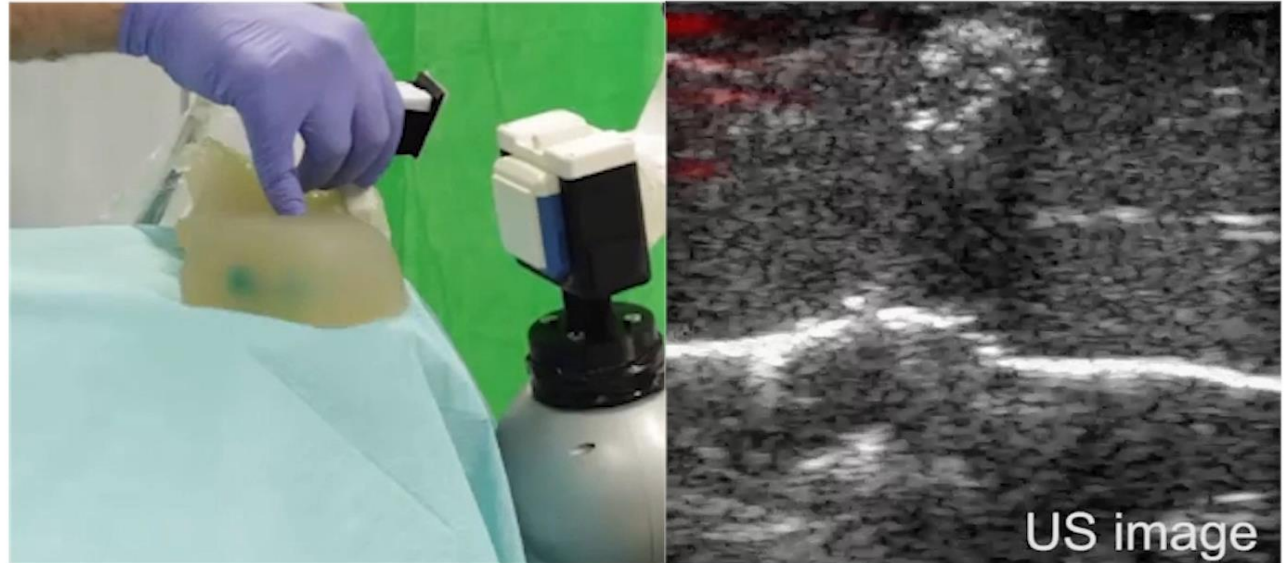
# OTS - SENSOR FUSION



## Robot-guided multimodal imaging



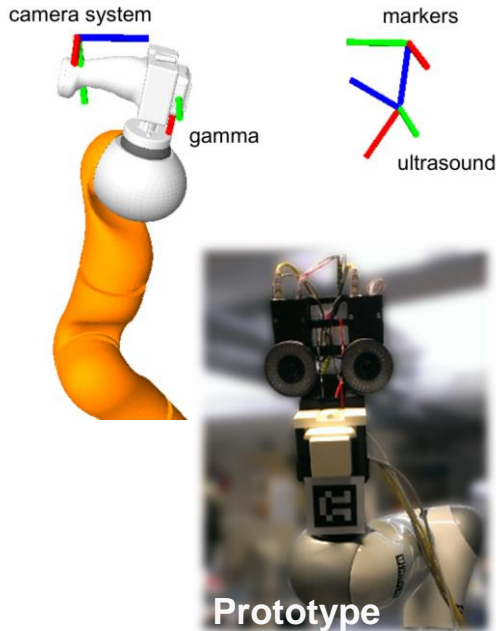
- Locate Sentinel Lymph Node



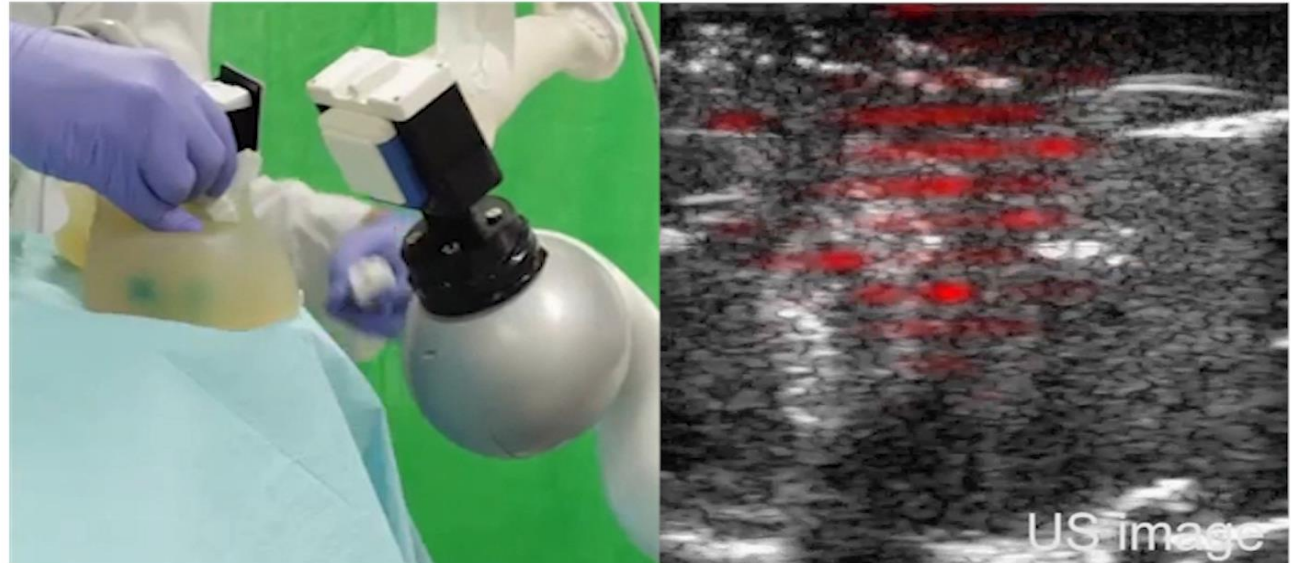
# OTS - SENSOR FUSION



## Robot-guided multimodal imaging

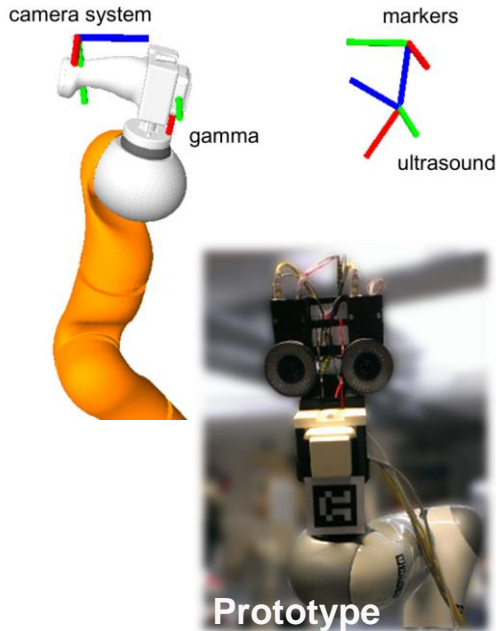


- Perform Biopsy



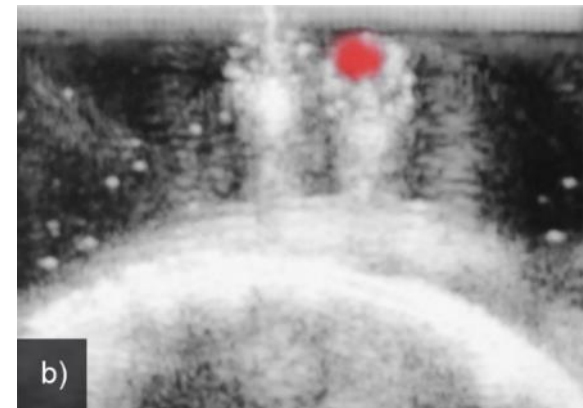
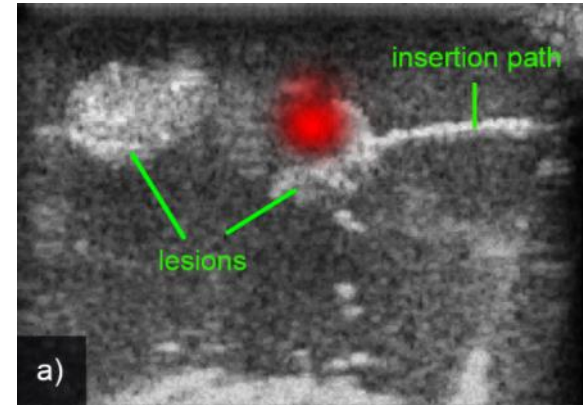
# OTS - SENSOR FUSION

## Proposed workflow



### Advantages

- Image fusion
- Multi-modal visualization
- Positioning of gamma cam
- Collaborative device
- Functional information in OP
- Reduce number of open SLN resections





# MOVEMENT THERAPY AFTER STROKE

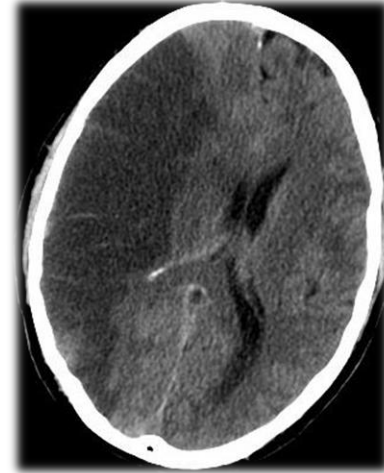


## Stroke

- Poor blood flow in brain
  - Cell damage
  - ~17 Mio incidents p.a.
  - 33 Mio affected patients
  - 80% hemiparesis
- Rehabilitation therapy



[1]



[2]

[1] K. A. Leber. Neurochirurgie Graz. 2015-11-12

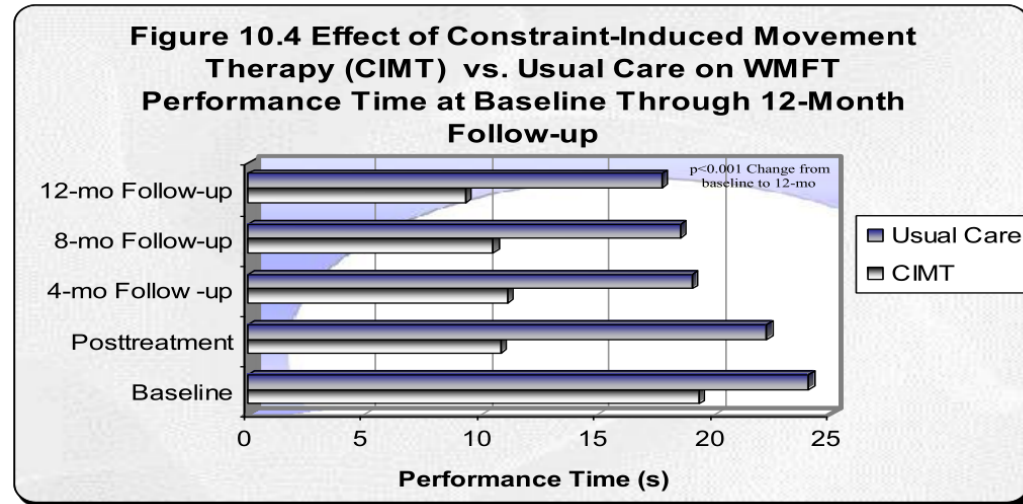
[2] L. Monfils. Dutch Radiology. 2008

# MOVEMENT THERAPY AFTER STROKE



## Therapeutic Measures

- Neurological therapeutics
- Constraint-induced movement
- Mirror therapy
- Repetitive practice
- Re-education of movements
  - Motion training
  - Immediate & long term



➤ Patient participation very important

[1]



# OTS - ASSISTIVE MOVEMENT THERAPY



## Motion Training

- Previous Systems
  - Joystick controlled
  - Exoskeletons
- Our Approach
  - Contactless with computer vision
  - Optical tracking controlled
  - Collaborative robot movement therapy



Bi-Manu Track

[2]



T-WREX Exoskeleton

[1]

[1] L. Marchal-Crespo et al. JNER. 2009

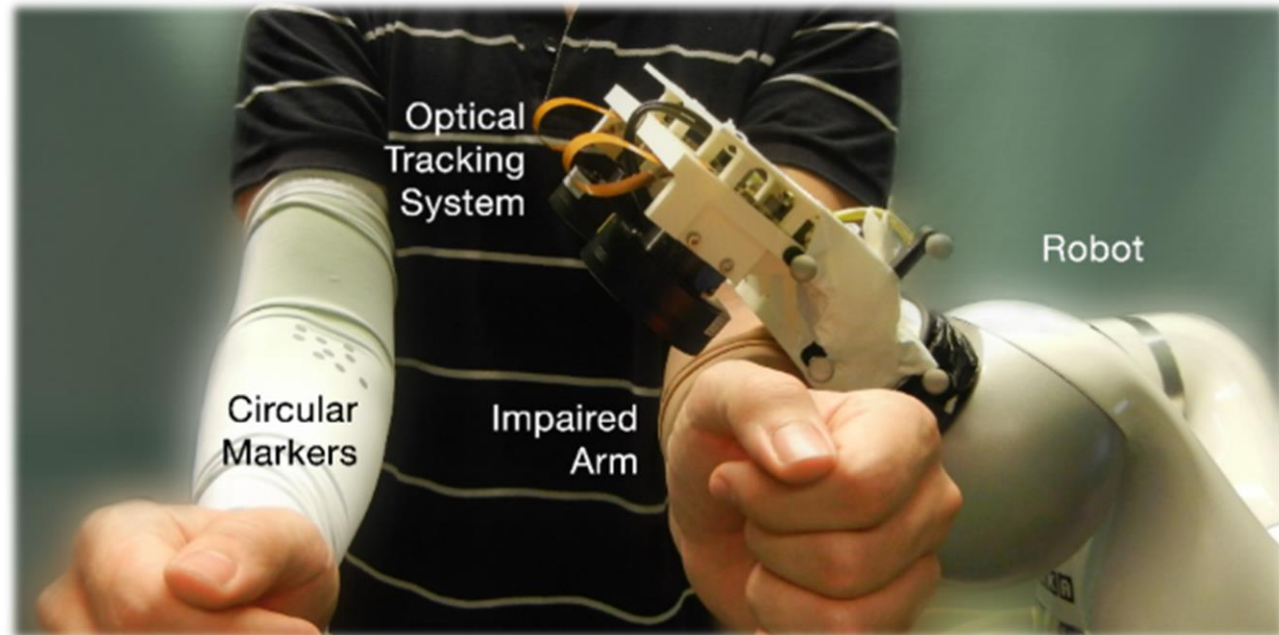
[2] Reha-Stim. Bi-Manu-Track. 2015-11-12

# OTS - ASSISTIVE MOVEMENT THERAPY

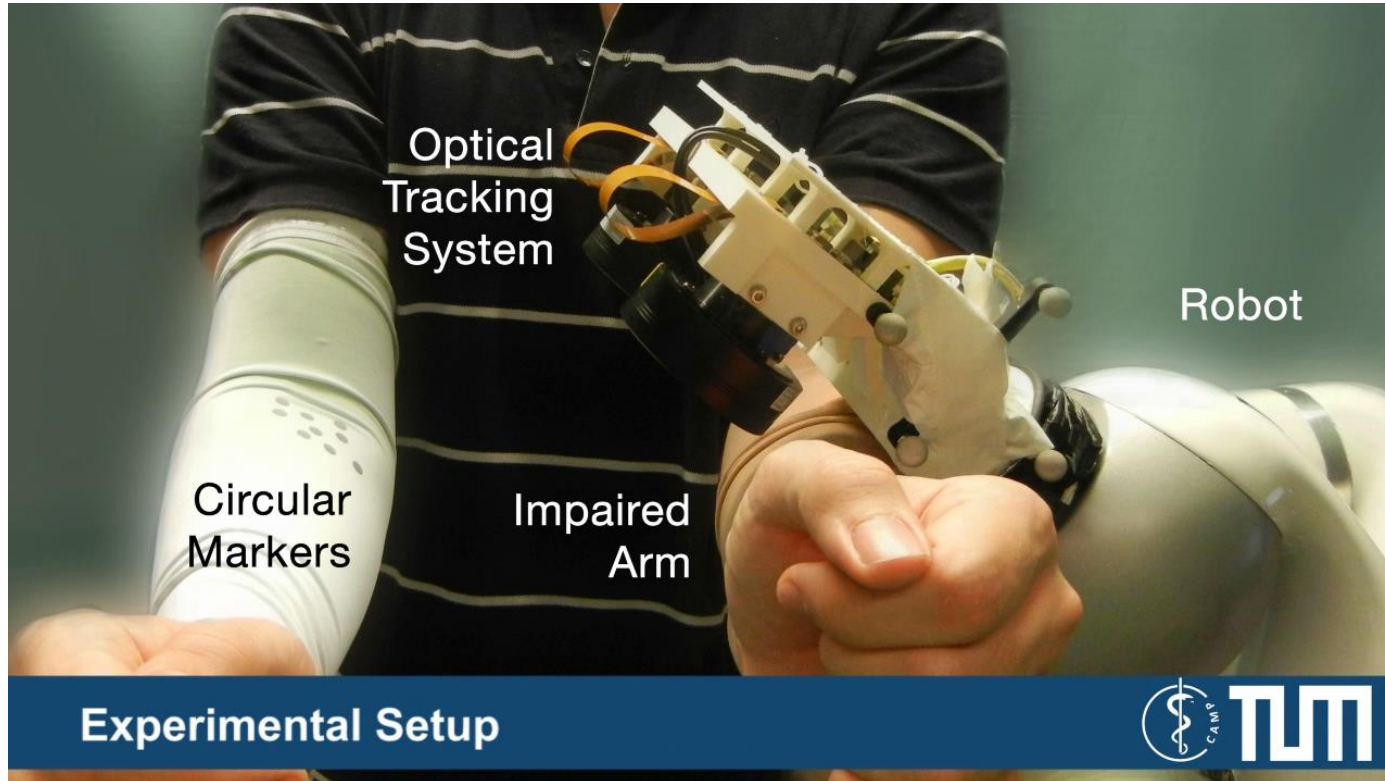


## Proposed treatment

- Camera-in-hand
  - Sleeve markers
  - Guiding arm
  - Robot supports deficient arm
- 
- Natural control
  - Better rehabilitation
  - Positive feedback



# OTS - ASSISTIVE MOVEMENT THERAPY



# CONCLUSION



- FRAMOS
  - Company & Medical Partners
- Tracking solutions
  - Concepts (EM, Optical)
  - Advantages & Drawbacks
  - High Performance OTS
  - Inside-out & Outside-in
- Wide range of medical applications
  - Navigation (e.g. medical instruments / sensors)
  - Visualization (functional information / additional localized data)
  - Collaboration (assistive robotics)

A close-up photograph of a microscope with a red laser line visible. The image is overlaid with text and a teal banner at the bottom.

solutions for industry applications  
& any imaging challenge

# WE ENABLE IMAGING

sensors, cameras  
& peripheries  
global services  
hardware & software  
development  
support

[www.framos.com](http://www.framos.com)

# THANK YOU!

Vielen Dank!

The logo for FRAMOS, consisting of a dark blue square with rounded corners. The top half of the square is dark blue, and the bottom half is a lighter teal color. The word "FRAMOS" is written in white, bold, uppercase letters across the dark blue section.

**FRAMOS**

*We enable You!*

Hall 3 E38

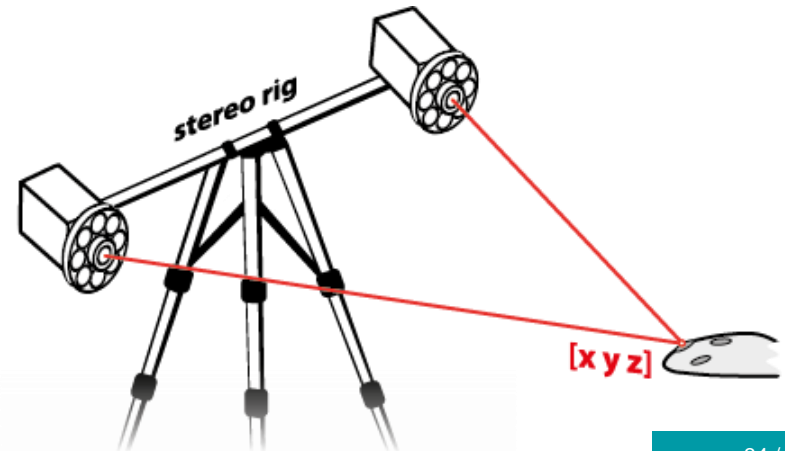
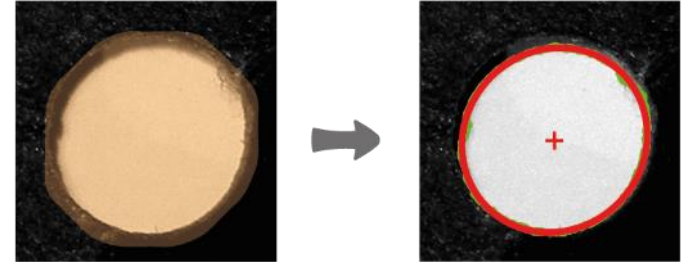
[www.framos.com](http://www.framos.com)

[b.busam@framos.com](mailto:b.busam@framos.com)

# OTS – IMAGE PROCESSING

## Algorithm – 2D/3D Object recognition

- Acquire images
- Find object (ROI)
- Calculate marker positions
- Fit contours
- Compute centres
- Triangulate 3D points



# TRACKING

## Available Solutions



- EM Tracking Systems
  - Oscillating fields
  - Quasistatic fields
  - Passive Transponder Systems
- Optical Tracking Systems
  - Videometric Tracking
  - IR-based Tracking
    - Active Trackers
    - Passive Trackers
  - Laser Tracking