Central Europe Call for Proposals

Paolo Fiorini

Department of Computer Science

University of Verona

Italy

General Description

- **Projects focussing on research demonstrating the translation of outputs into concrete and sustainable results**
- CENTRAL EUROPE includes:
  - All regions from Austria, Croatia, the Czech Republic, Hungary, Poland, Slovakia and Slovenia,
  - Eight Länder from Germany (Baden-Württemberg, Bayern, Berlin, Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt, Thüringen)
  - Nine regions from Italy (Emilia-Romagna, Friuli Venezia Giulia, Liguria, Lombardia, Piemonte, Provincia Autonoma Bolzano, Provincia Autonoma Trento, Valle d'Aosta, and Veneto
  - **Project proposals for step 1 of this call must be submitted through the eMS at the latest by Monday 13 April 2015, 18.00 CET**

General Description

- **CooperProposal Type/size**
  - at least three financing partners, - from at least three countries and - being at least two of the partners located in CENTRAL EUROPE regions
  - The recommended financial size is in the range of EUR 1 to 5 mil total cost.
  - The maximum size of a partnership should not exceed 12
  - The following co-financing rates shall apply:
    - Up to 85 %for applicants of Croatia, the Czech Republic, Hungary, Poland, Slovakia, Slovenia;
    - Up to 80 % for applicants of Austria, Germany, Italy;
    - Up to 80 % for applicants located in EU regions outside the Interreg CENTRAL EUROPE Programme area.
    - The recommended project duration is 30 to 36 months

- AWARD CRITERIA
- The selection of proposals is based on the assessment of received applications following a standardised procedure, which safeguards the principles of transparency and equal treatment.
- Step 1 Following a formal/administrative compliance check, each proposal which has positively passed the formal/administrative check is assessed on its contents against the following two strategic assessment criteria:
- - Relevance
- - Partnership
- Each criterion is composed of several sub-criteria measured according to scores (1 to 5). The number of applications pre-selected within step 1 shall ensure an adequate competition in step 2 of the call.

Priority axis 1 - Cooperating on innovation to make CENTRAL EUROPE more competitive	Priority axis 2 - Cooperating on low-carbon strategies in CENTRAL EUROPE
Specific objectives: 1.1 To improve sustainable linkages among actors of the innovation systems for strengthening regional innovation capacity in central Europe 1.2 To improve skills and entrepreneurial competences for advancing economic and social innovation in central European regions	**Specific objectives:** 2.1 To develop and implement solutions for increasing energy efficiency and renewable energy usage in public infrastructures 2.2 To improve territorially based low-carbon energy planning strategies and policies supporting climate change mitigation 2.3 To improve capacities for mobility planning in functional urban areas to lower CO_2 emissions
Priority axis 3 - Cooperating on natural and cultural resources for sustainable growth in CENTRAL EUROPE	**Priority axis 4 - Cooperating on transport to better connect CENTRAL EUROPE**
Specific objectives: 3.1 To improve integrated environmental management capacities for the protection and sustainable use of natural heritage and resources 3.2 To improve capacities for the sustainable use of cultural heritage and resources 3.3 To improve environmental management of functional urban areas to make them more liveable places	**Specific objectives:** 4.1 To improve planning and coordination of regional passenger transport systems for better connections to national and European transport networks 4.2 To improve coordination among freight transport stakeholders for increasing multimodal environmentally-friendly freight solutions

Innovation

- SO 1.1 To improve sustainable linkages among actors of the **innovation systems** for strengthening regional innovation capacity in central Europe
- SO 1.2 To **improve skills and entrepreneurial competences** for advancing economic and social innovation in central European regions

- ➢ Incubator design
- ➢ Professional skill courses
- ➢ Entrepreneurship camps

Energy

- SO 2.1 To develop and implement solutions for increasing energy efficiency and renewable energy usage in public infrastructures
- SO 2.2 To improve territorially based low-carbon energy planning strategies and policies supporting climate change mitigation
- SO 2.3 To improve capacities for mobility planning in functional urban areas to lower CO2 emissions

- SO 3.1 To improve **integrated environmental management capacities for the protection and sustainable use of natural heritage** and resources
- SO 3.2 To improve **capacities for the sustainable use of cultural heritage** and resources
- SO 3.3 To improve **environmental management** of functional urban areas to make them more liveable places

➢ Monument management and protection

- SO 4.1 To improve **planning and coordination of regional passenger transport systems** for better connections to national and European transport networks
- SO 4.2 To improve **coordination among freight transport stakeholders** for increasing multimodal environmentally-friendly freight solutions

➢ Logistics planning

Medical Robotics – Born in space

Paolo Fiorini
Department of Computer Science
University of Verona
Italy

ALTAIR

A View from the Past

The Early Promoters

- DARPA
  - Military desire to save soldier lives without endangering medical personnel
  - Need to quickly stabilize injured soldiers

- NASA
  - Support Astronauts during EVA missions
  - Enable Earth-based space medicine

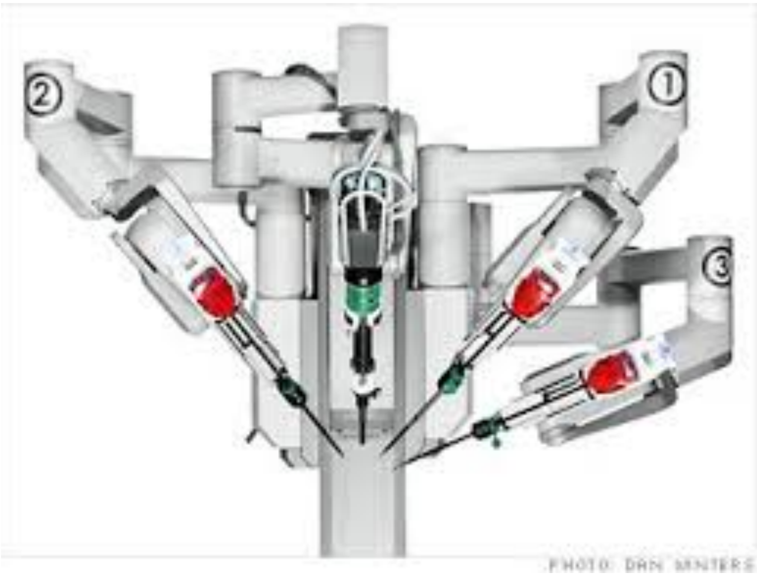
- IBM
  - New computer applications

Richard Satava,
UW - DARPA

Antal Bejczy,
NASA - JPL

Russell Taylor
IBM-JHU

Results of Their Research



Intuitive Surgical
Da Vinci robot

Computer Motion
Zeus robot

Curexo
Robodoc robot

Evolution of General Surgery

➔

➔

- Better layout
- Better treatment
- Less fatigue
- ……

Open Surgery **Laparoscopic Surgery** **Robotic Surgery**

There are basically two main advantages:

perception and dexterity

A surgical robot combines the small instrument size of laparoscopic surgery, with the hand dexterity and visual perception of open surgery.

The Key Elements

The surgical robot is the carrier of the instruments and all the "value" of the system lies in the instruments and in the stereo camera

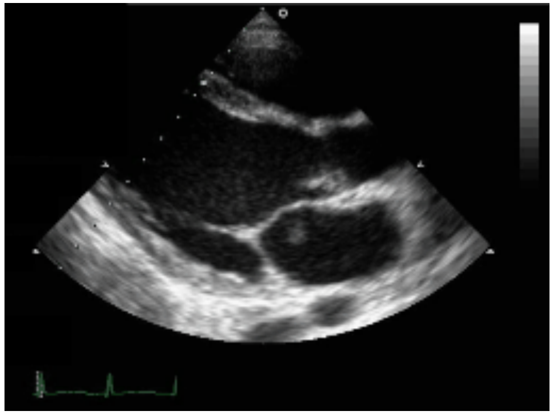
All the rest is supporting hardware that should be minimized.

Outline

- So… where should we go?
  - Sensors
  - Perception and processing
  - Minimization
  - Cognition
  - Autonomy
  - Support to medical staff

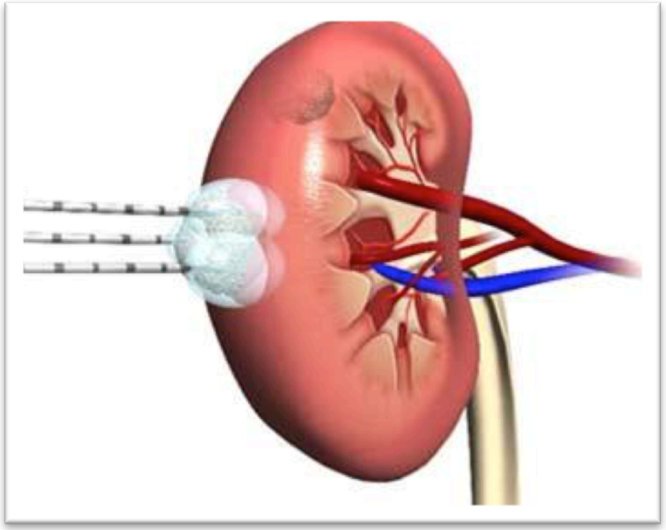
Sensor Processing

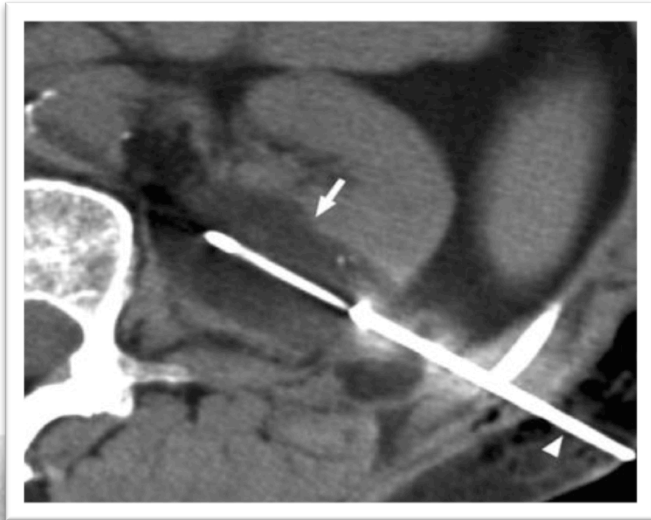
- Modern minimally invasive surgical procedure could greatly benefit from the adoption of image guided navigation
- Between different medical image types, Ultrasound (US) is a very attractive modality for many reasons:
  - Harmless for the patient
  - High frame rate
  - Compact dimensions of the device
  - Inexpensive
- But it suffer of two main limitations:
  - US produces mainly 2D images
  - Lower image quality (contrast & resolution) compared with other modalities



Percutaneous cryoablation

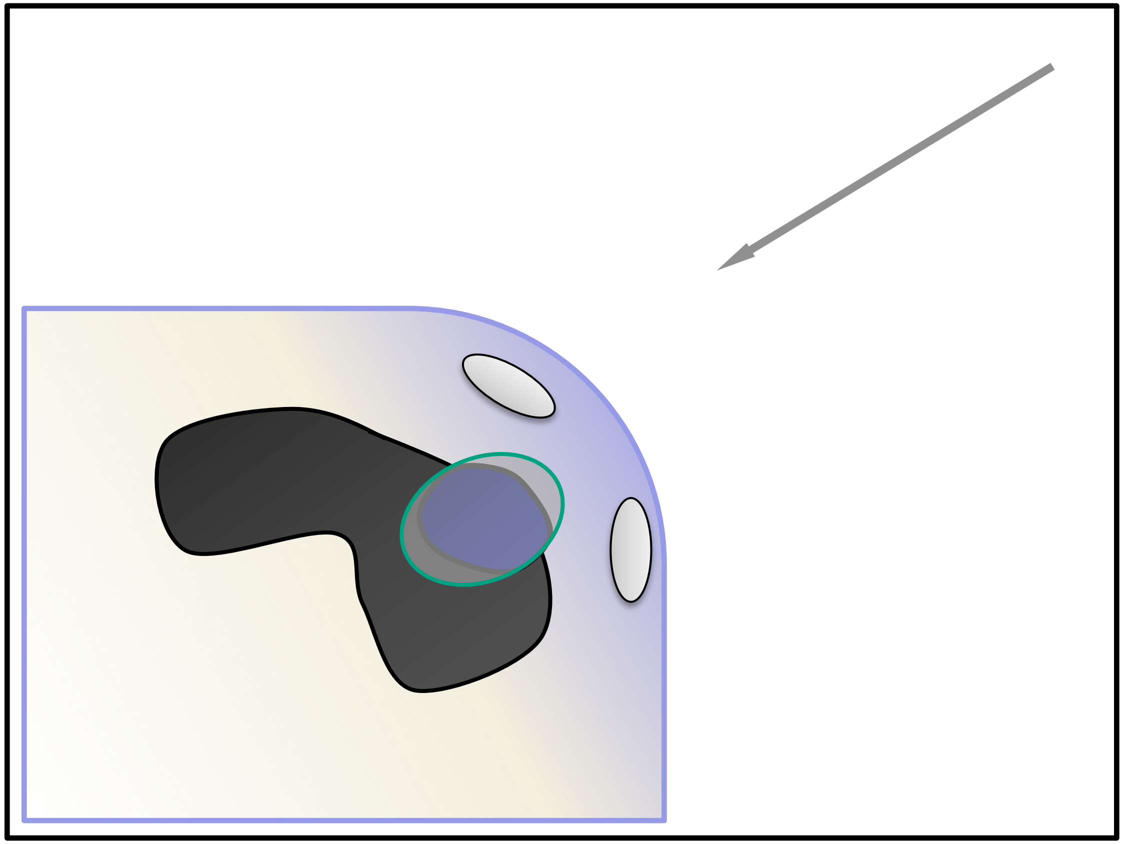
- Percutaneous cryoablation (CA) is a minimally invasive approach
- This approach is widely used in many structures for treatment of small tumors.
- CA requires image guidance.
- Ultrasound (US) guidance is commonly used in percutaneous needle based procedures





Problems of cryoablation

- Localizing target area
- Correct positioning the ablation tool
- Monitoring and verification of the full coverage of the ablated zone

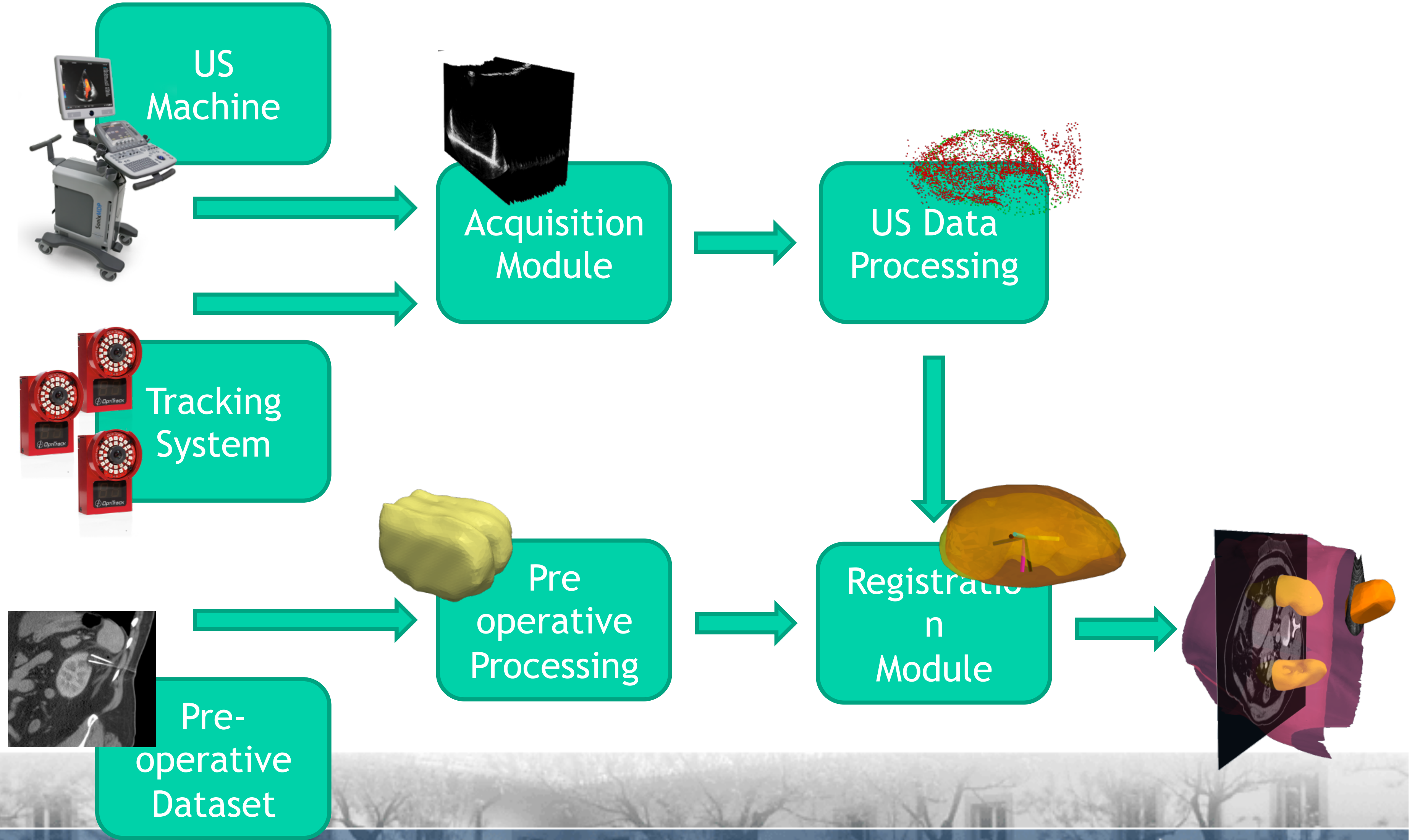


All these points are fundamental to improve the actual outcome of the approach.

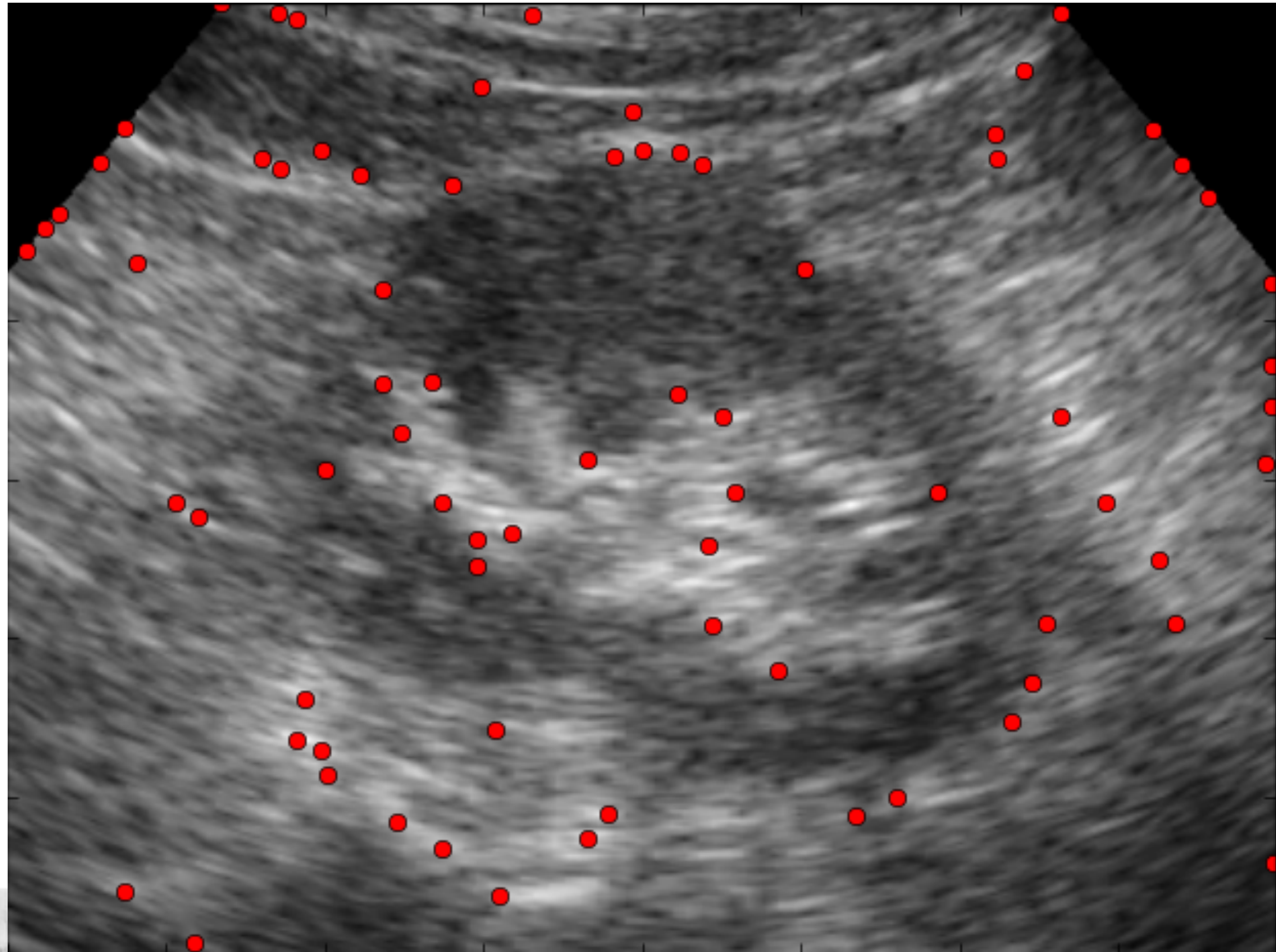
Main Aspects

- **Localizing target area in the US images used for guiding the procedure**
  - Tracked US freehand system for 3D reconstruction
  - US feature points detector and descriptor
- **Correct positioning the ablation tool inside the pathological region**
  - Compact navigation system for guiding percutaneous procedures

Ultrasound Guided Workflow

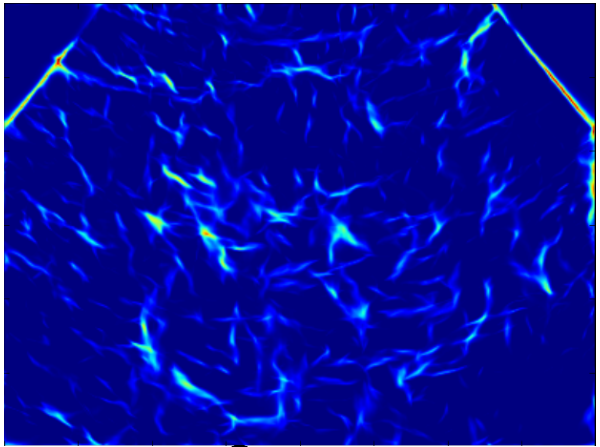


Feature Detection

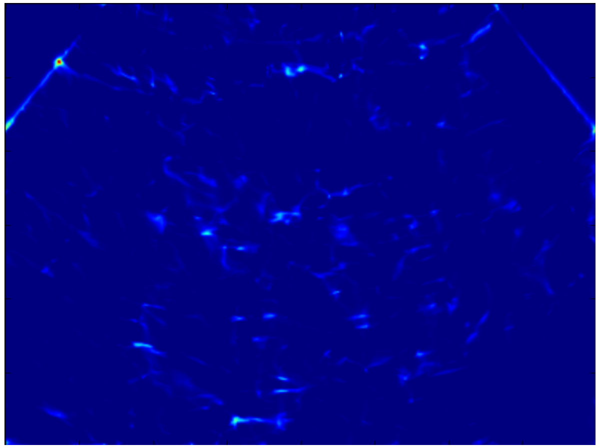


Phase Congruency outputs

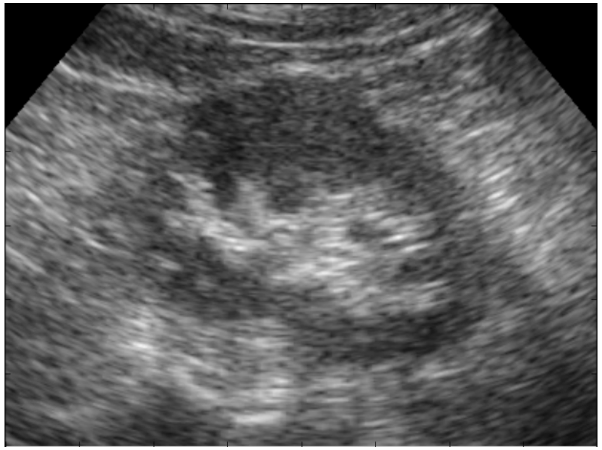
DETECTOR



Q map
Maximum moments $\mathbf{M}$

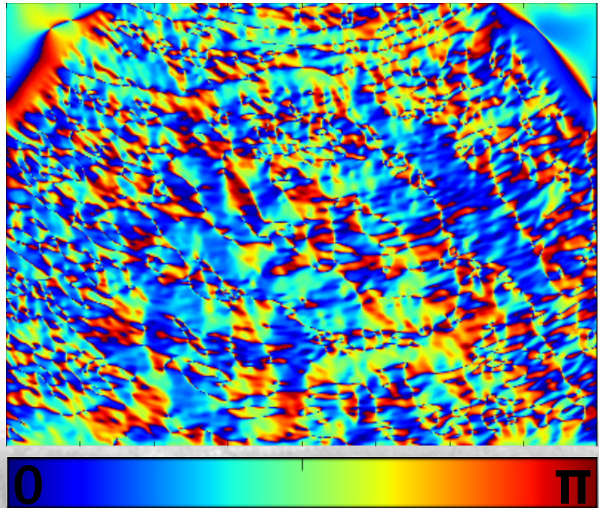


q map
minimum moment $\mathbf{m}$

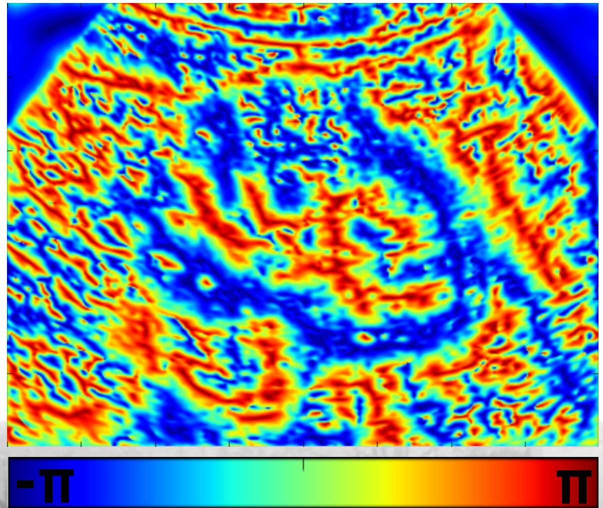


Input Image

DESCRIPTOR

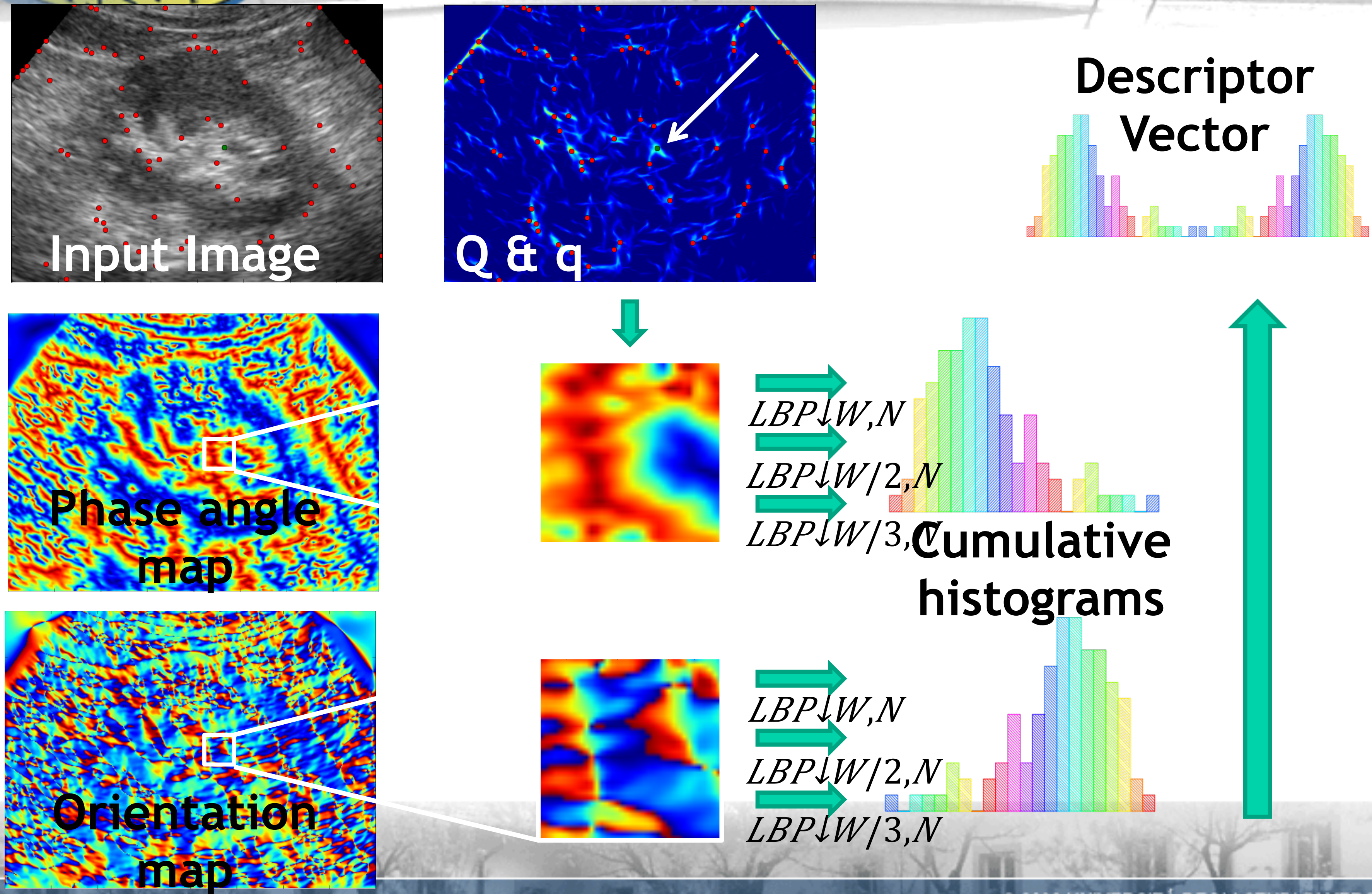


Orientation map

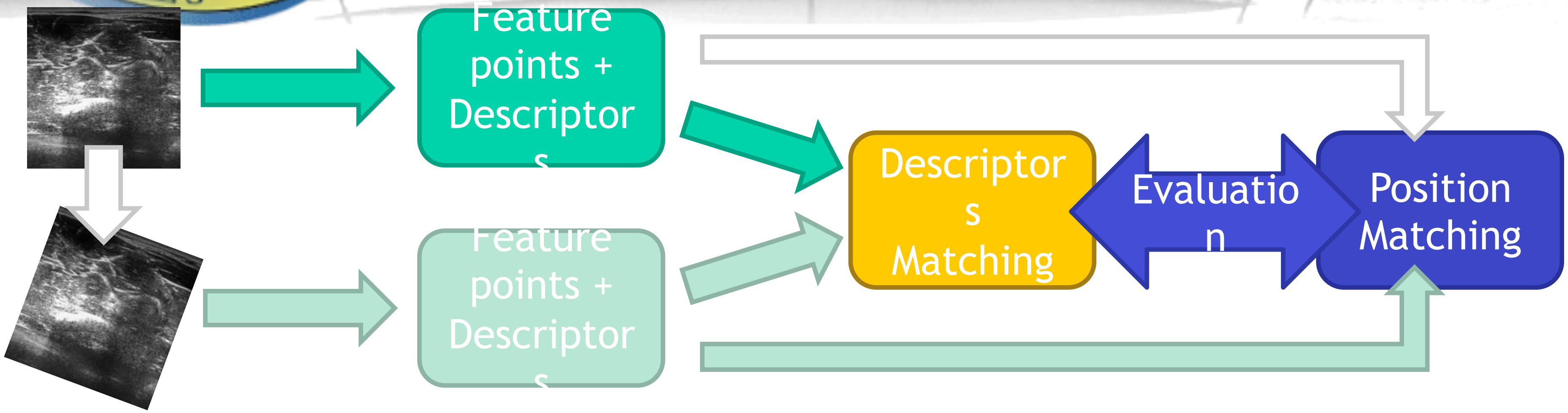


Phase angle map

Descriptor Scheme



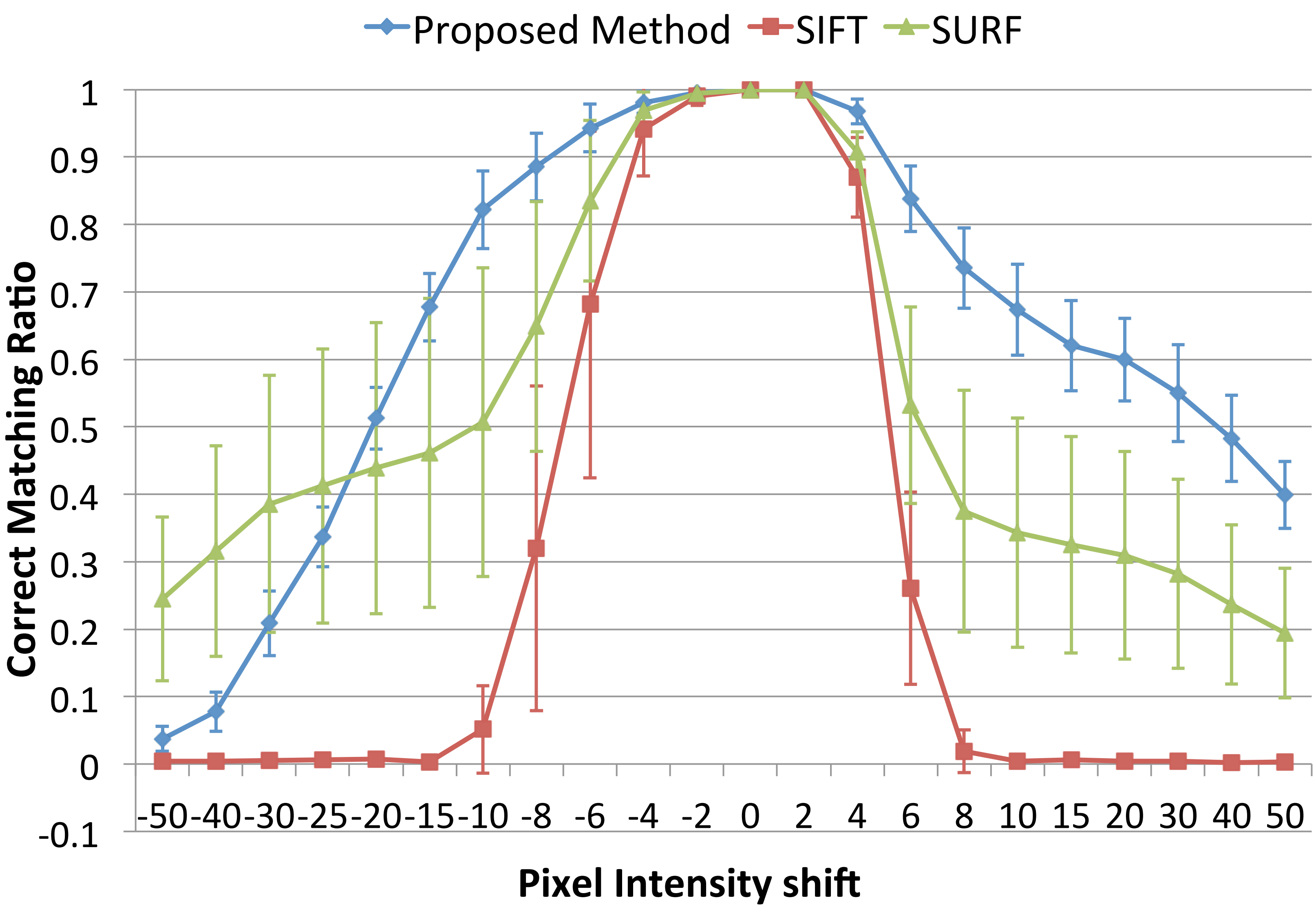
Synthetic evaluation



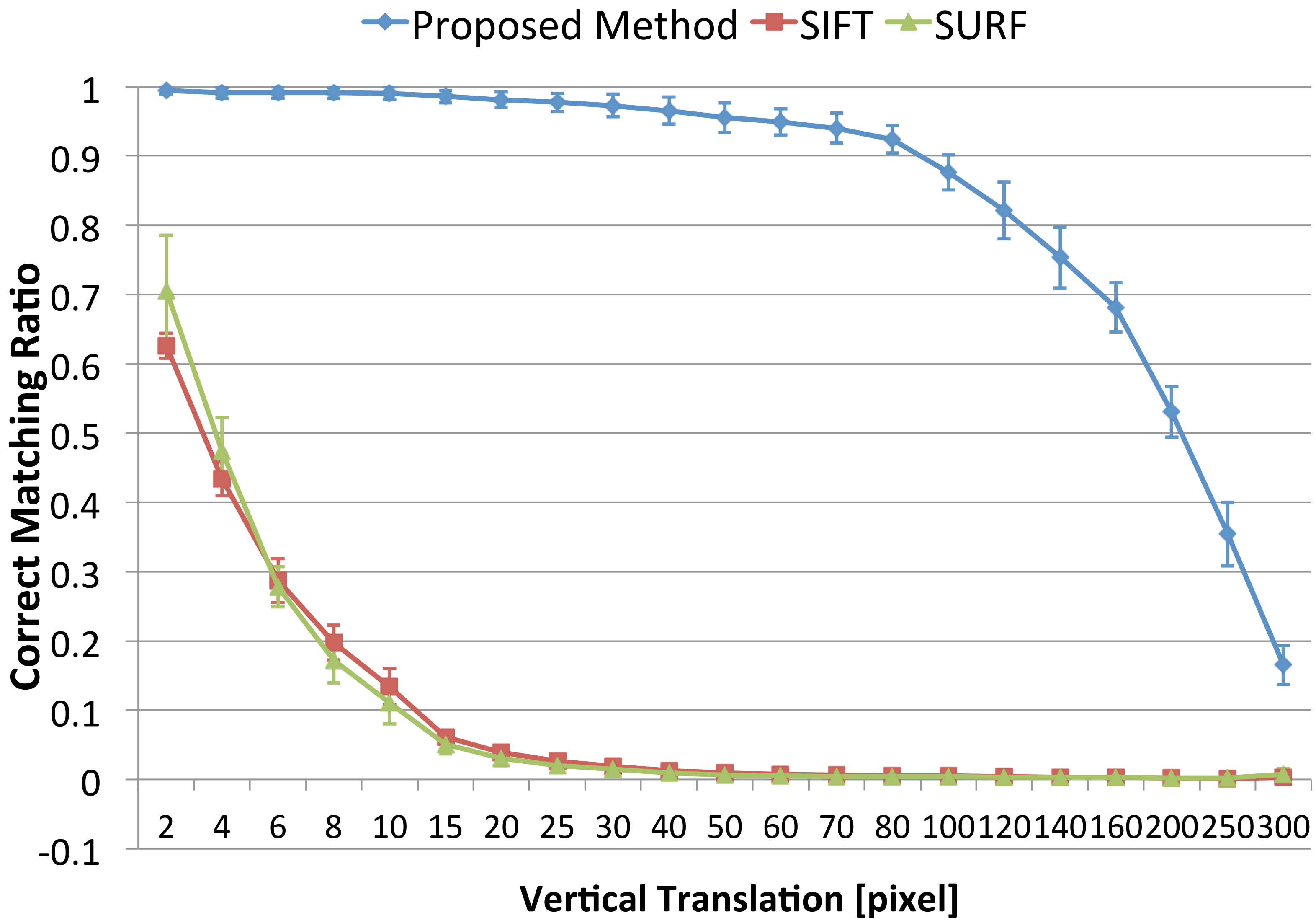
- We compute matching (based on brute-force method) between the results extracted from the two images
- To evaluate the performance of the method we consider the correct matching ratio:

- We compare the results with SIFT and SURF methods.

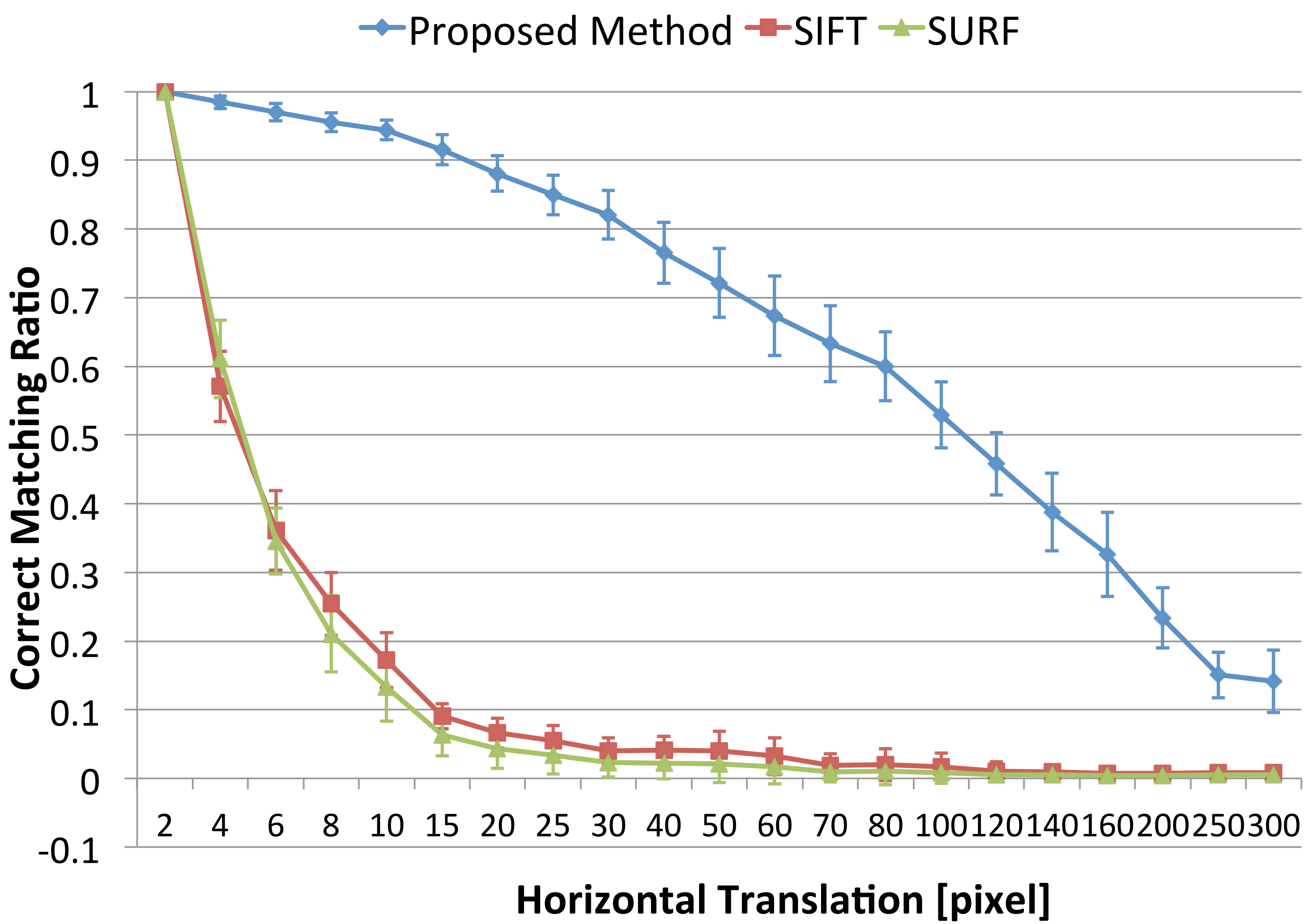
Intensity variation



Vertical Translation



Horizontal Translation



In-plane Rotation

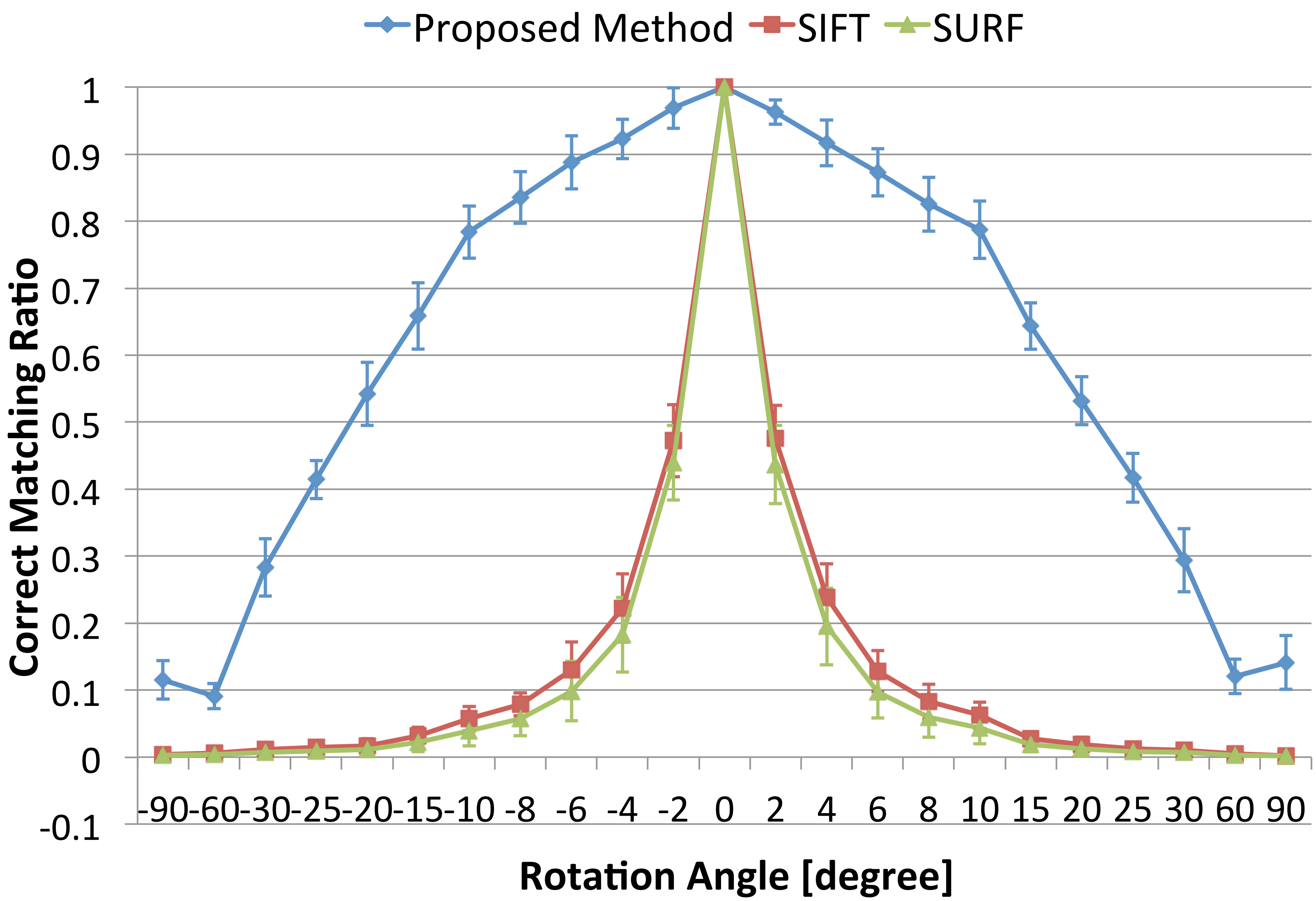
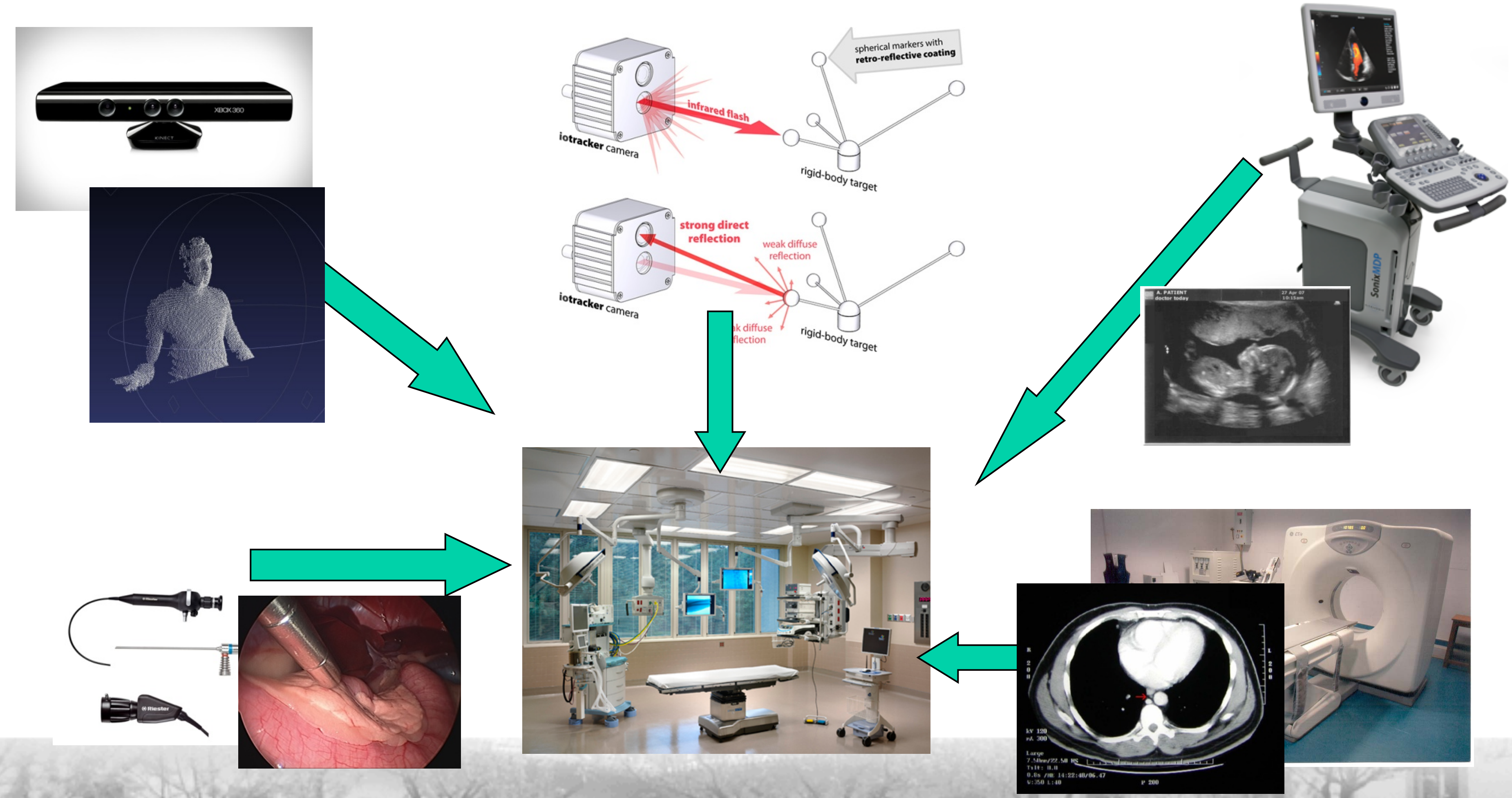


Image Registration

Problem Statement



Rigid Transformation

Problem Statement

- Image registration is the procedure of aligning two or more images of the same scene taken from different viewpoints, at different time, and/or by different sensors, so that corresponding features can be easily related.

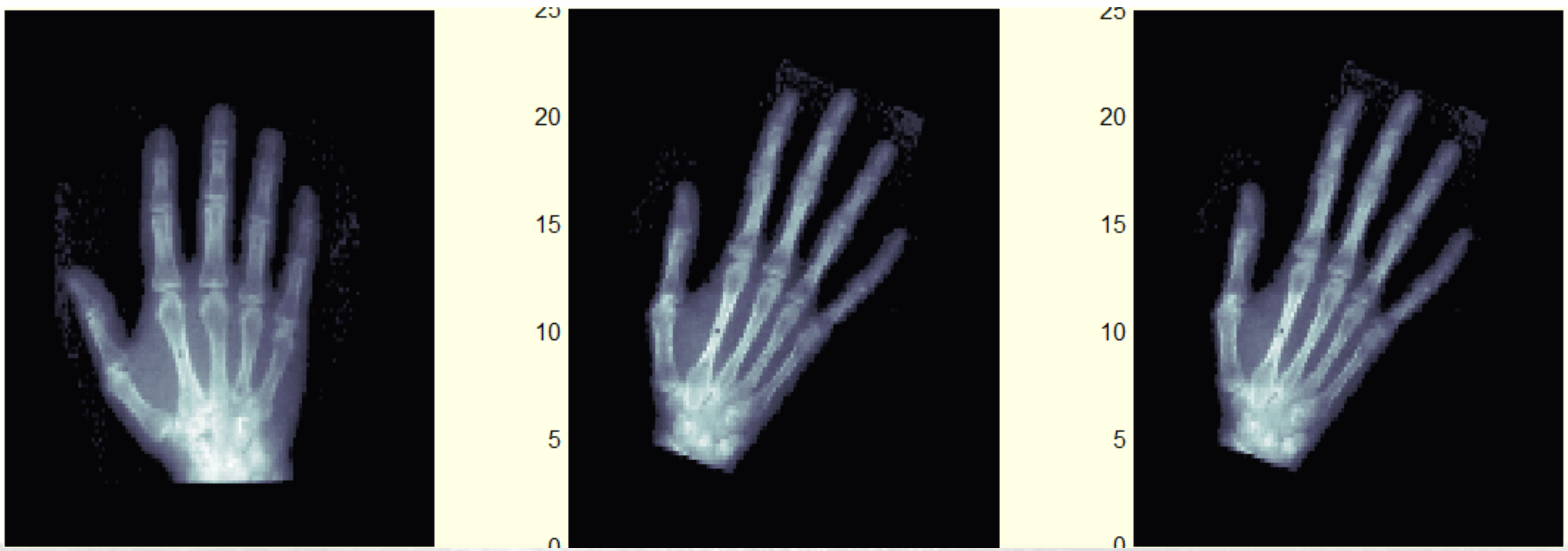
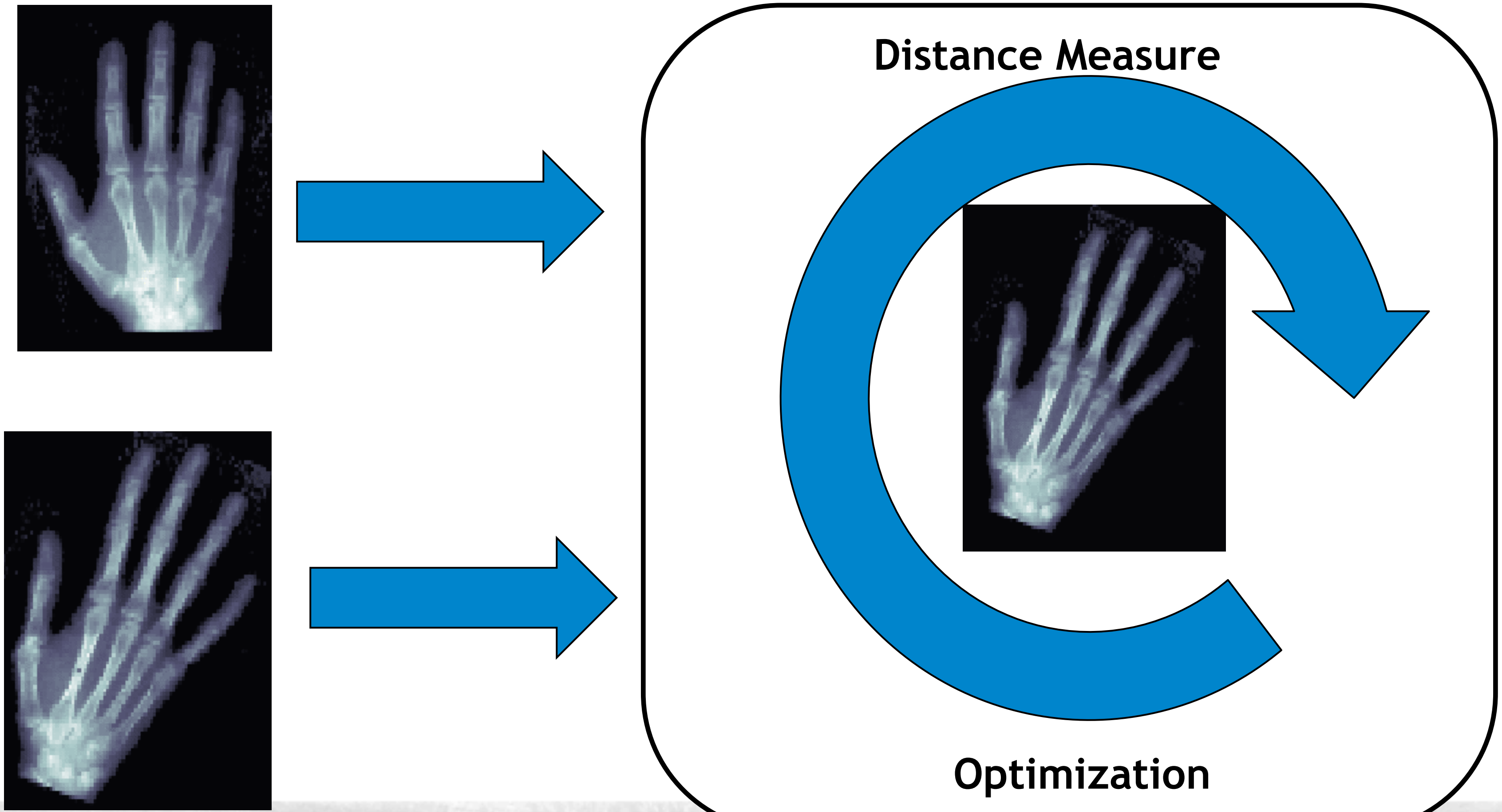
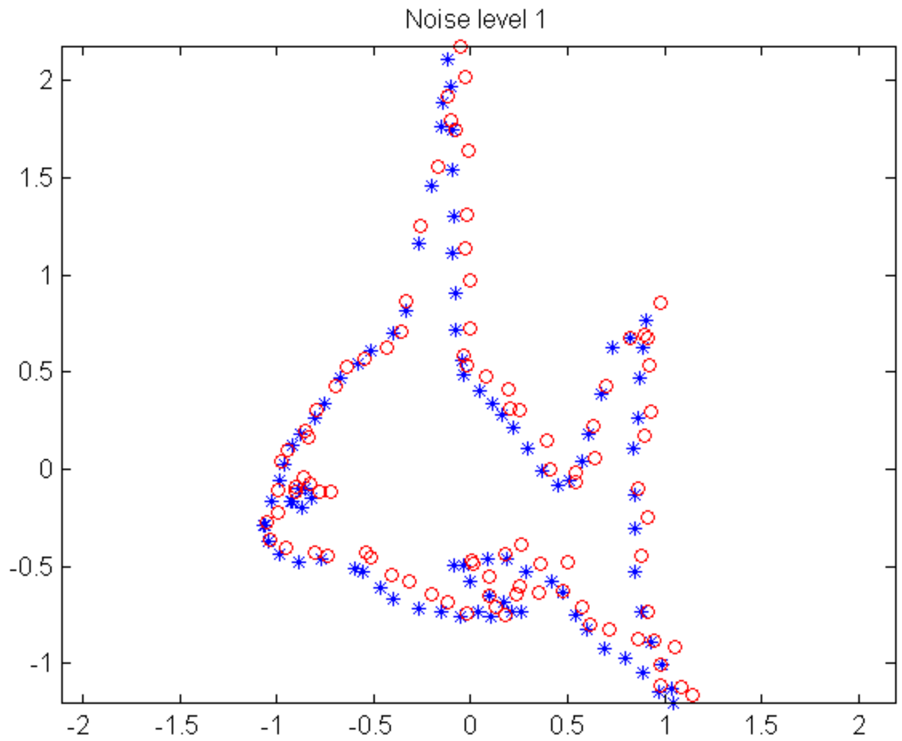


Image registration as an optimization problem

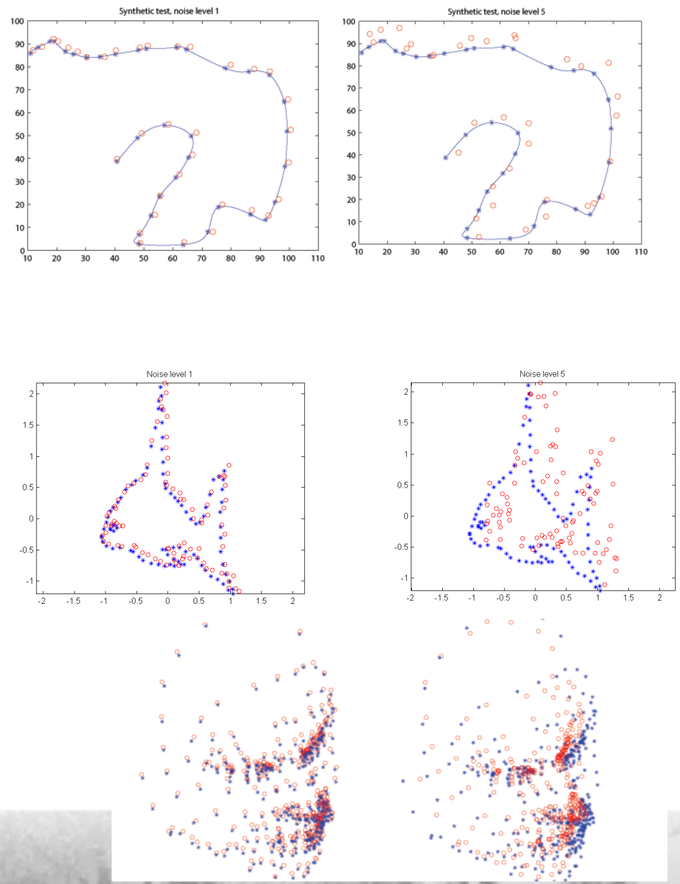


Computation of correspondences: syntethic tests



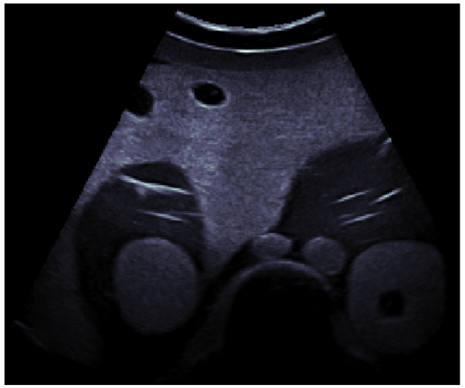
Computation of correspondences: results

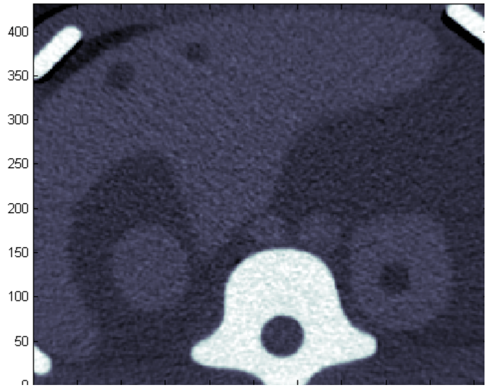
Test no-points no	Noise level	Good corresp.
1-34	1%	88%
1-34	2%	76%
1-34	3%	65%
1-34	4%	56%
1-34	5%	41%
2-38	1%	89%
2-38	2%	70%
2-38	3%	62%
2-38	4%	53%
2-38	5%	44%
fish-91	1%	72%
fish-91	2%	65%
fish-91	3%	58%
fish-91	4%	37%
fish-91	5%	34%
face 3D-392	1%	65%
face 3D-392	2%	48%
face 3D-392	3%	37%
face 3D-392	4%	35%
face 3D-392	5%	24%



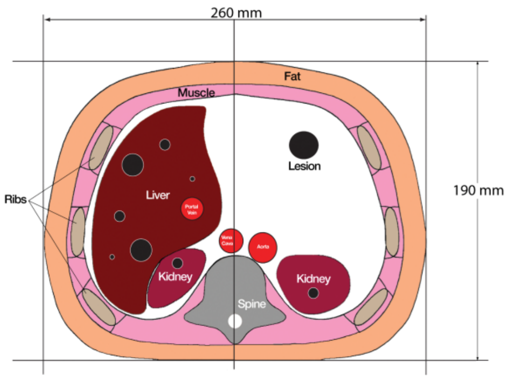
Feature based and intensity based algorithms for image registration

US (ultrasound)
Intra-operative

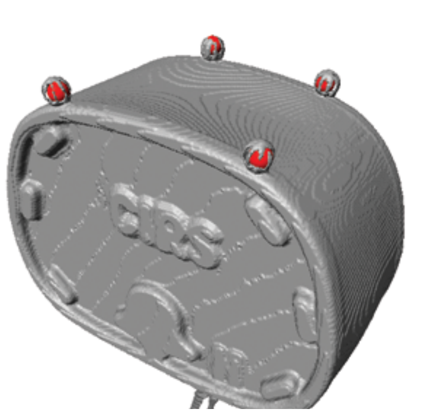




CT (computed tomography)
Pre-operative

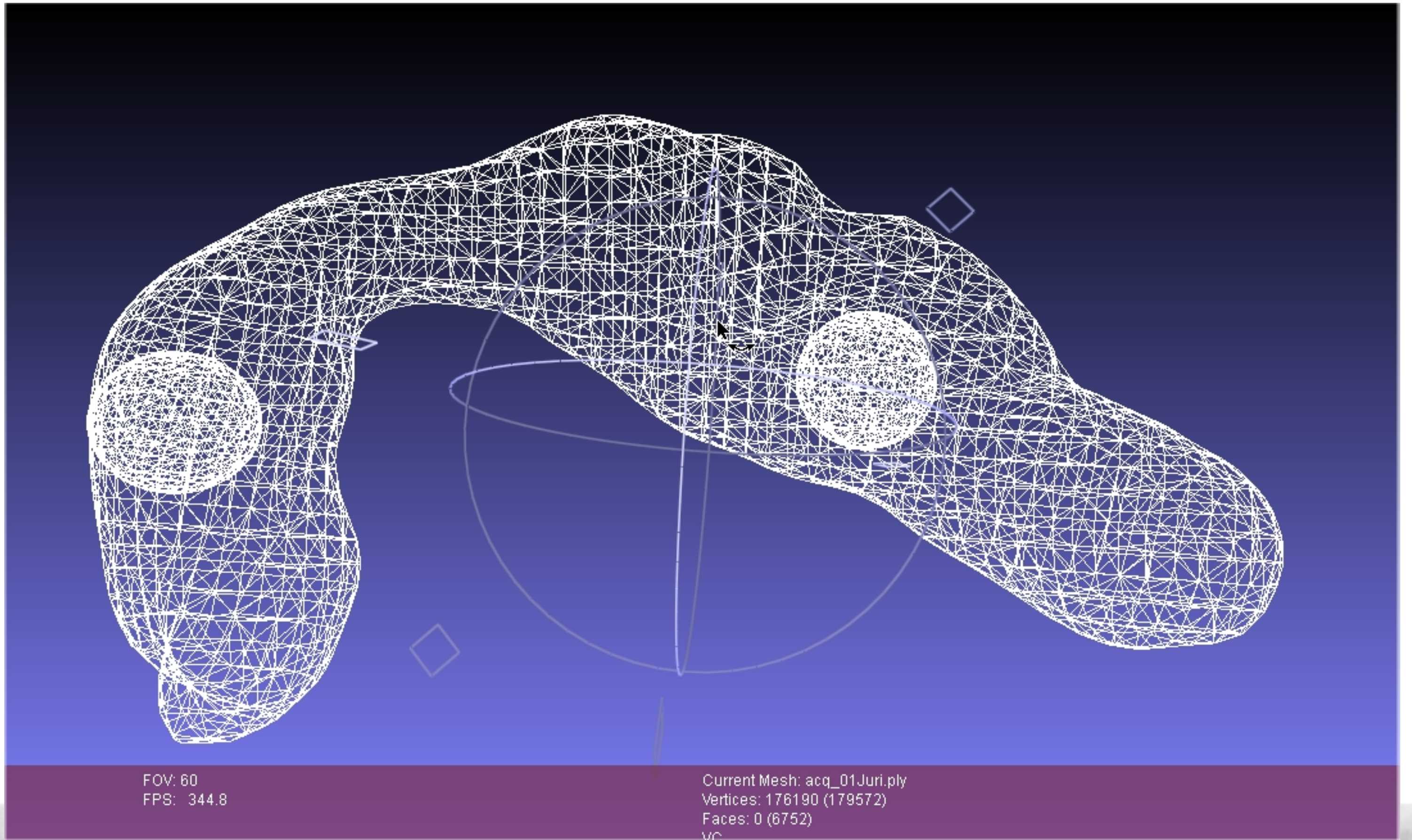


The structure of the phantom

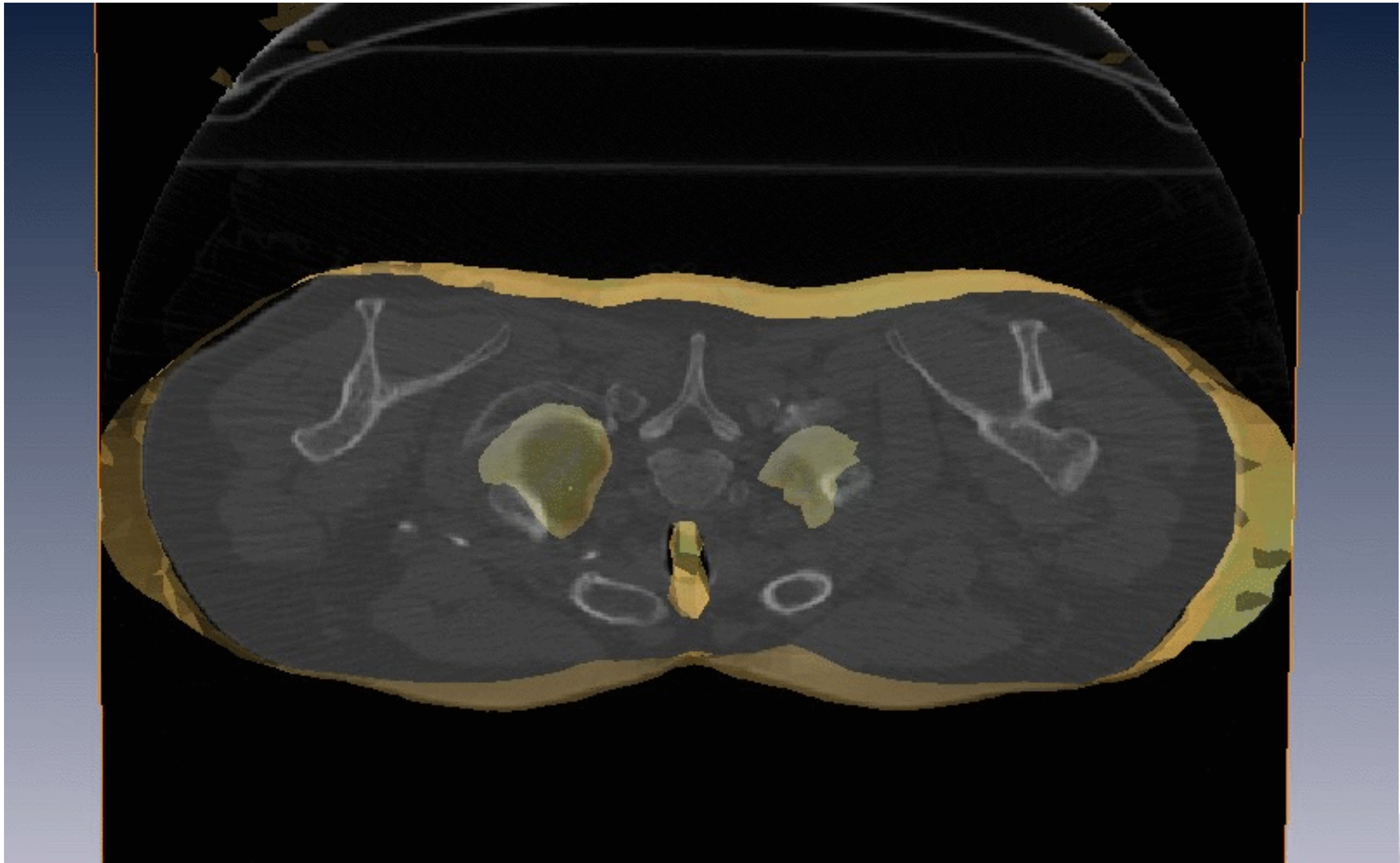


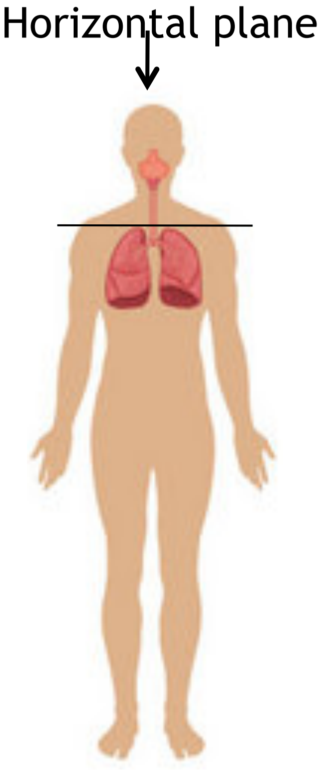
3D reconstruction of the phantom

- Move from a synthetic setup to a real image-guided surgery system.



Computation of correspondences: test on medical images



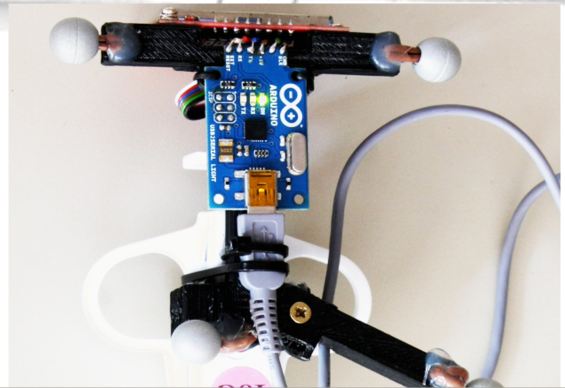


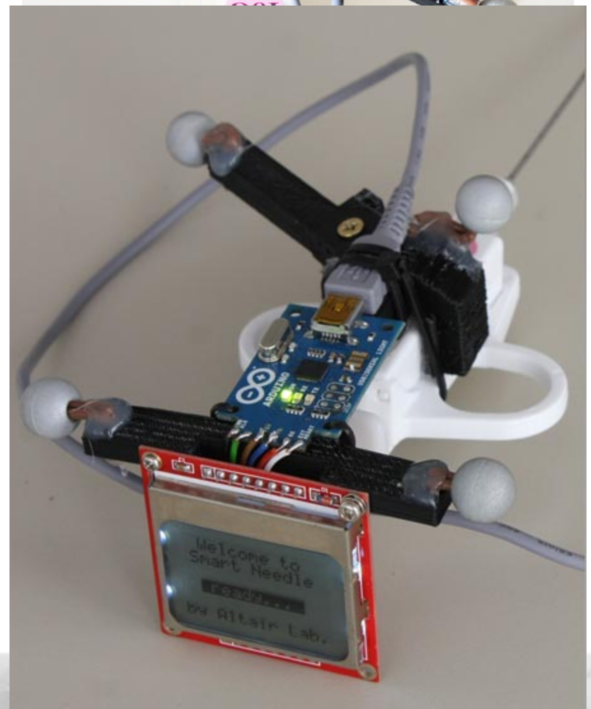
Problems of cryoablation

- Localizing target area in the US images used for guiding the procedure
- **Correct positioning the ablation tool inside the pathological region**

Miniaturized Needle Guidance

- Light and compact device for interventional radiology attached to a standard needle.
- Fast and simple to calibrate, therefore easy to be integrated in the operating room scenario.
- Provides navigation information in an intuitive and ergonomic way.
- The system helps the user to execute the procedure with high accuracy and precision.

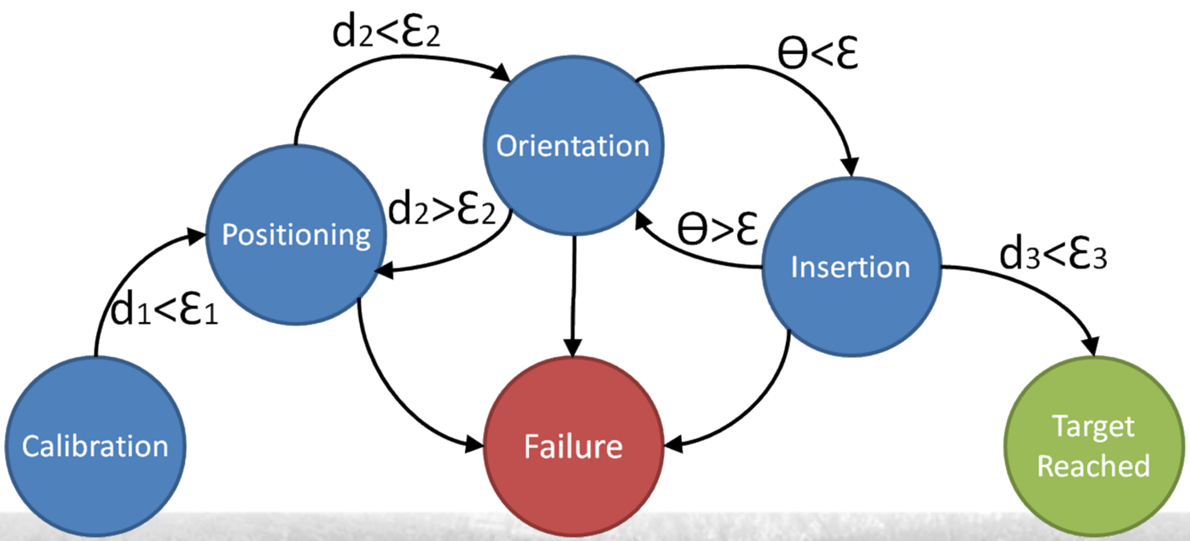


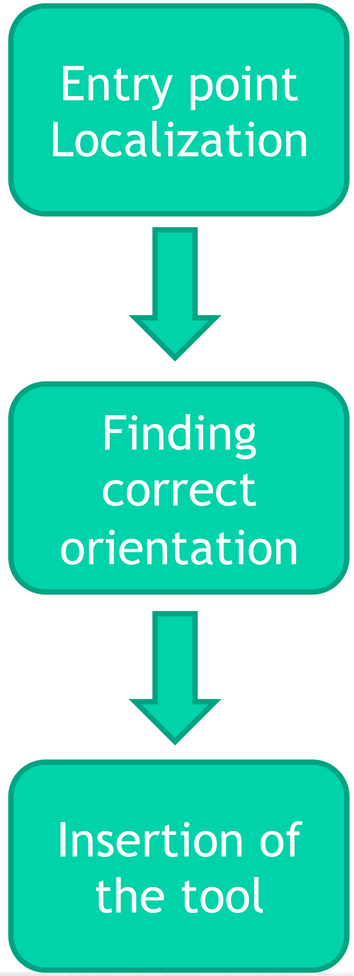


Ablation tool guidance

It could be subdivided in 3 phases:

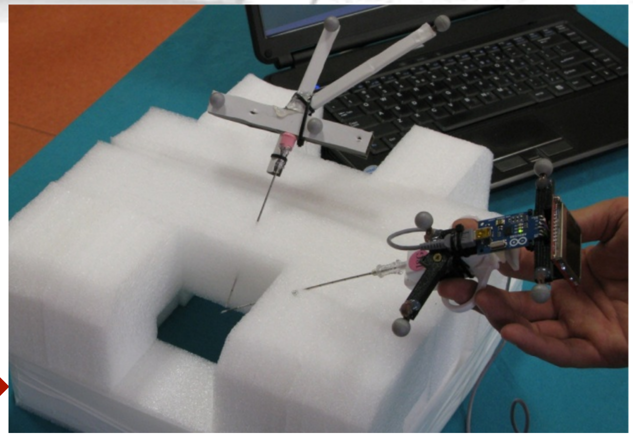
- Finding entry point on the patient skin
- Finding the correct orientation to reach the target
- Inserting the tool with the correct depth

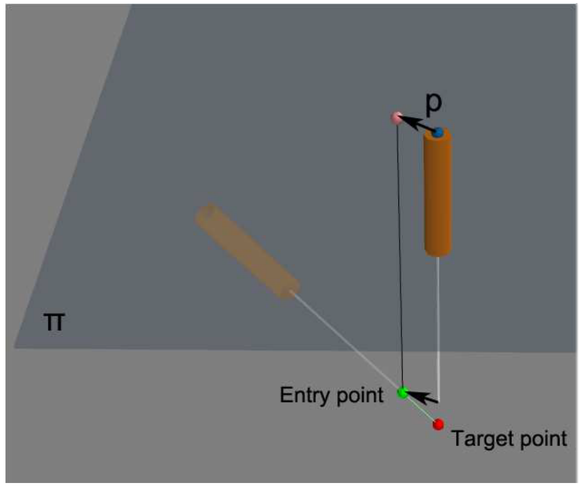




Experimental Evaluation

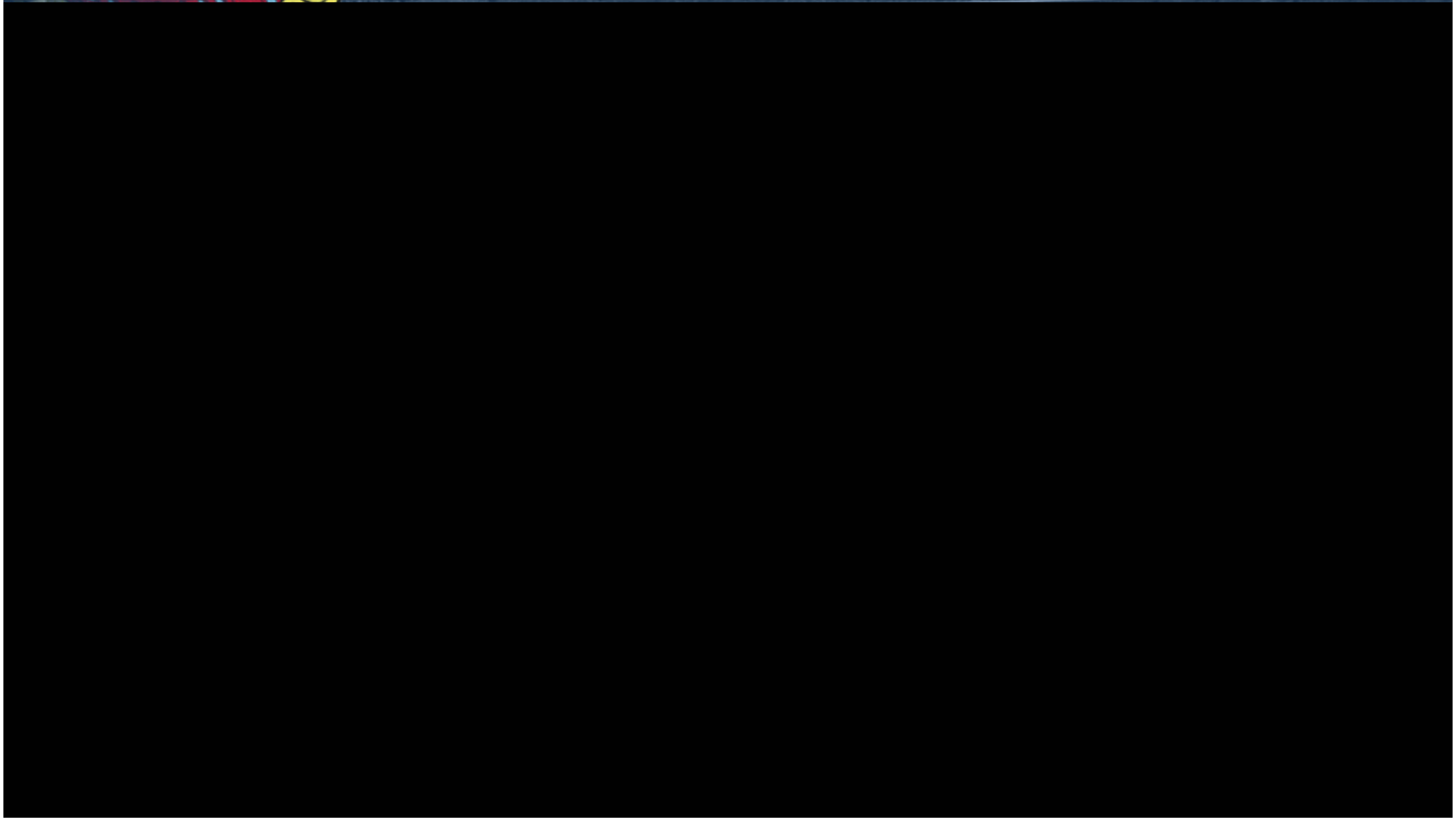
- Synthetic phantom
- Fixed target point position in common reference system
- 5 pre-defined entry point positions → 5 planned insertion orientations
- 6 user without previous experience, 5 insertion for each entry points
- Two experimental setups:
  - Proposed navigation system
  - Standard navigation system (external display with 3d navigation information)





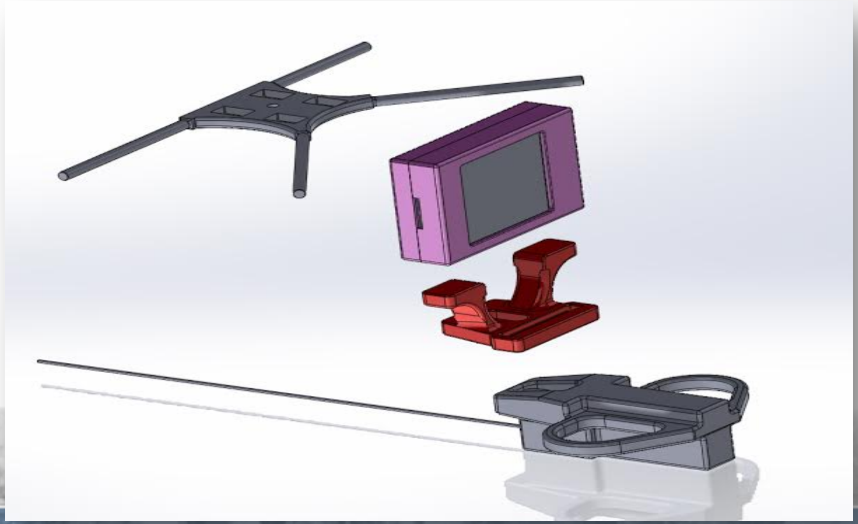
System in Action

Preliminary Tests



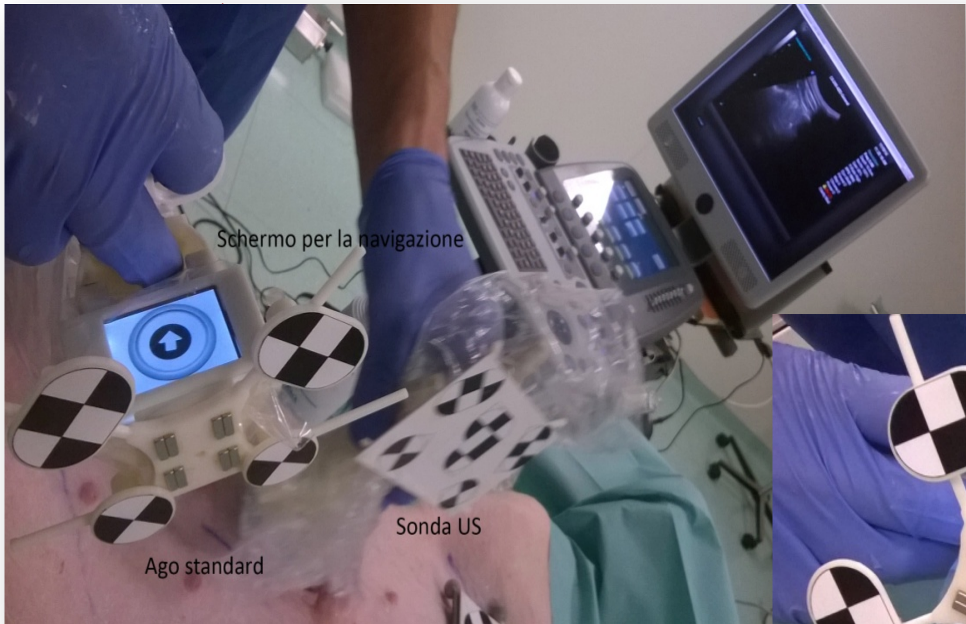
Work in progress

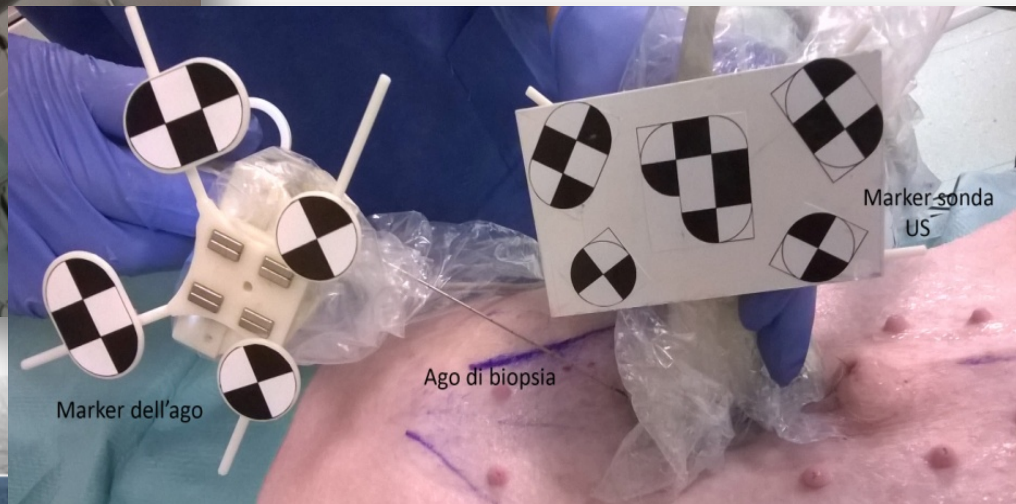
- Re-design of the compact navigation system
  - Modular and ergonomic design
  - High resolution color display
  - Sterile environment compliant



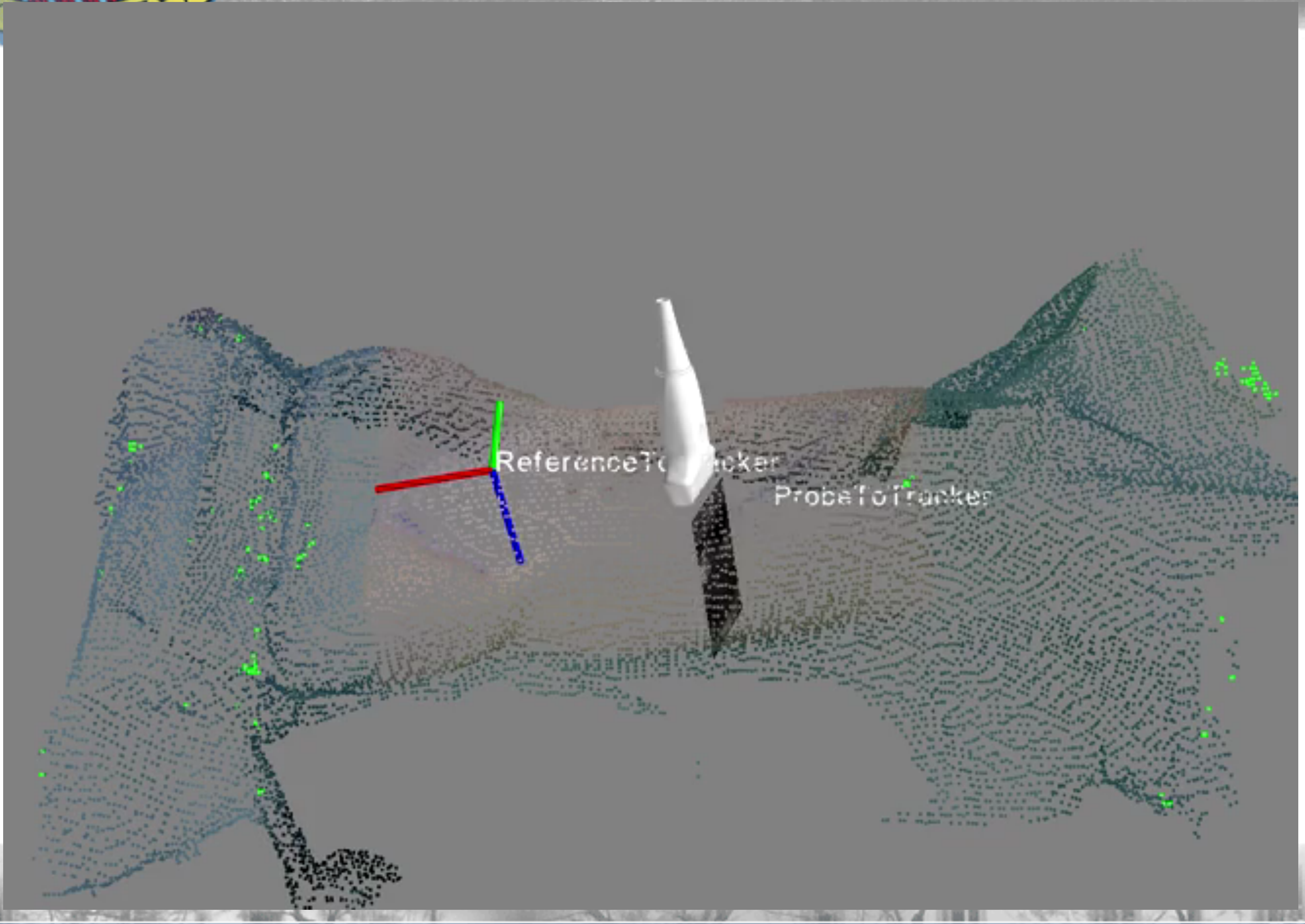
Work in progress

- Pre-clinical evaluation (animal trials) of the compact navigation

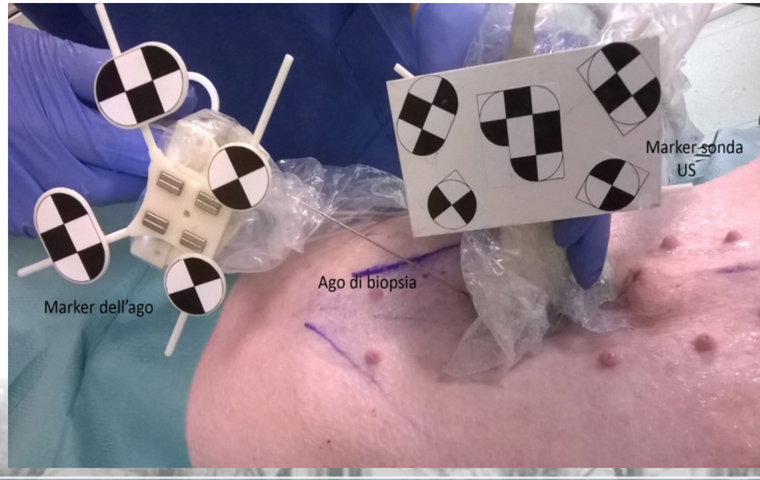




Example application



- Tracker registration point precision < 0.7 mm
- Rigid registration between point cloud (Bogdan) and tracker error: 0.467 ± 2.227 mm
- Needle calibration error: 0.864±0.629
- US probe calibration error: 0.733±0.397
- Needle tip localization error from tracked US images: **3.421 ± 2.772**



Cognitive Surgical Robotics

A cognitive surgical robot architecture needs the following technologies:

- New methods for representing the ***medical knowledge*** relevant to soft organ surgery,
- New methods for the interactive planning of surgery in ***deformable environments***,
- New designs of dexterous, sensorized ***instruments*** for robotic surgery,
- New methods for ***intervention*** execution and monitoring,
- New methods for real time data processing and medical ***situation awareness***,
- New ***communication*** methods between the robotic instrument and the operating surgeon.

Proposed Framework

We have designed and implemented a new control and coordination framework for the automation of surgical tasks

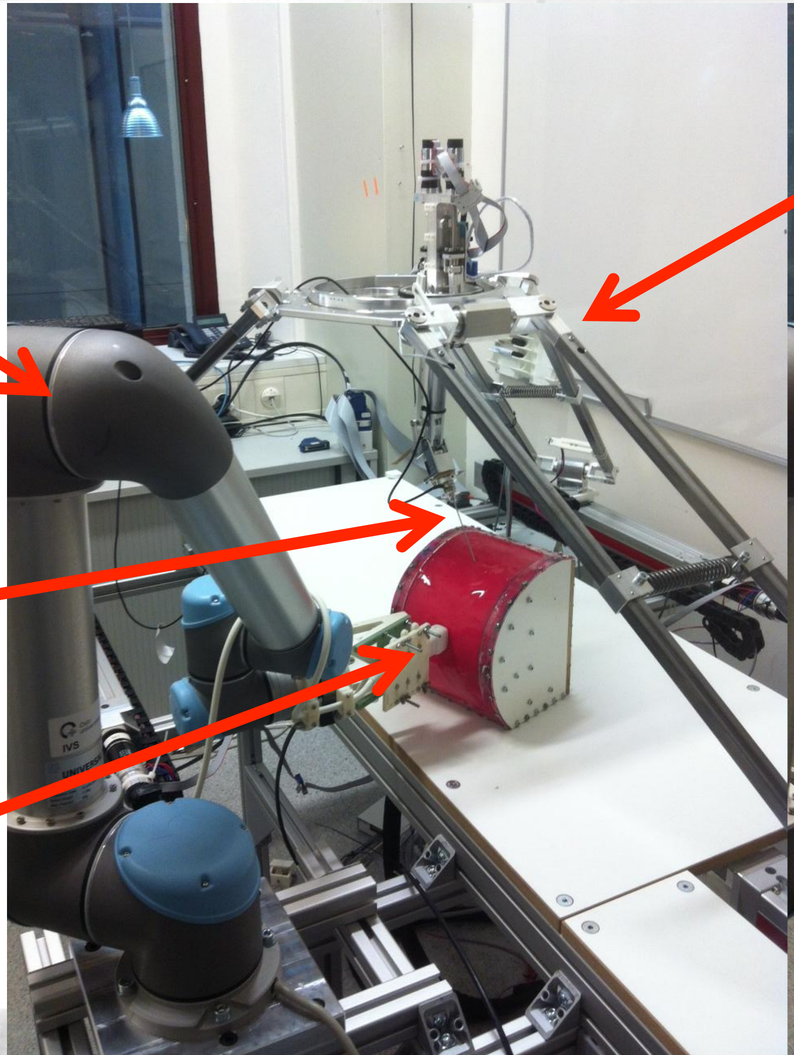
The selected surgical tasks are

- US-guided/supervised insertion of a needle (i.e. puncturing for cryoablation)
- Suturing with an endostich

Key elements:

1. rigorous assessment of surgical requirements,
2. formal specification of robotic system behavior (e.g. multiple arm coordination and human/system interaction),
3. control software development with state-of-the-art component-based technologies.

Experimental Setup



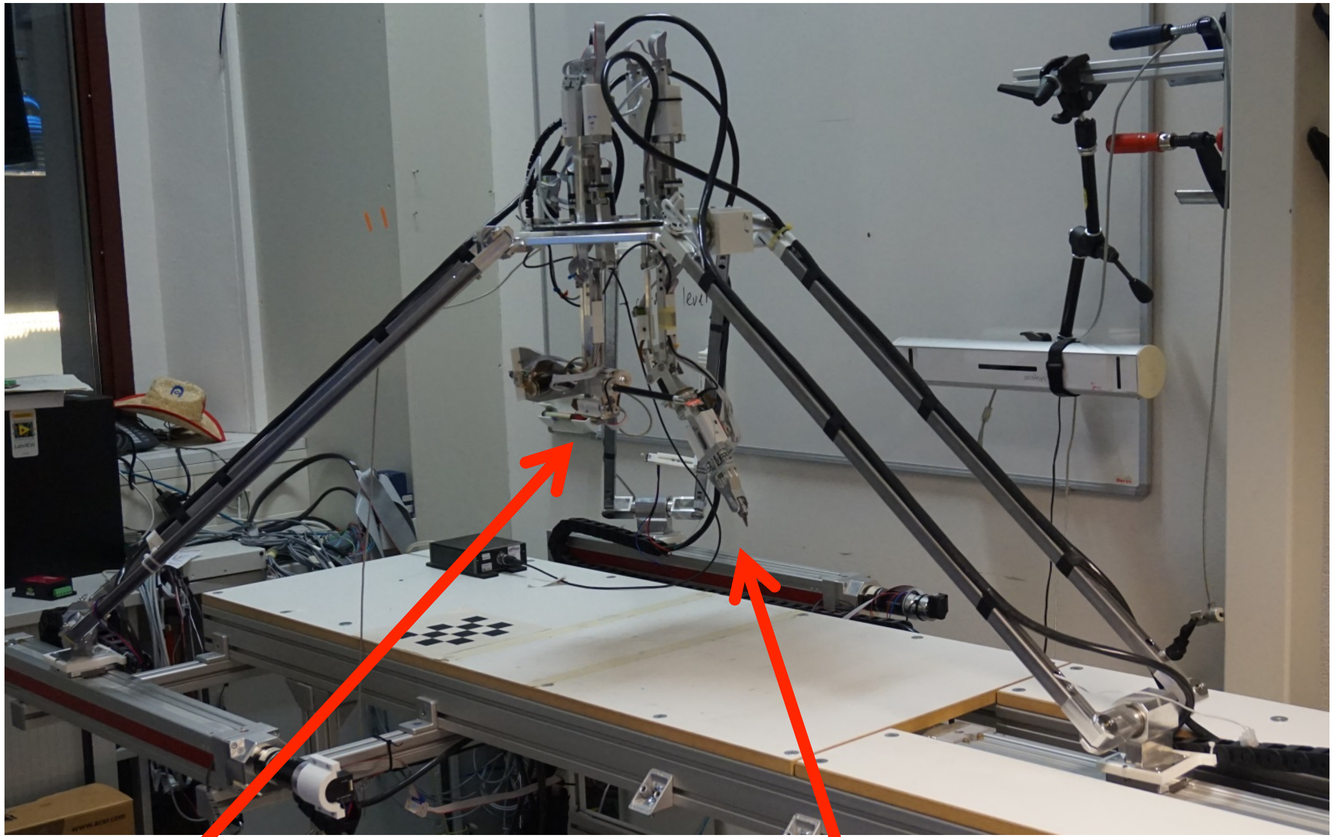
ISUR robot

Developed and manufactured at ETH (RElab)

It is based on a macro-micro mechanical approach

The macro unit is a parallel robot for the coarse movement, whereas the micro unit is devoted to the fine movement

Experimental Setup



Endostitch

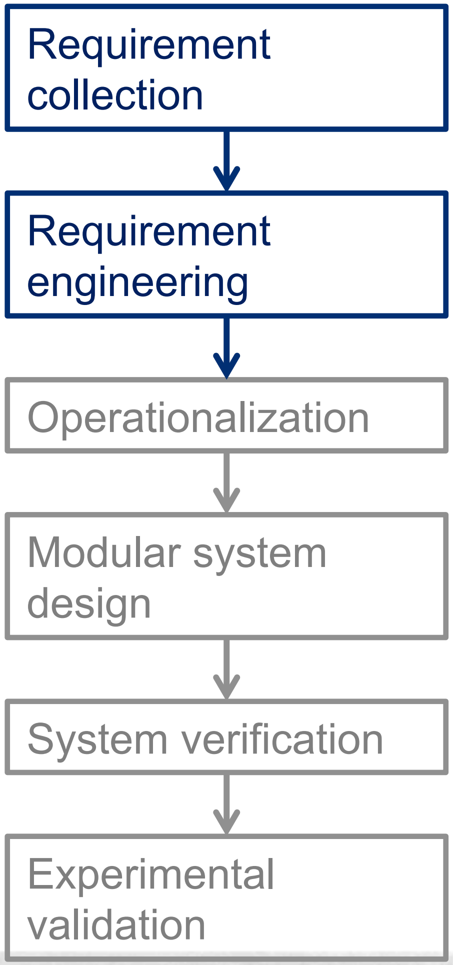
Second arm

Requirement Engineering Approach

- **Requirement collection**
- Requirement engineering
- Operationalization
- Modular system design
- System verification
- Experimental validation

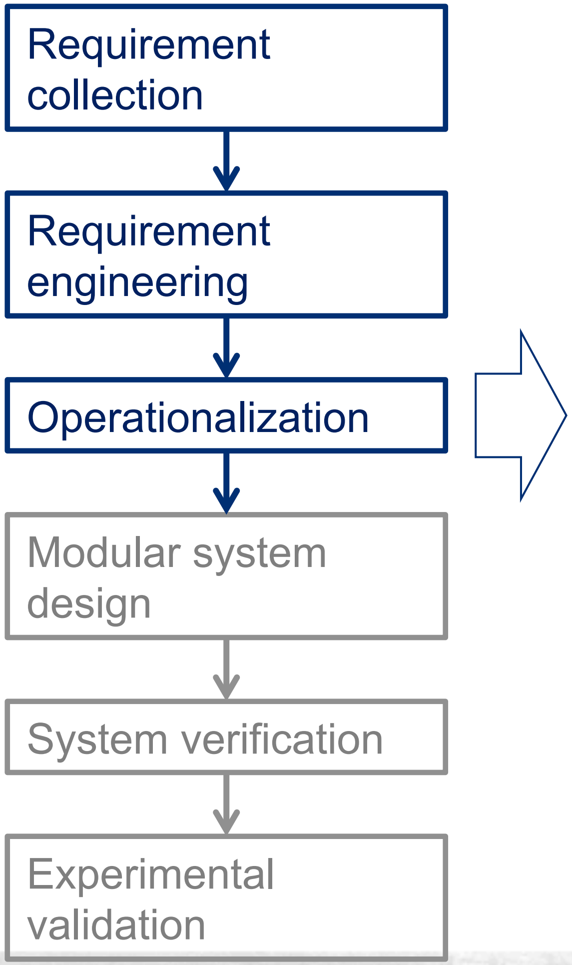
Interviews with surgeons to understand the surgical procedure and the critical events

Requirement Engineering Approach



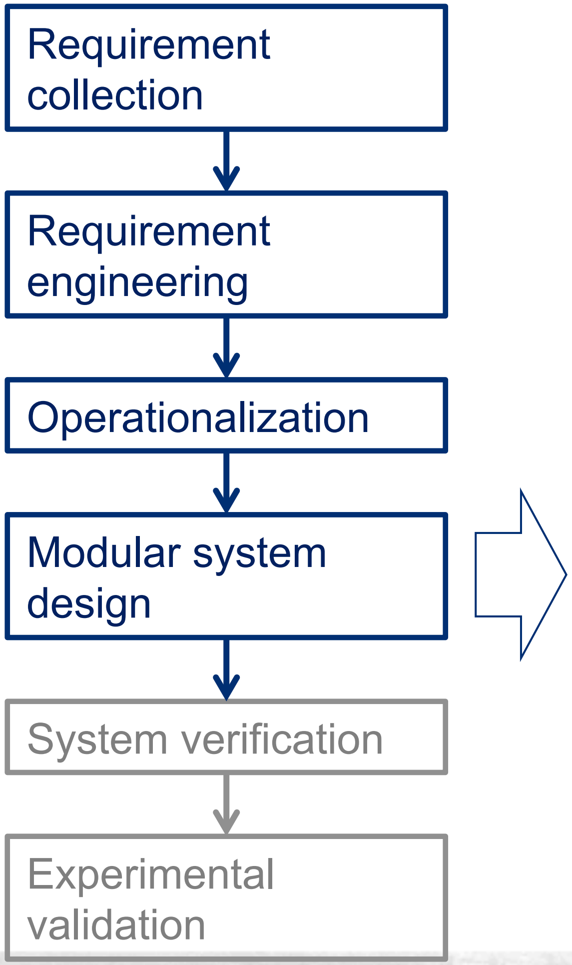
Surgical requirements expressed using a goal-oriented methodology.
First-Order Logic (FOL) and Linear Temporal Logic (LTL) are used to formally describe the surgical task

Requirement Engineering Approach



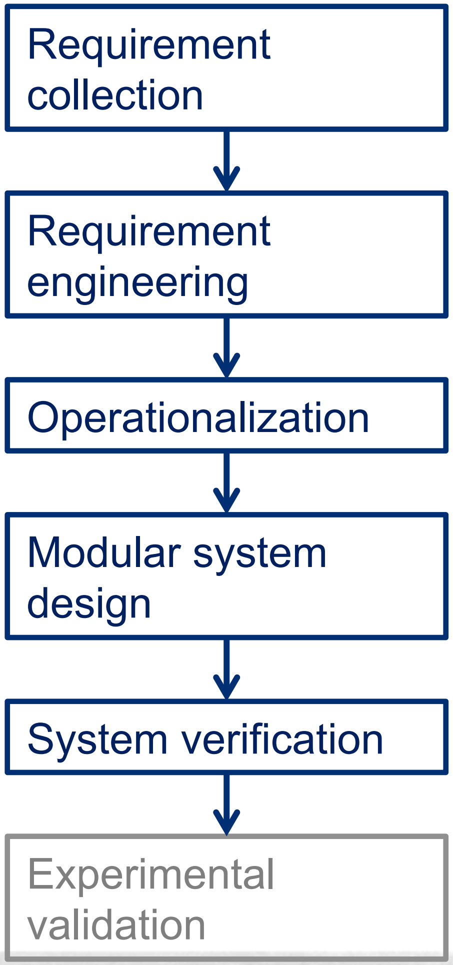
The goal model is transformed into a sequence of operations and adaptations satisfying the requirements

Requirement Engineering Approach



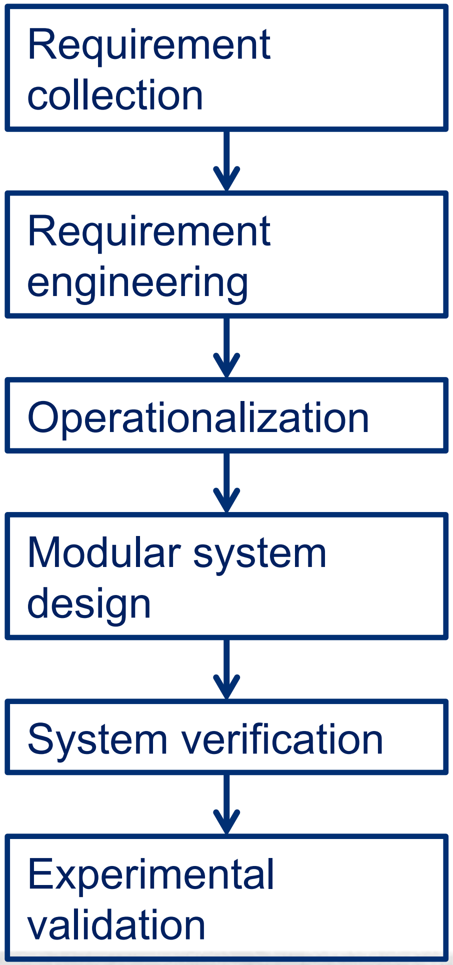
The sequence of operations and adaptations are refined and partitioned into the subsystems implementing a collaborative and coordinate behavior

Requirement Engineering Approach



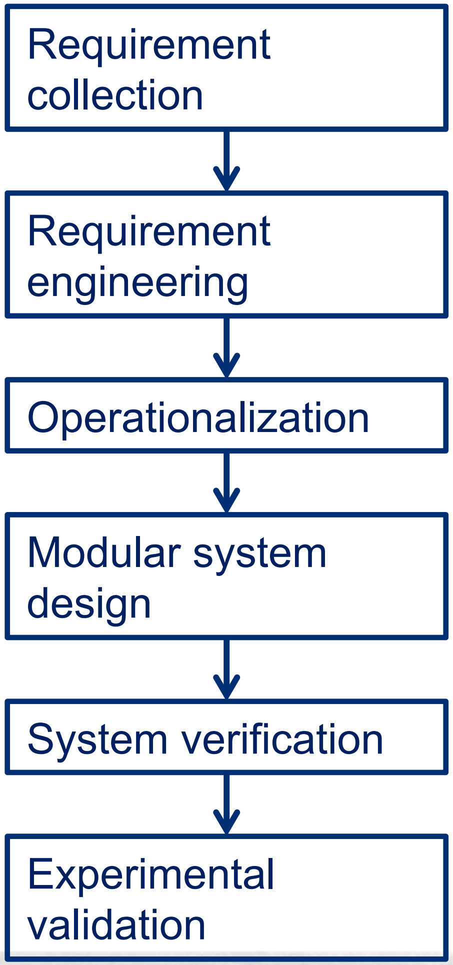
Model checking techniques are applied to verify that the system model preserves the requirements of the goal model

Requirement Engineering Approach



Test the surgical robotic platform in realistic scenarios

Requirement Engineering Approach

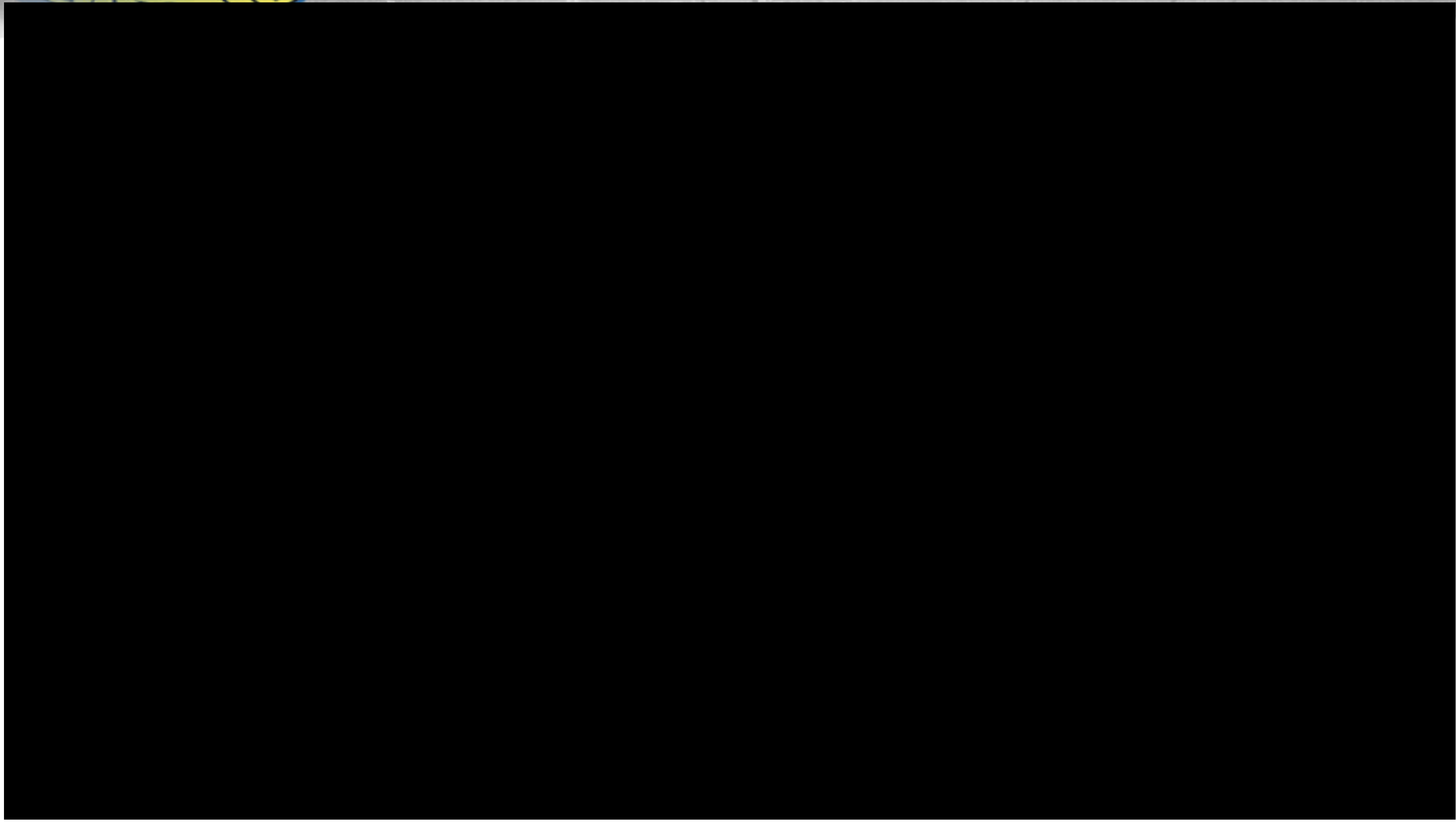


!!!
SW tools are available to perform these operations in a straightforward manner
!!!

Requirement Engineering Approach

Requirement collection
↓
Requirement engineering
↓
Operationalization
↓
Modular system design ⇒ Design the high level controllers and the logic
↓
System verification
↓
Experimental validation ⇒ video

Videos



Videos

Questions

Robotics Tomorrow in Central Europe: Trends and Challenges

Paolo Fiorini

Department of Computer Science

University of Verona

Italy

Central Europe Common Elements

- Big disparities among different regions
- “Islands of innovation” in certain areas, next to
- Rural regions/areas with low or no technology
- Different financing and innovation opportunities for SME’s.
- These differences are intensified by the economic crisis

The dynamism of regions must be exported to other areas through networks in a regional globalisation process

Focus on Services to the Citizen

New investments are justified by services to the Citizens:

- Health care
- Energy
- Environment
- Mobility

Through:

- Importing working models
- Creating opportunities
- Education and training
- Addressing legal and ethical issues of innovation

How Can Robotics Help?

- Robotics is “technolgies and systems” that can work across different domains
- Robotics can help solve problems in many domains
- However it is difficult to make it into a sustainable business

- The main challenges will be to find an approach that solves the mixture of technical and non technical problems and reach the market in a short time.

- We are competing with geographical areas, (e.g. Silicon Valley, Israel) that have a different culture of some European areas.

Trends & Challenges

- Key elements are:
  - Benefits to users (people-centered design)
  - Reduced risk to investors
  - Shorter time to market
  - “Personalized” business model

- Trends & Challenges:
  - Surgical robotics, an example

Trends

- Robotic surgery is a reality and is the current trend in operating room procedures
- Medical personnel and patients are “sold” on the use of robots in surgery (thanks Intuitive ☺ !)
- Hundreds of European laboratories are generating ideas and prototypes
- Algorithms and controls are demonstrated successfully
- System validation and animal tests are carried out everywhere

- **However no European surgical robot is on the market!!**
- **Is this a challenge or a message?**

Challenges

- Key Factors:
  - Benefits to users (people-centered design)
  - Reduced risk to investors
  - Shorter time to market
  - "Personalized" business model

- Robotic surgery ➔ benefit to patients?
  - Not all the time:
    - Need better training
    - Need new professional figures

Challenges

- Key Factors:
  - Benefits to users (people-centered design)
  - Reduced risk to investors
  - Shorter time to market
  - “Personalized” business model

- Robotic surgery ➔ reduced risk to investors?
  - Not at all, unless:
    - Validated projects are selected
    - Investment is proportional to risk

Challenges

- Key Factors:
  - Benefits to users (people-centered design)
  - Reduced risk to investors
  - Shorter time to market
  - “Personalized” business model

- Robotic surgery → shorter time to market?
  - Not at, all unless:
    - Certification carefully planned
    - Simple/niche markets are addressed

Challenges

- Key Factors:
  - Benefits to users (people-centered design)
  - Reduced risk to investors
  - Shorter time to market
  - "Personalized" business model:
    - Use "results" of European research not "ideas"
    - Design an investment plan proportional to the risk
    - Identify markets not in conflict with big players
    - Stay away from Venture Capital (we want to create industries and not speculations)
    - Invest on training:
      - Develop an entrepreneurship culture
      - Develop/find start-up manager figures
      - Develop the robotic "profession"

Conclusions

- Robotics can be an engine of technological development and economical growth
- We need to leverage on Central Europe strengths:
  - Great role models (e.g. DLR)
  - Strong work ethics
  - Common cultural background and heritage
- We need to avoid the myths of high tech start-up's
- We must adapt "any" approach to the specific needs of each area to leverage on (and bypass) the local strengths

Questions