

# Human – Robot Cooperation Techniques in Surgery

*Alícia Casals*

Robotics Group

Institute for Bioengineering of Catalonia, Barcelona  
Universitat Politècnica de Catalunya, Barcelona Tech,

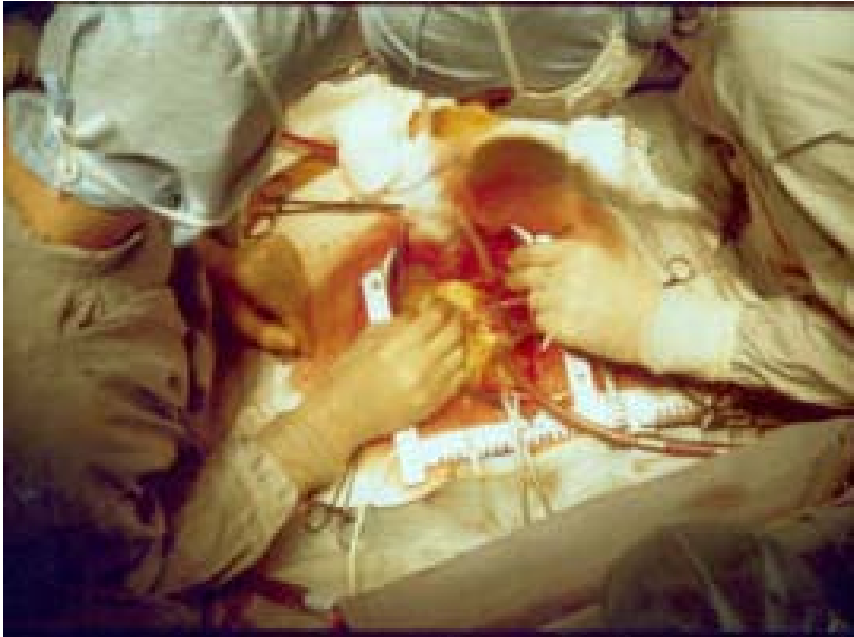


## ICINCO 2010

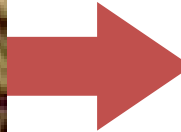
*7<sup>th</sup> International Conference on Informatics in Control, Automation and Robotics*

15 - 18 June, 2010  
Funchal, Madeira - Portugal

# Progress in Surgical Procedures



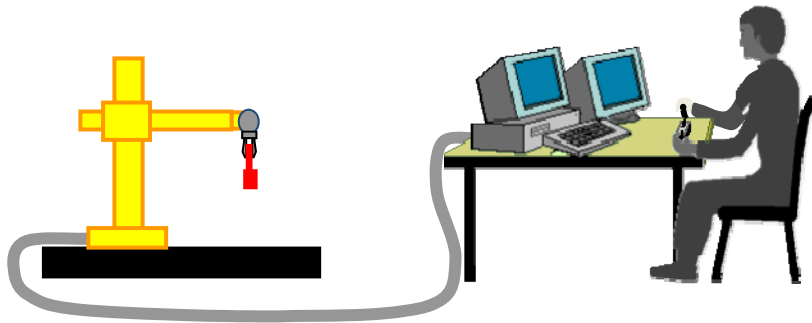
Open surgery



Minimally Invasive Surgery



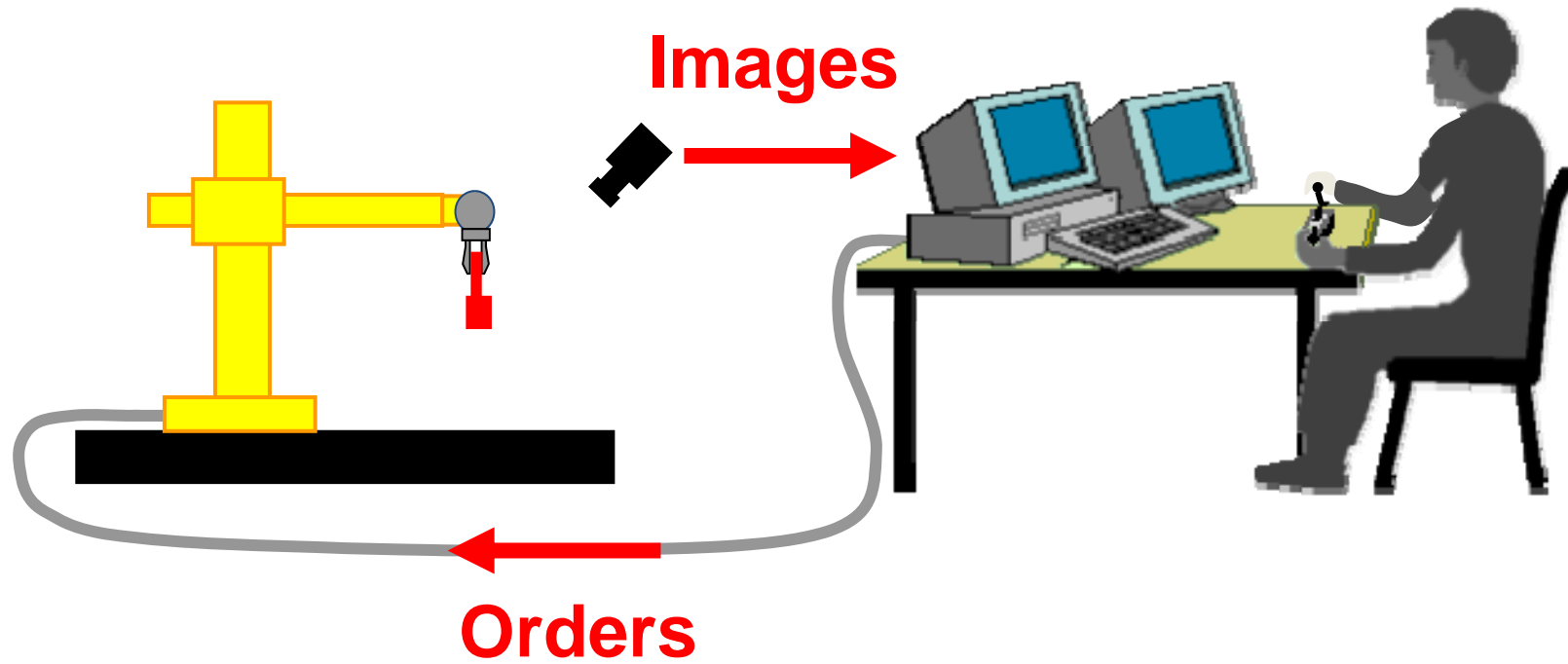
# Human - Robot Cooperation



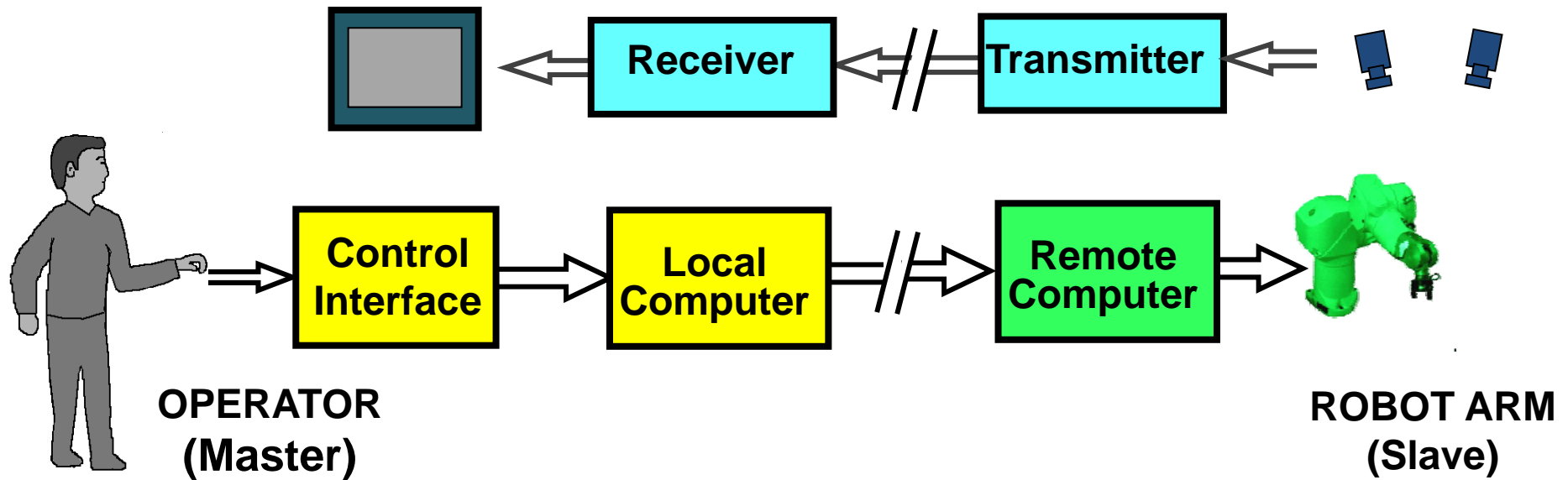
## Why Teleoperation?

- Not enough intelligent robots
- Human limitations to operate directly
  - Access to the working space
  - Unsafe environments
  - **Improving Human / Robot performances**

# Human - Robot Cooperation

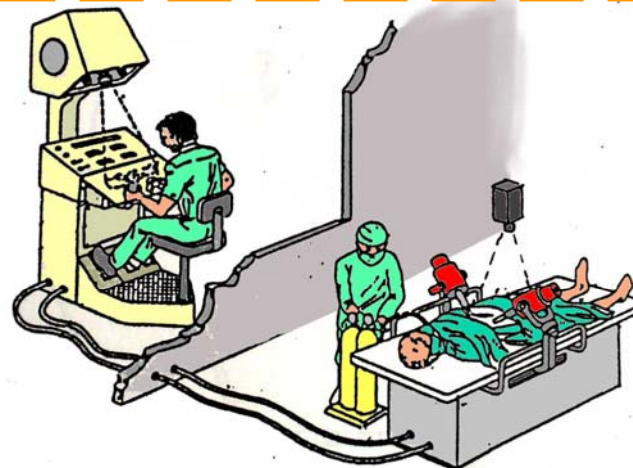
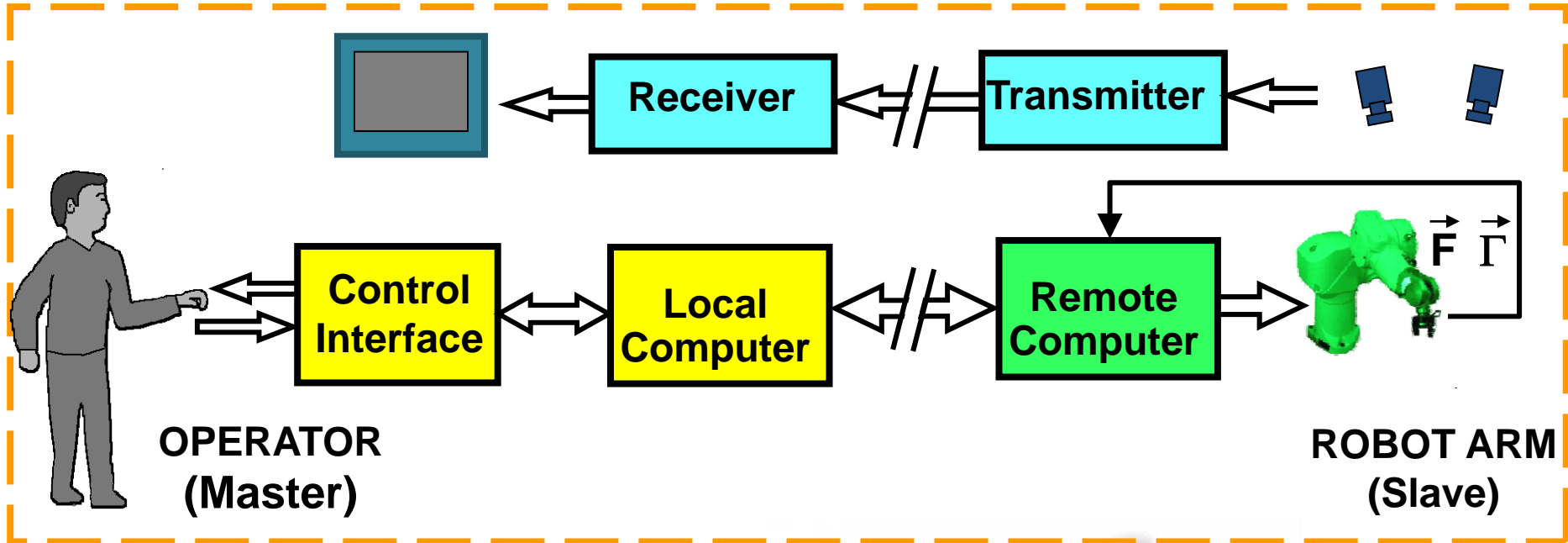


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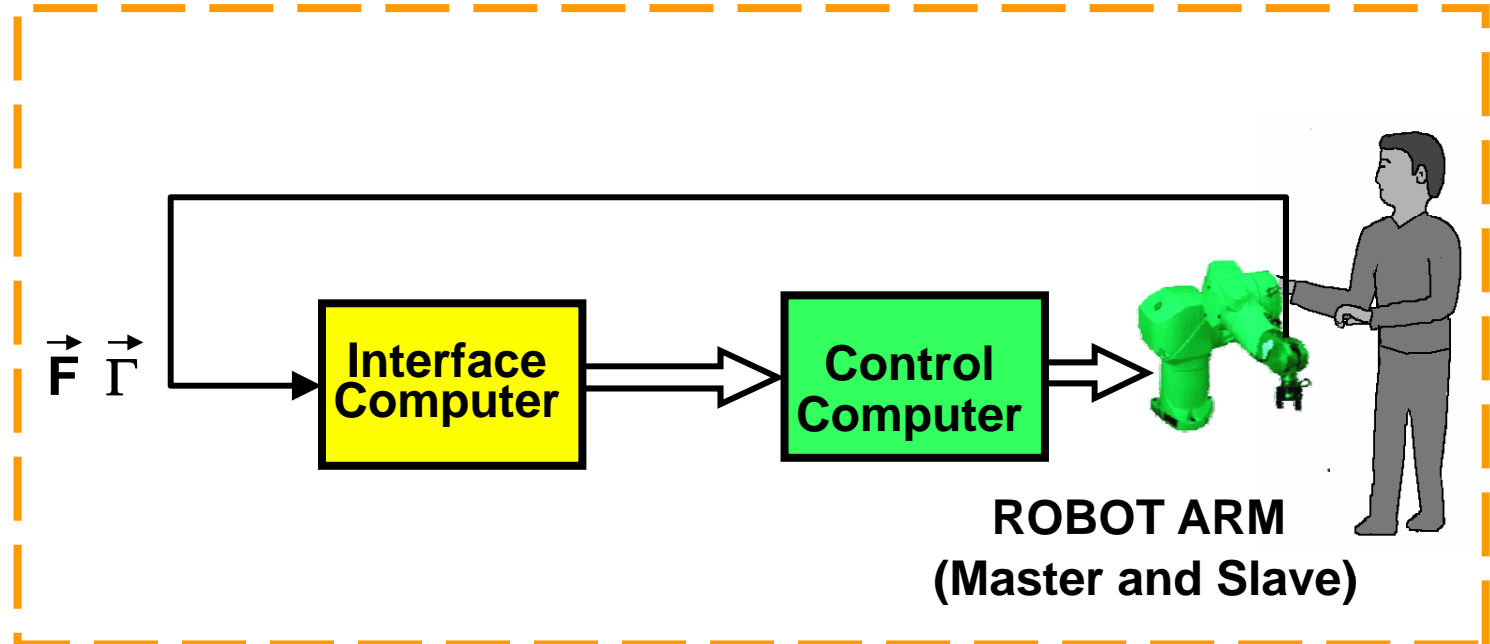


$$F_{a', slave}(s) = Z_c(s) (a V_{master}(s) - V_{slave}(s))$$

# Human - Robot Cooperation



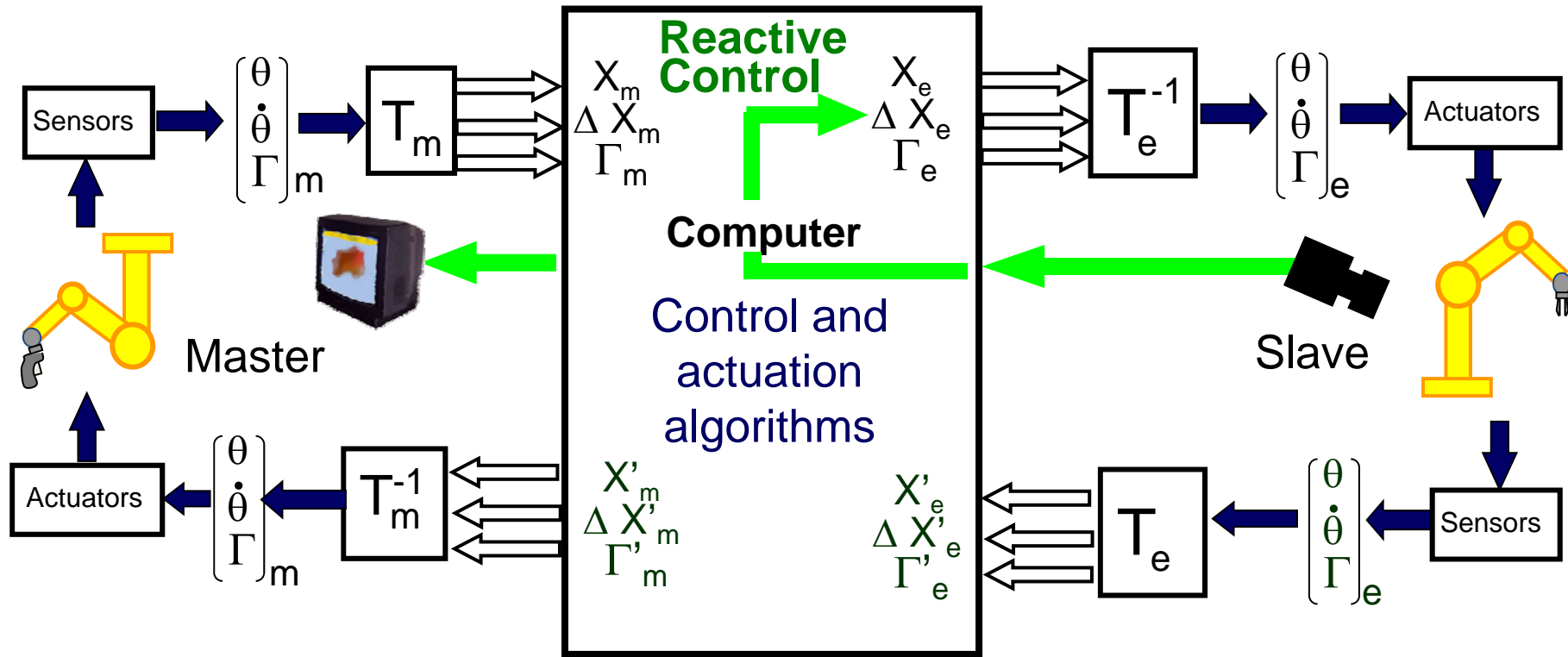
# Human - Robot Cooperation



## Comanipulation / Cooperation

$$V(s) = Y(s) \cdot F(s)$$

# Human - Robot Cooperation levels



*Processed Vision  
(Virtual Reality)*



## Surgical Environments

- Hard tissues {
  - Stereotaxis techniques applicable  
(Skull or pelvis)
  - Stereotaxis not applicable  
(Femur or humerus)
- Soft tissues {
  - Plastic parts  
(Kidney or liver) {
    - Static  
(Brain or pancreas)
  - Elastic parts  
(Nerves or tendons) {
    - Dinamic  
(Heart or lungs)

# Human - Robot Cooperation

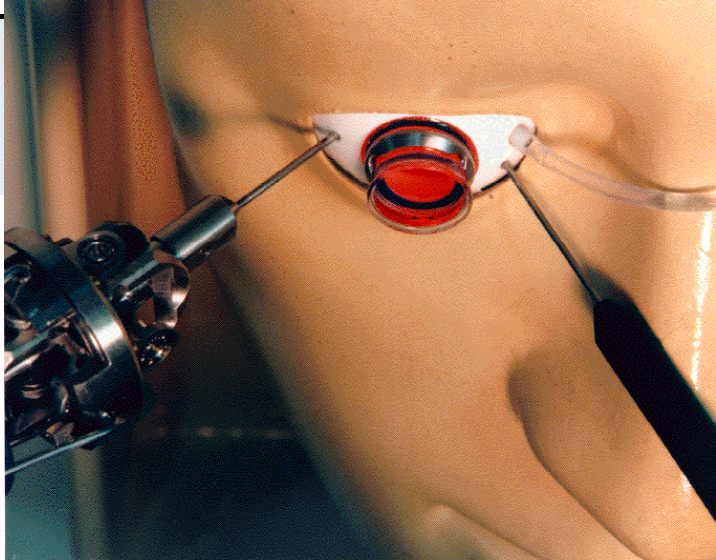
<b>Type</b>	<b>Robot contribution</b>	<b>The role of cooperation</b>
Microsurgery		
Neurosurgery		
Transcutaneous		
Percutaneous		
Intracavity		
Orthopedics		

# Human - Robot Cooperation

<b>Type</b>	<b>Robot contribution</b>
Microsurgery	3D surface generation, task precision, 6DoF teleoperation



# Human - Robot Cooperation

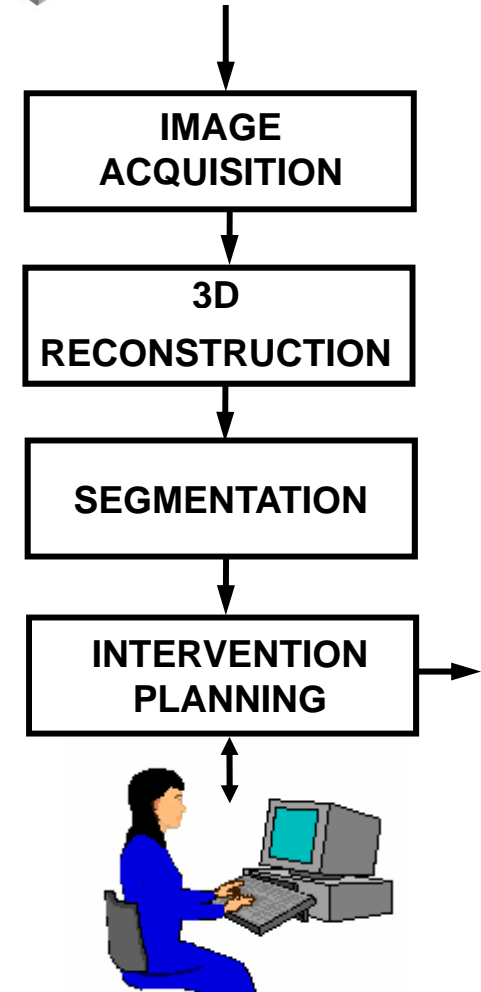
Type	Robot contribution	Cooperation needs
Microsurgery	3D surface generation, task precision, 6DoF teleoperation	

$$\frac{1}{y_1} + \frac{1}{y_2} = \frac{1}{f}$$



# Human - Robot Cooperation

Type	Robot contribution
Microsurgery	3D surface generation, task precision, 6DoF teleoperation
Neurosurgery	3D trajectories, increase precision and minimizing damage




# Human - Robot Cooperation

Type	Robot contribution	Cooperation needs
Microsurgery	3D surface generation, task precision, 6DoF teleoperation	Real time supervision and anatomic adaptation
Neurosurgery	3D trajectories, increase precision and minimizing damage	



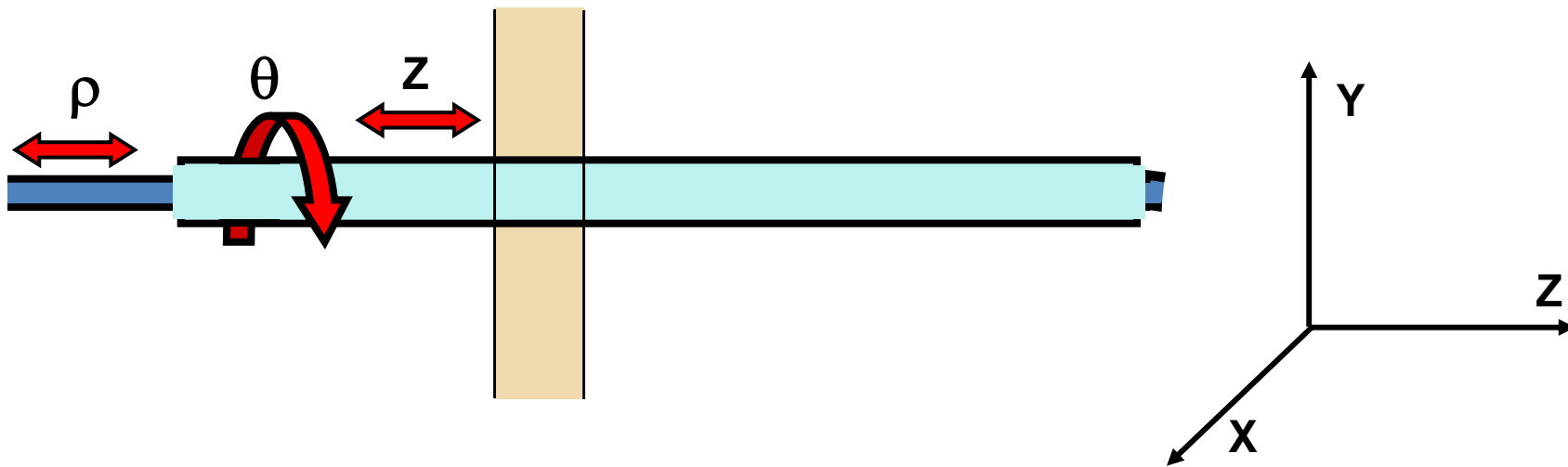
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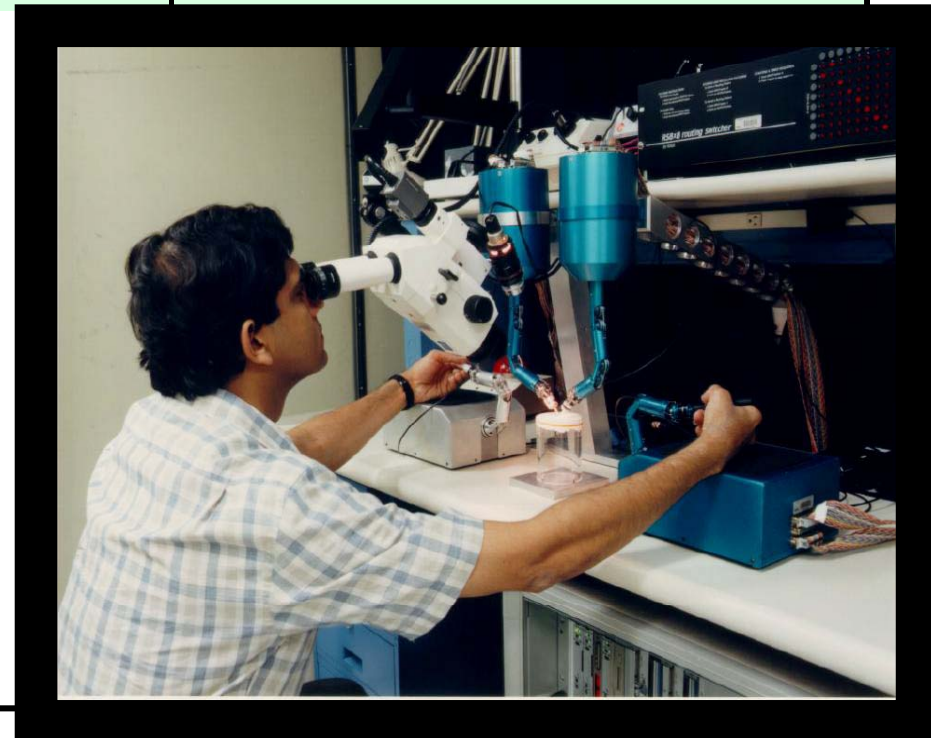
# Active probes

Prebended coaxial tubes

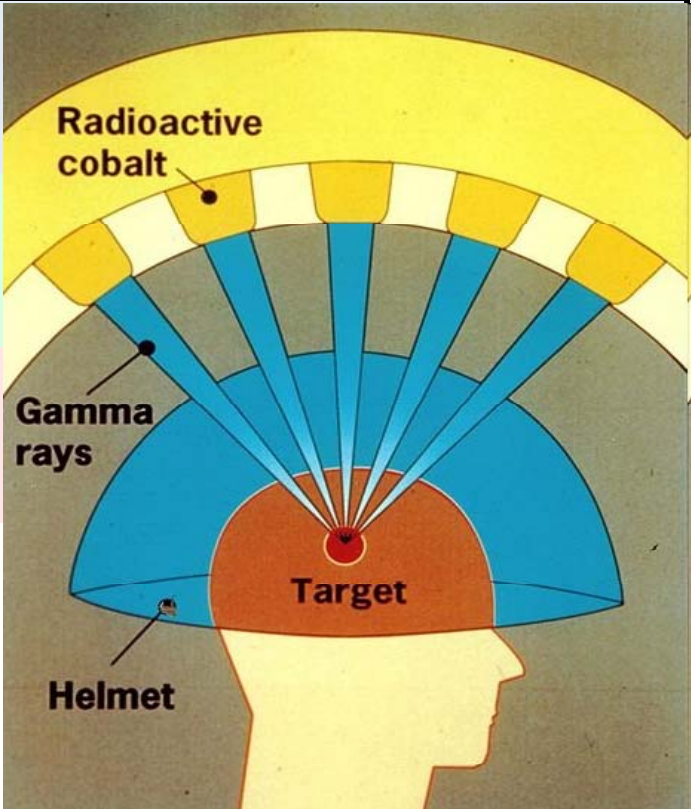


# Human - Robot Cooperation

Type	Robot contribution	Cooperation needs
Microsurgery	3D surface generation, task precision, 6DoF teleoperation	Real time supervision and anatomic adaptation
Neurosurgery	3D trajectories, increase precision and minimizing damage	Real time guidance, validation or corrections



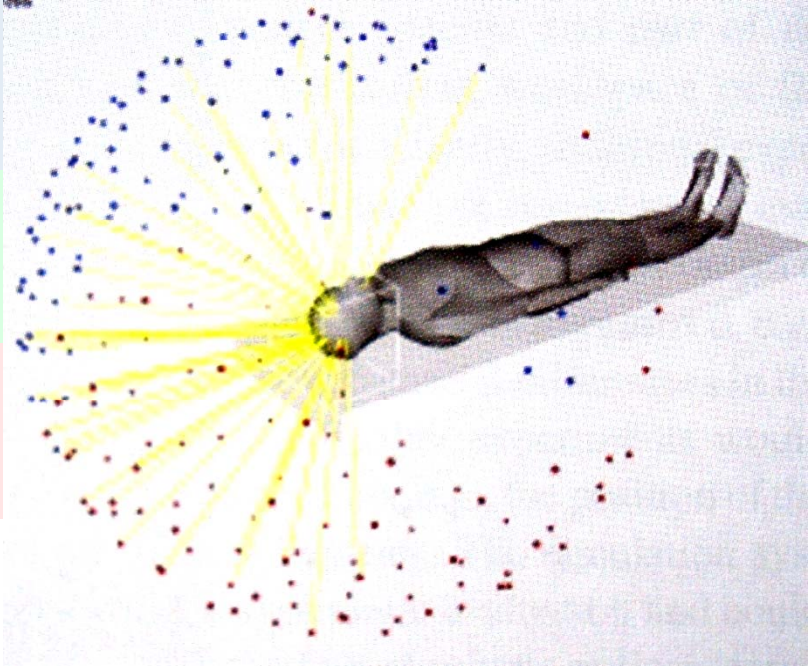
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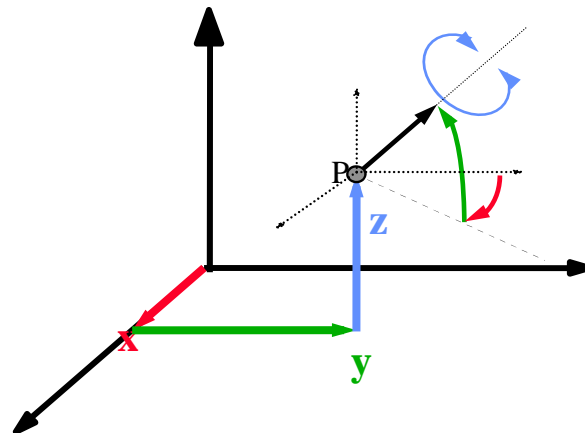
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Microsurgery	3D surface generation, task precision, 6DoF teleoperation	
Neurosurgery	3D trajectories, increase precision and minimizing damage	
Transcutaneous	Precise positioning	



**Gamma Knife**

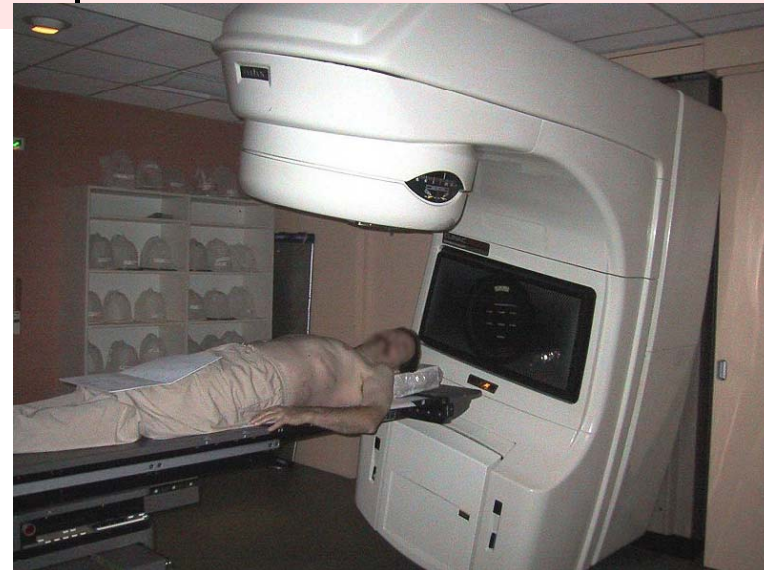
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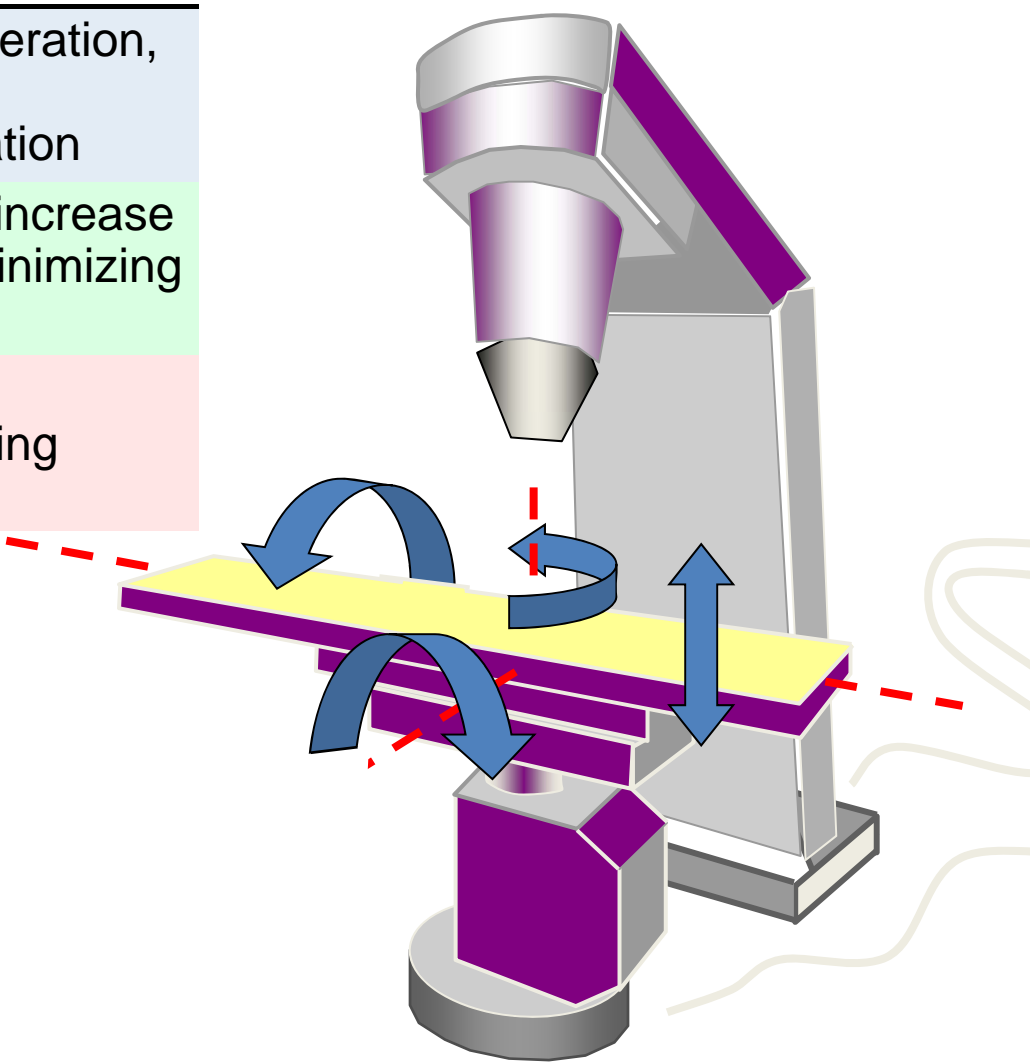


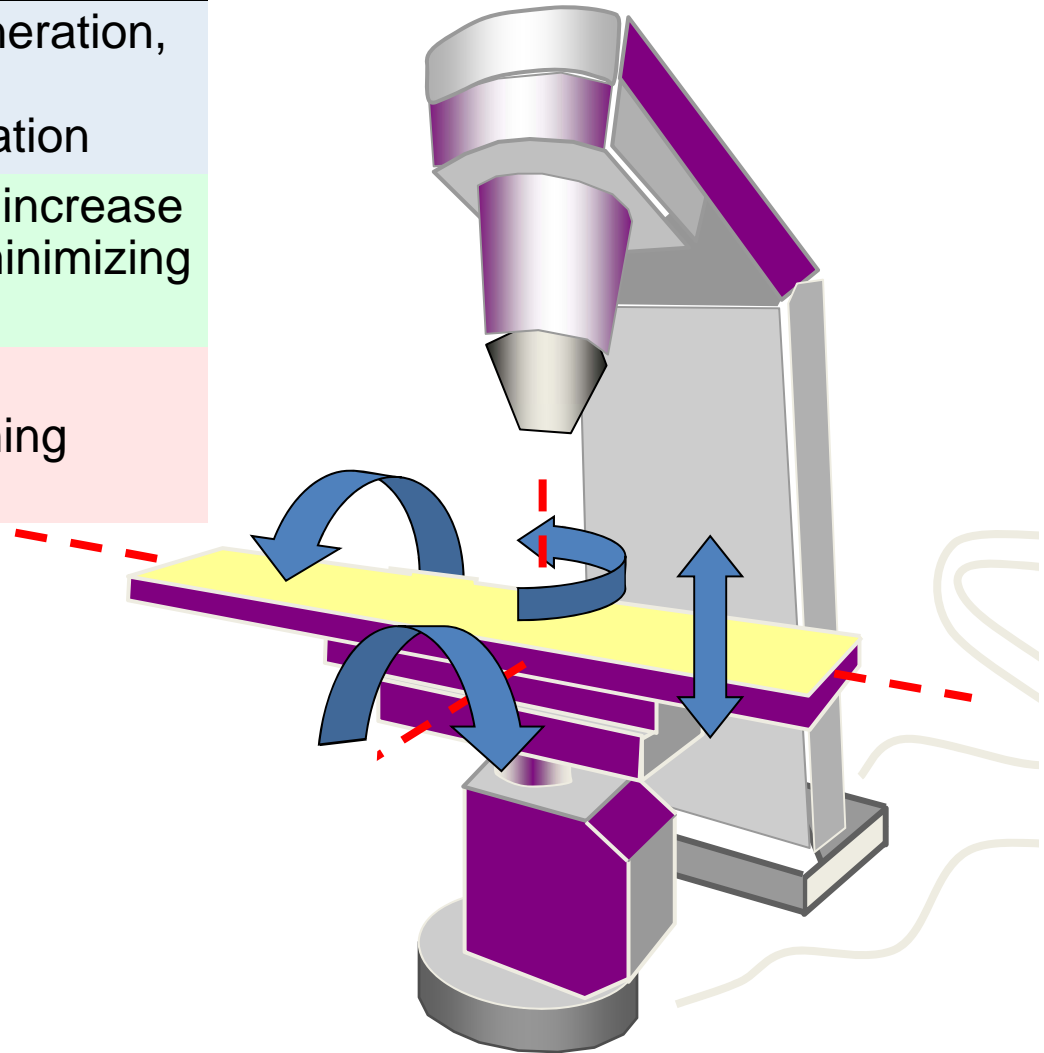
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Transcutaneous	Precise positioning	Adjustments and surveillance



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- Previous systems: Based on a beam of the tumor size

Beam size: from 4cm to 15 cm




- Robot performances: Allow focalization in the precise tumor area (adapt to its shape)

- Beam size: ~3 mm

- Scanning over the tumor area



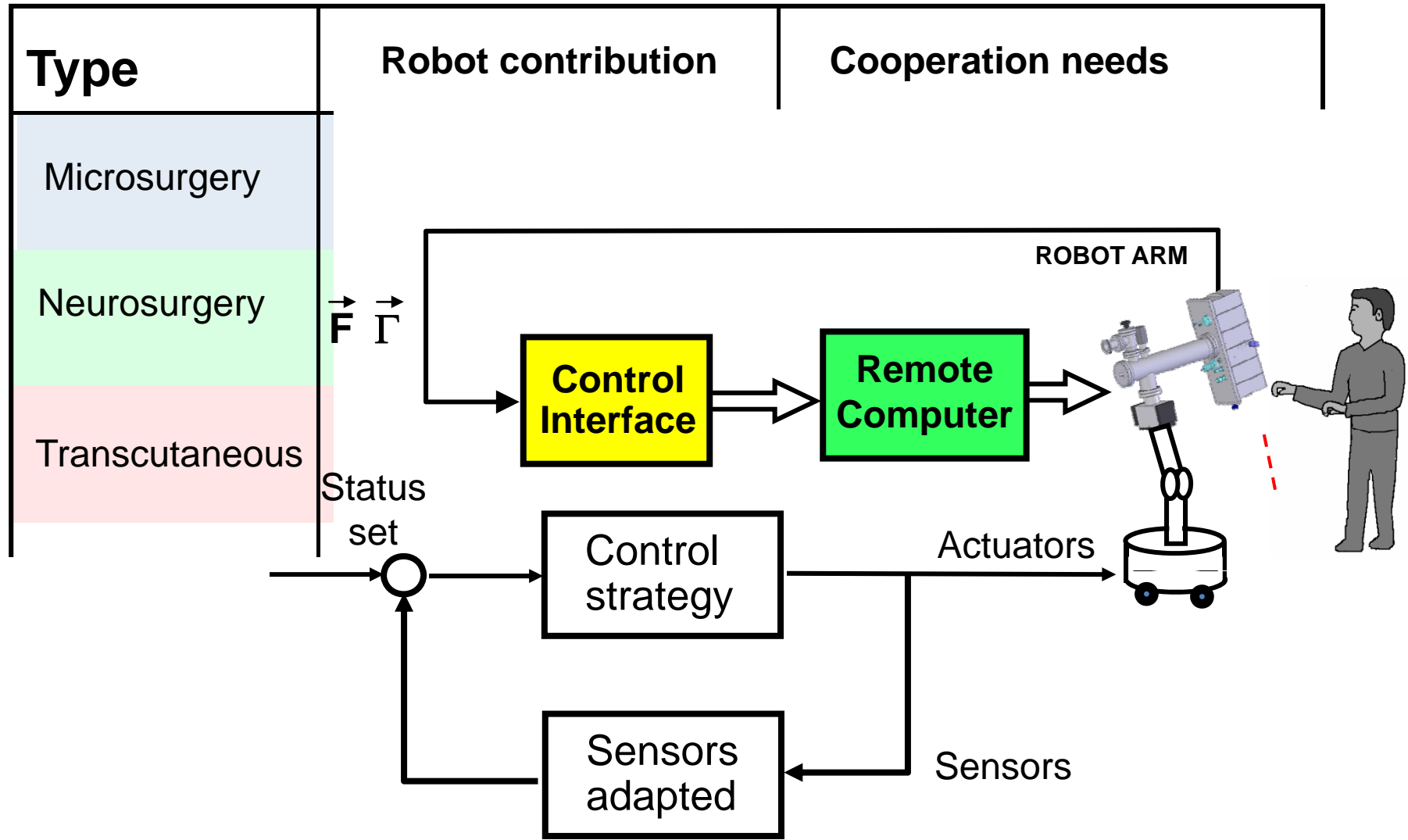
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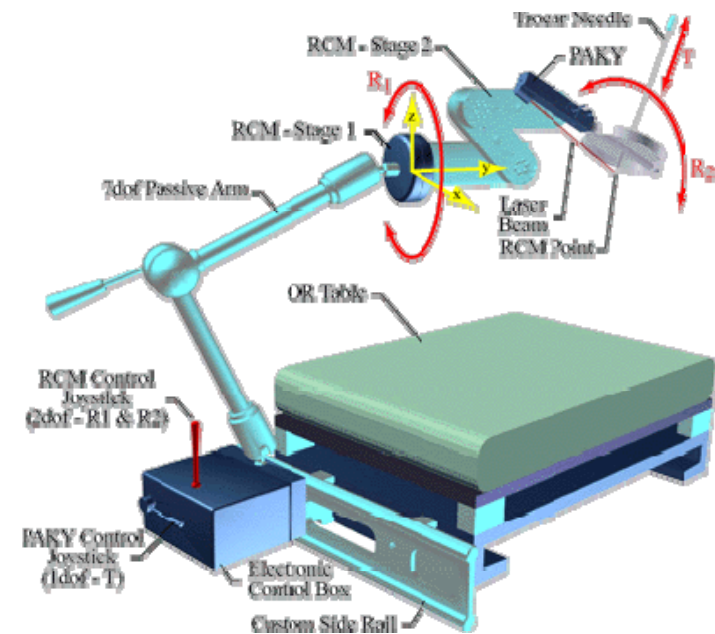
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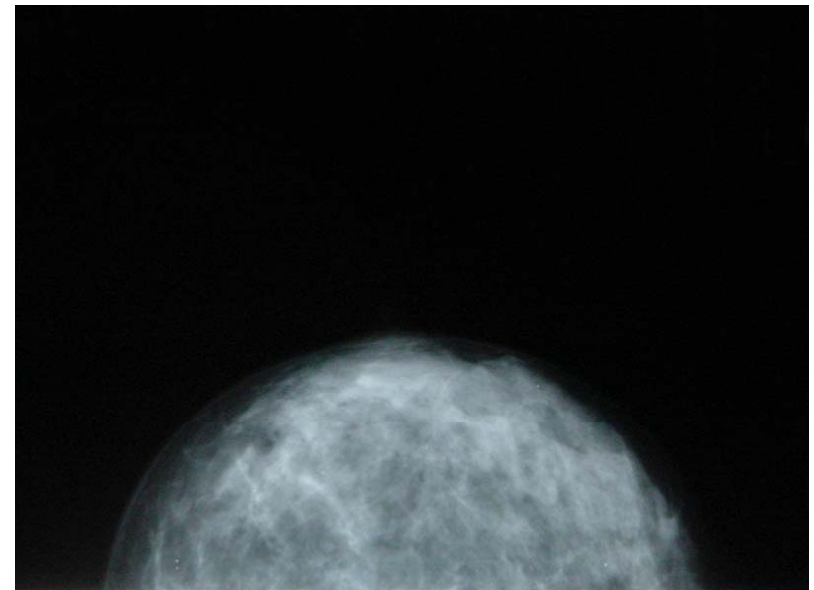
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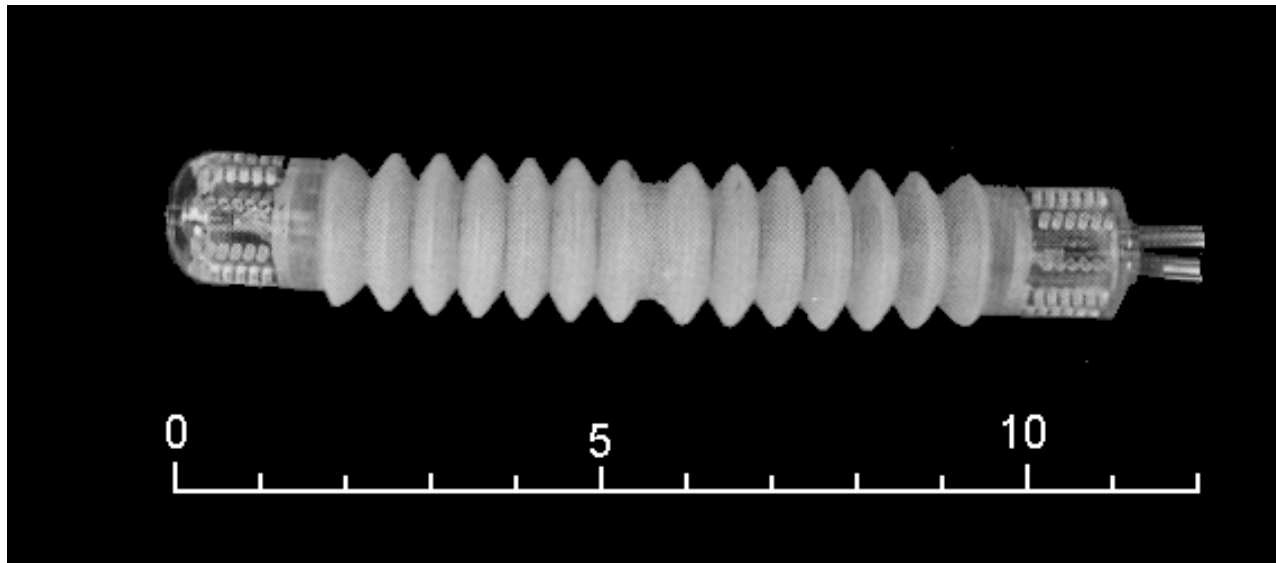


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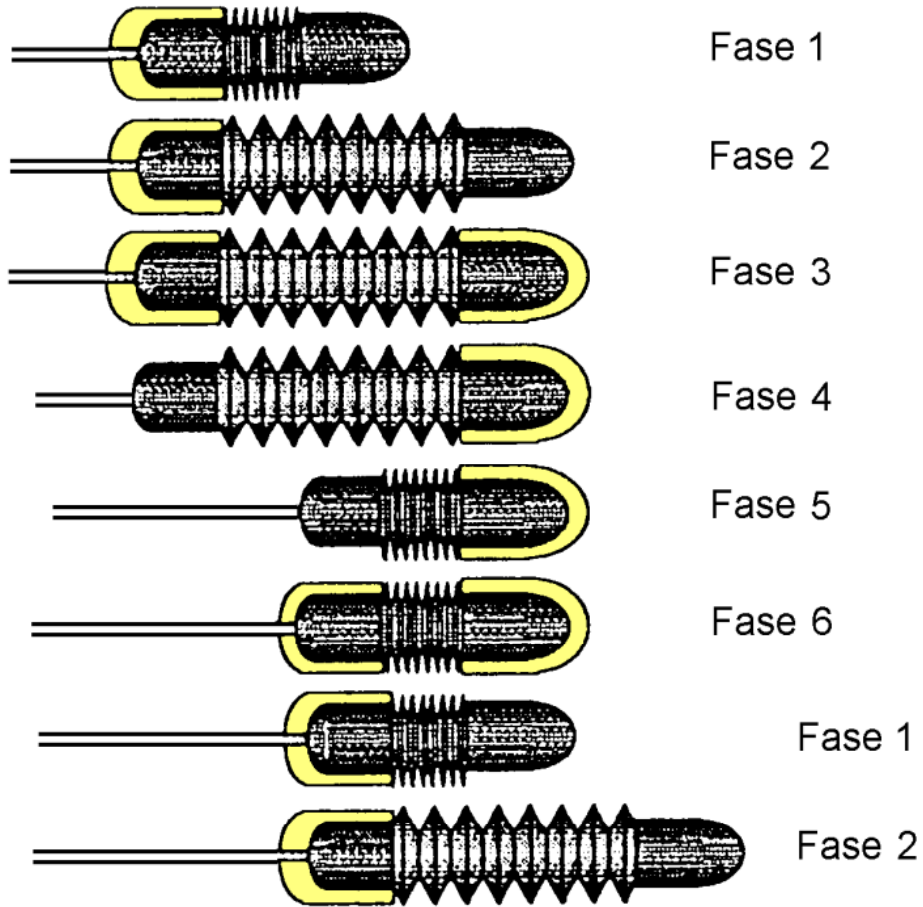
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Neurosurgery	3D trajectories, increase precision and minimizing damage	Real time validation and corrections
Transcutaneous	Precise positioning	Adjustments and surveillance
Percutaneous	Precise advancing and avoidance	Real time restrictions identification and safety
Intracavity	Ergonomical dexterity, anti stress operation and precision	
Orthopedic		

# Human - Robot Cooperation

Type	Robot contribution	Cooperation needs
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Intracavity	Ergonomical dexterity, anti stress operation and precision	
Orthopedic		



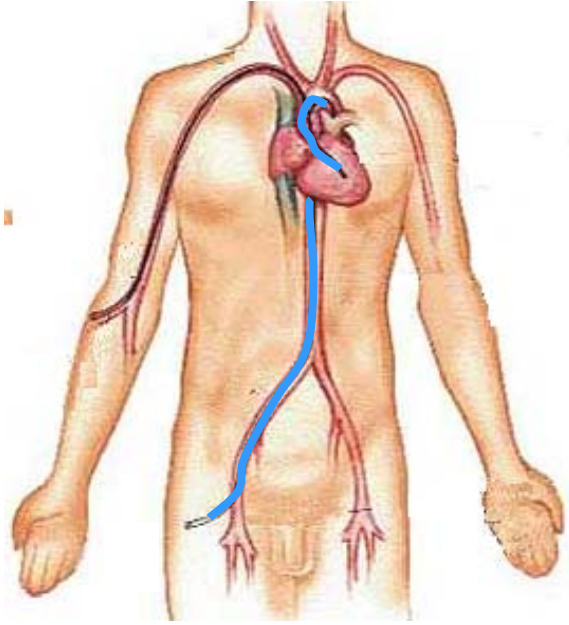
## Operation

Cooperation needs

Intracavity	Ergonomical dexterity, anti stress operation and precision	
Orthopedic		



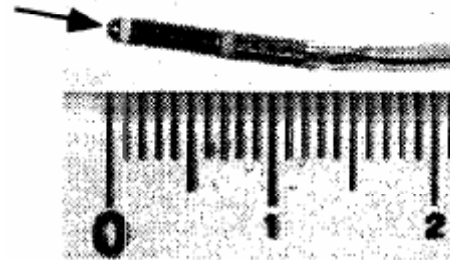
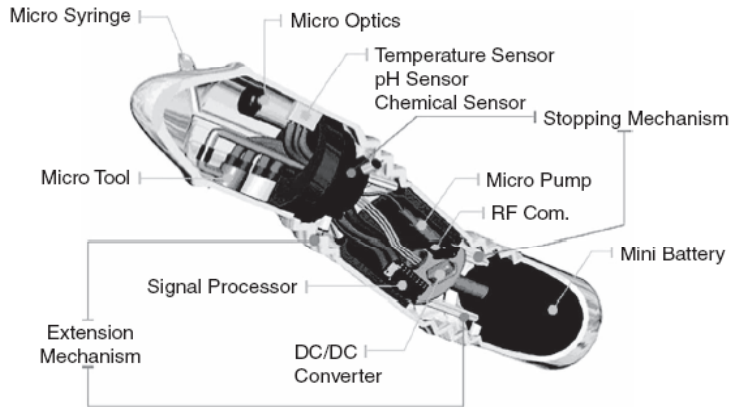
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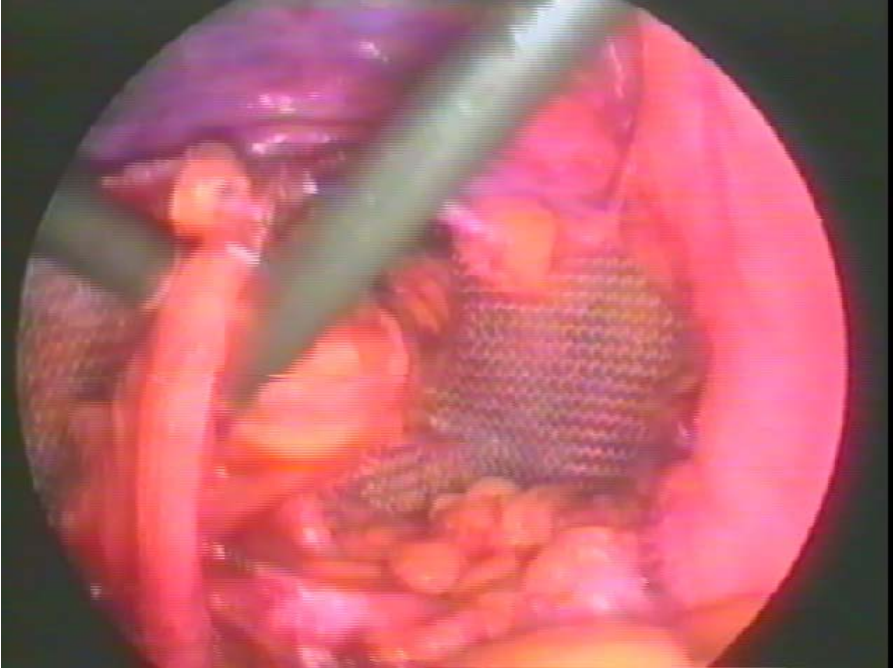
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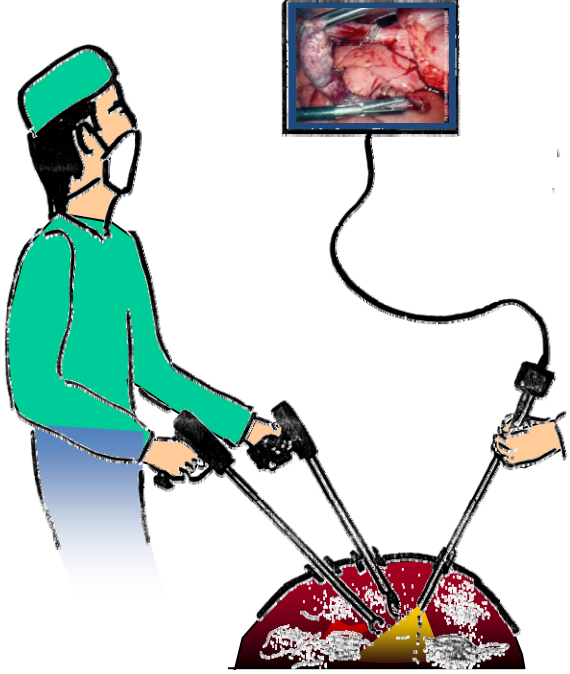


Intracavity	Ergonomical dexterity, anti stress operation and precision	
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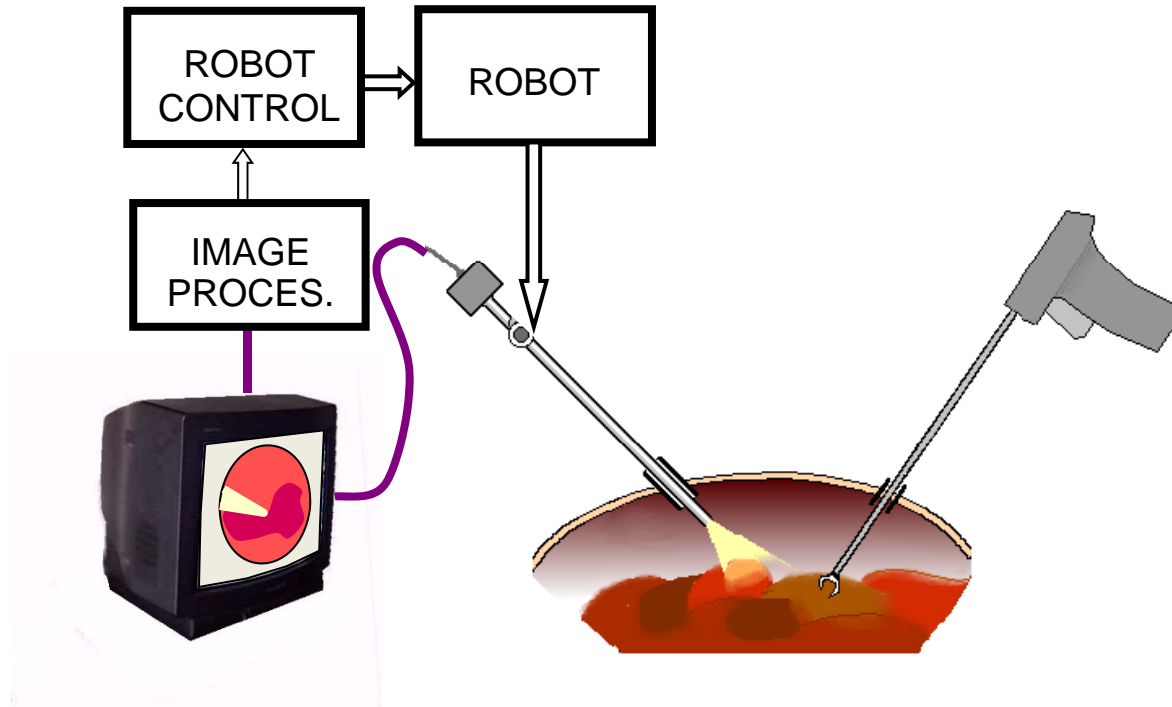
Type	Robot contribution	Cooperation needs
Intracavity	 An endoscopic view of a surgical site. The image shows internal organs, including what appears to be the stomach or intestines, with a textured, mesh-like structure. Several green surgical instruments are visible, interacting with the tissue. The lighting is bright, highlighting the pinkish-red colors of the internal organs.	Manual guidance, multiplexed arms

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Intracavity	Ergonomical dexterity, anti stress operation and precision	
Orthopedic		

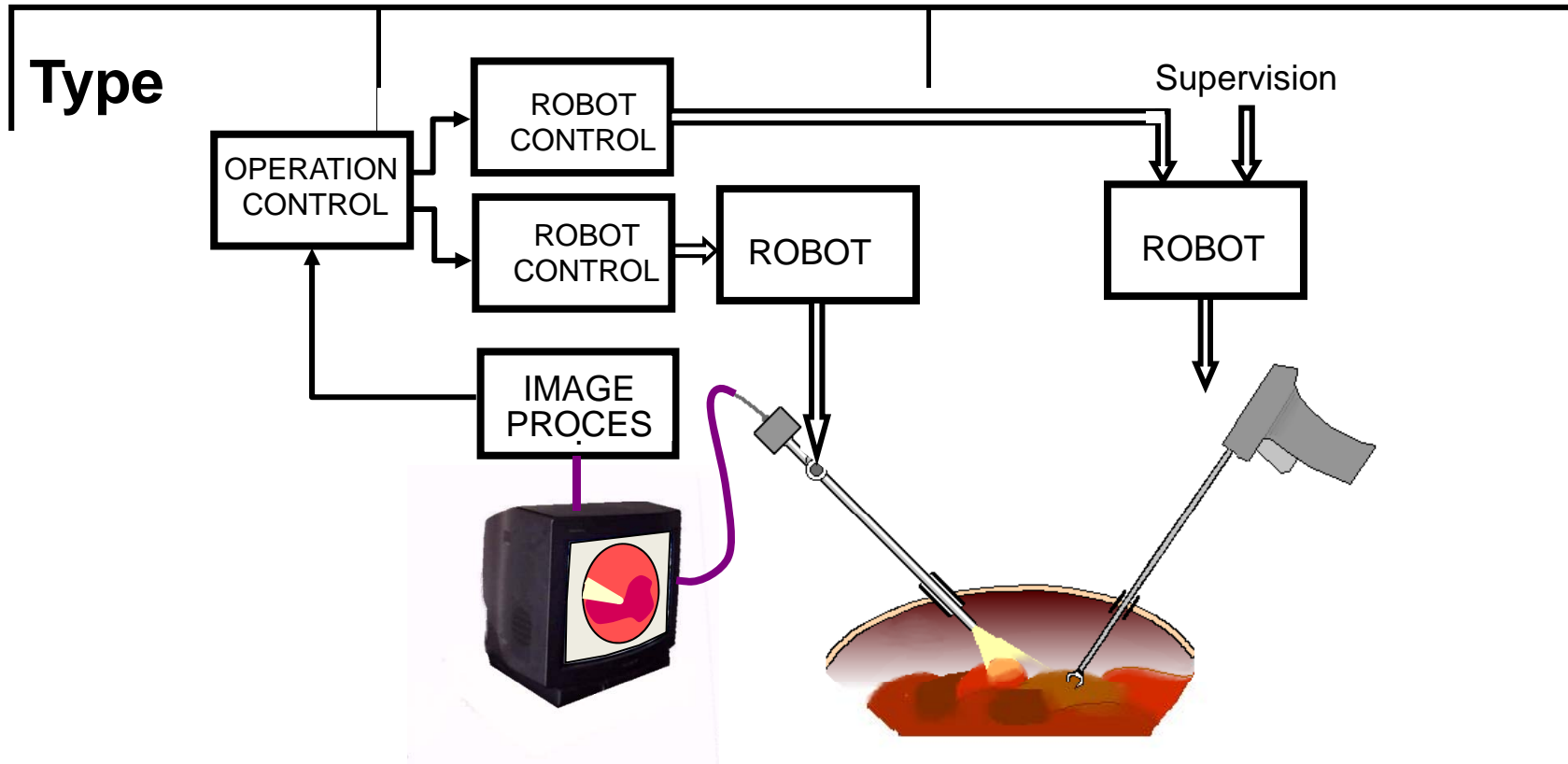
# Human - Robot Cooperation

Type





Intracavity	Ergonomical dexterity, anti stress operation and precision	
Orthopedic		

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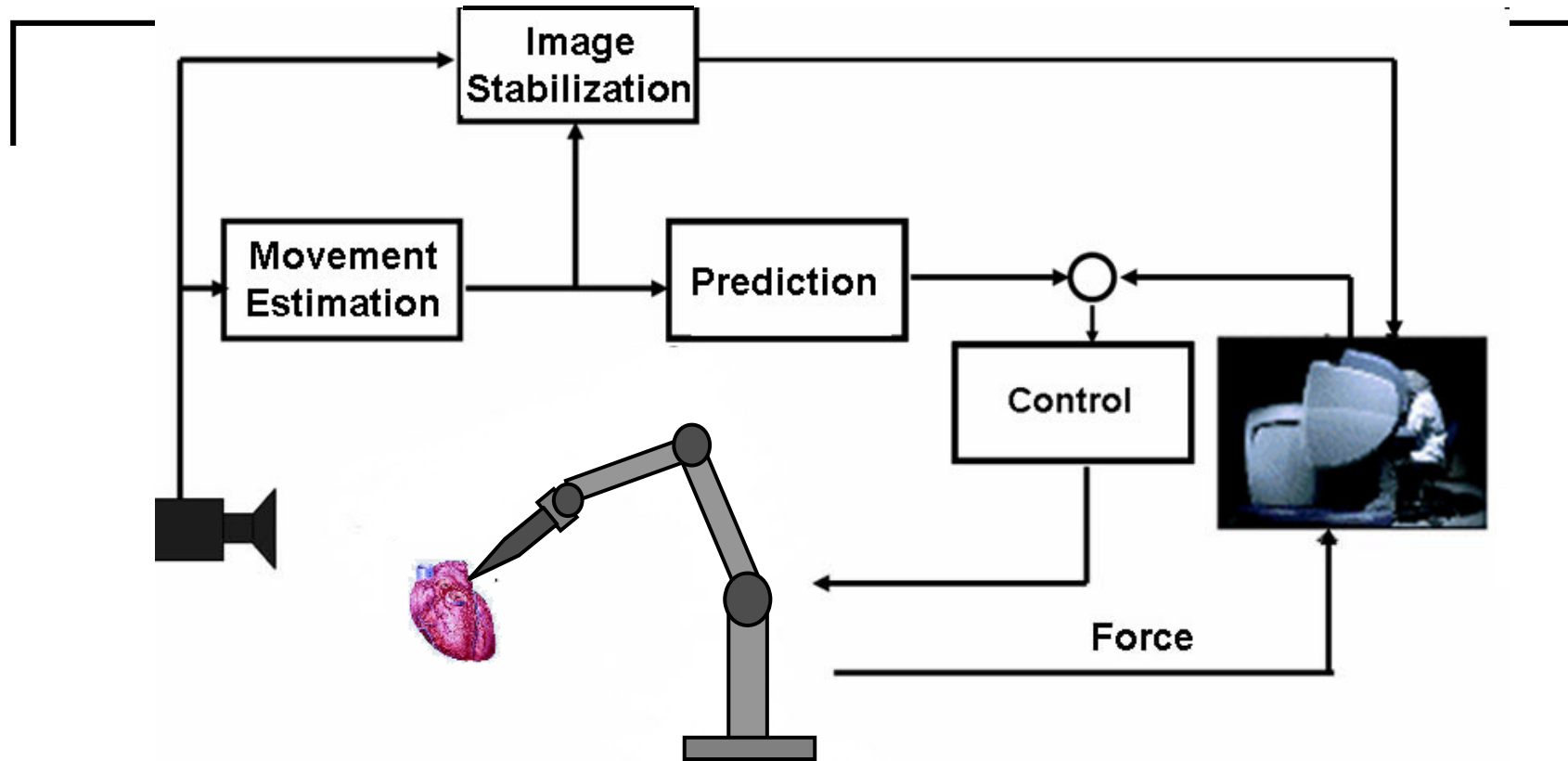
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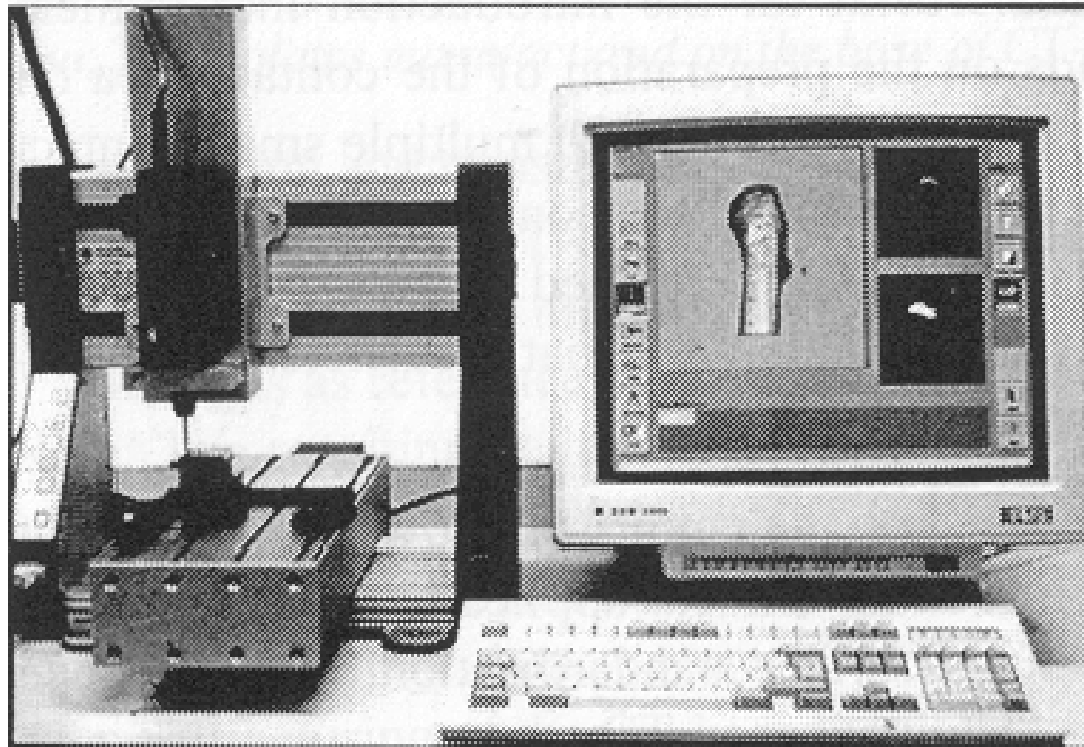
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Intracavity	Ergonomical dexterity, anti stress operation and precision	Manual guidance, multiplexed arms
Orthopedic	Precision, complex fitting, CAD/CAM	

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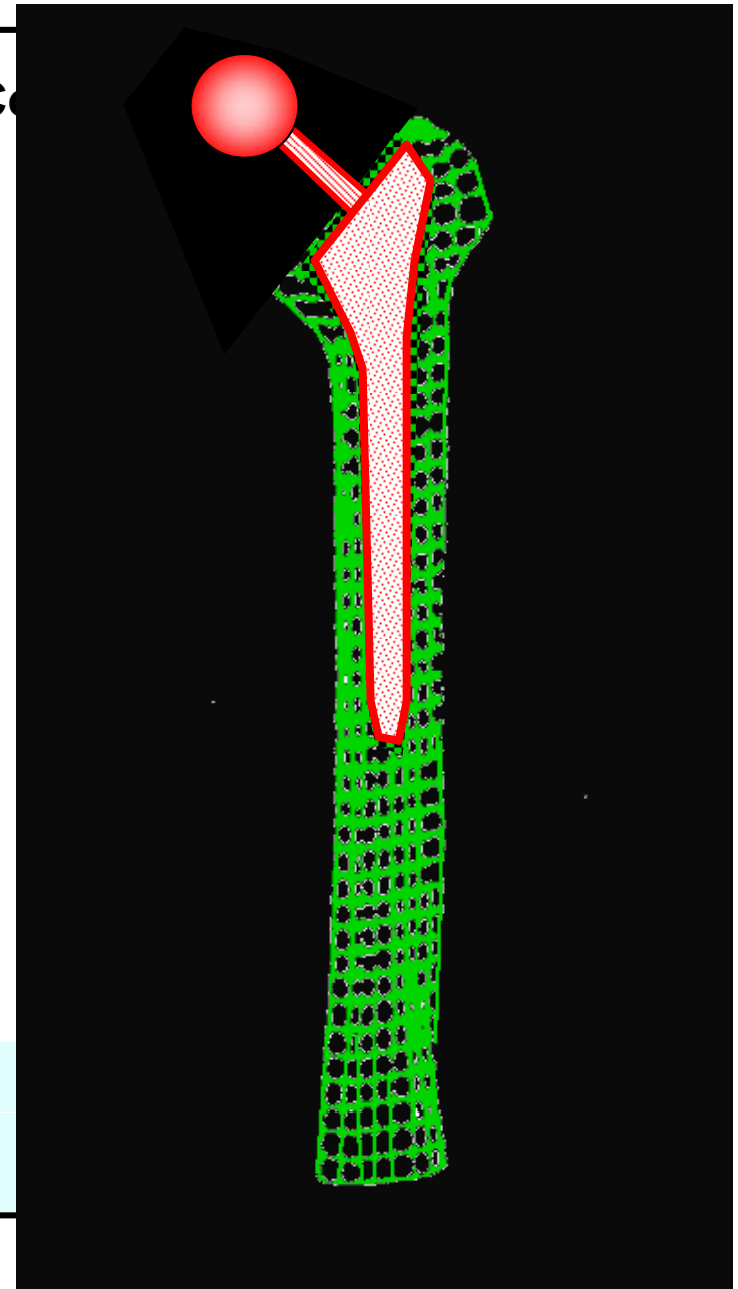
Type	Robot contribution	Cooperation needs
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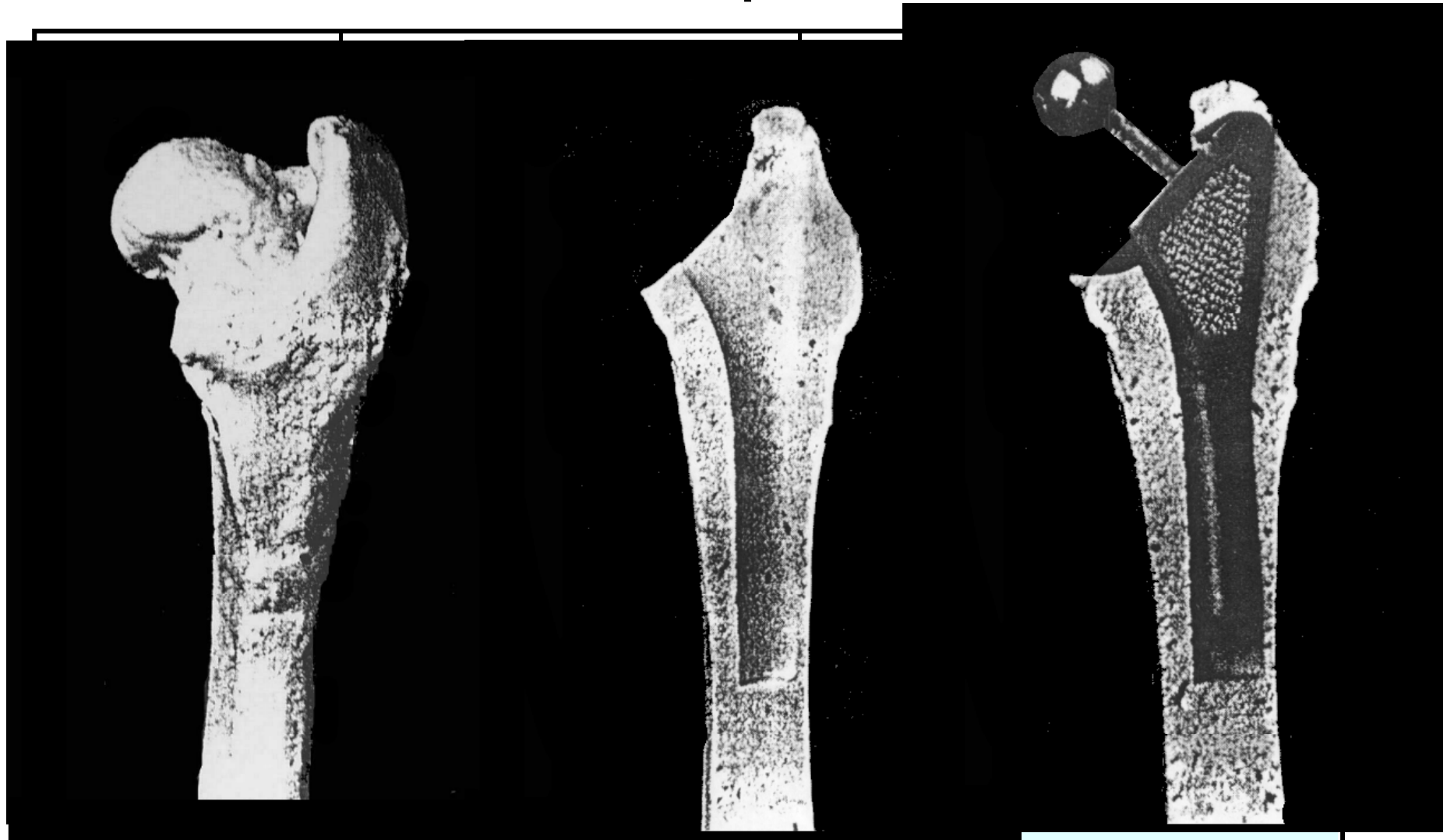
Orthopedic	Precision, complex fitting, CAD/CAM	
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# Human - Robot Cooperation



Orthopedic

Precision, complex fitting, CAD/CAM

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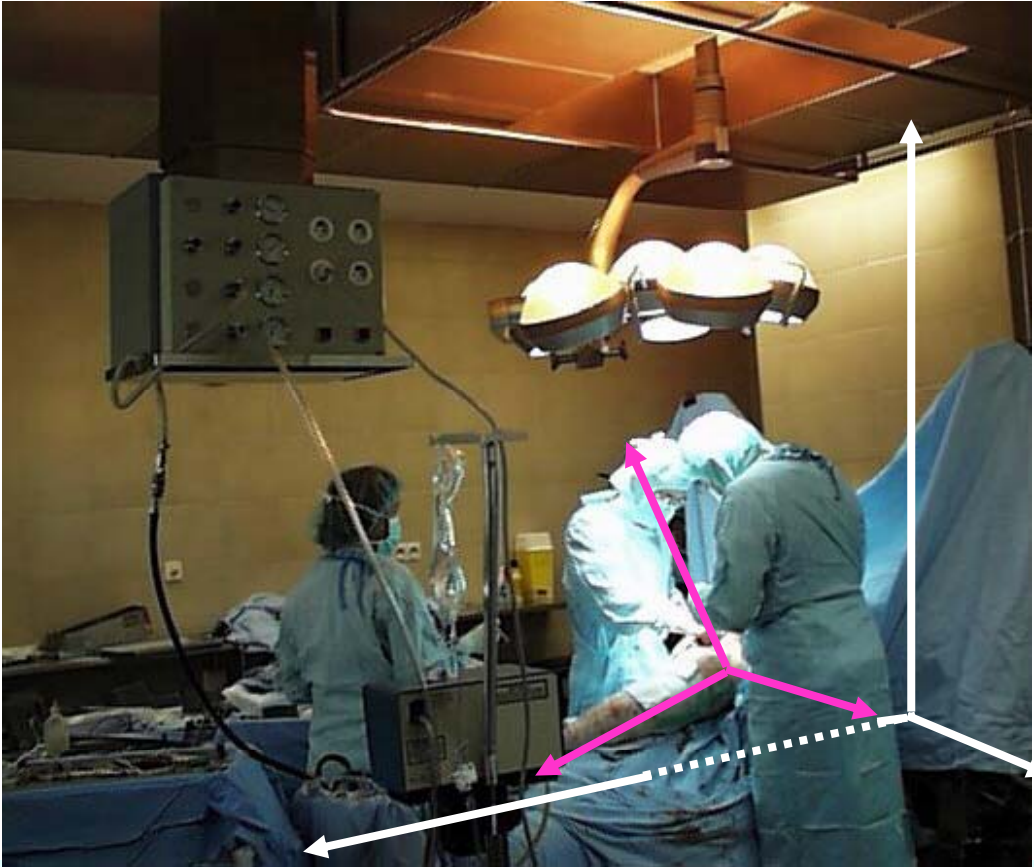
Type	Robot contribution	Cooperation needs
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IMAGE  
ACQUISITION

3D  
RECONSTRUCTION

SEGMENTATION

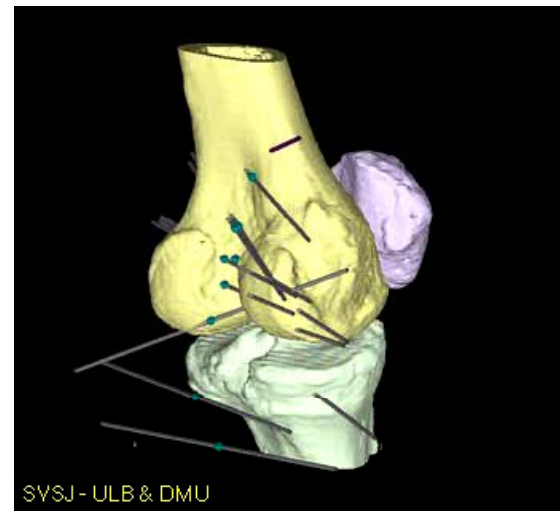
INTERVENTION  
PLANNING

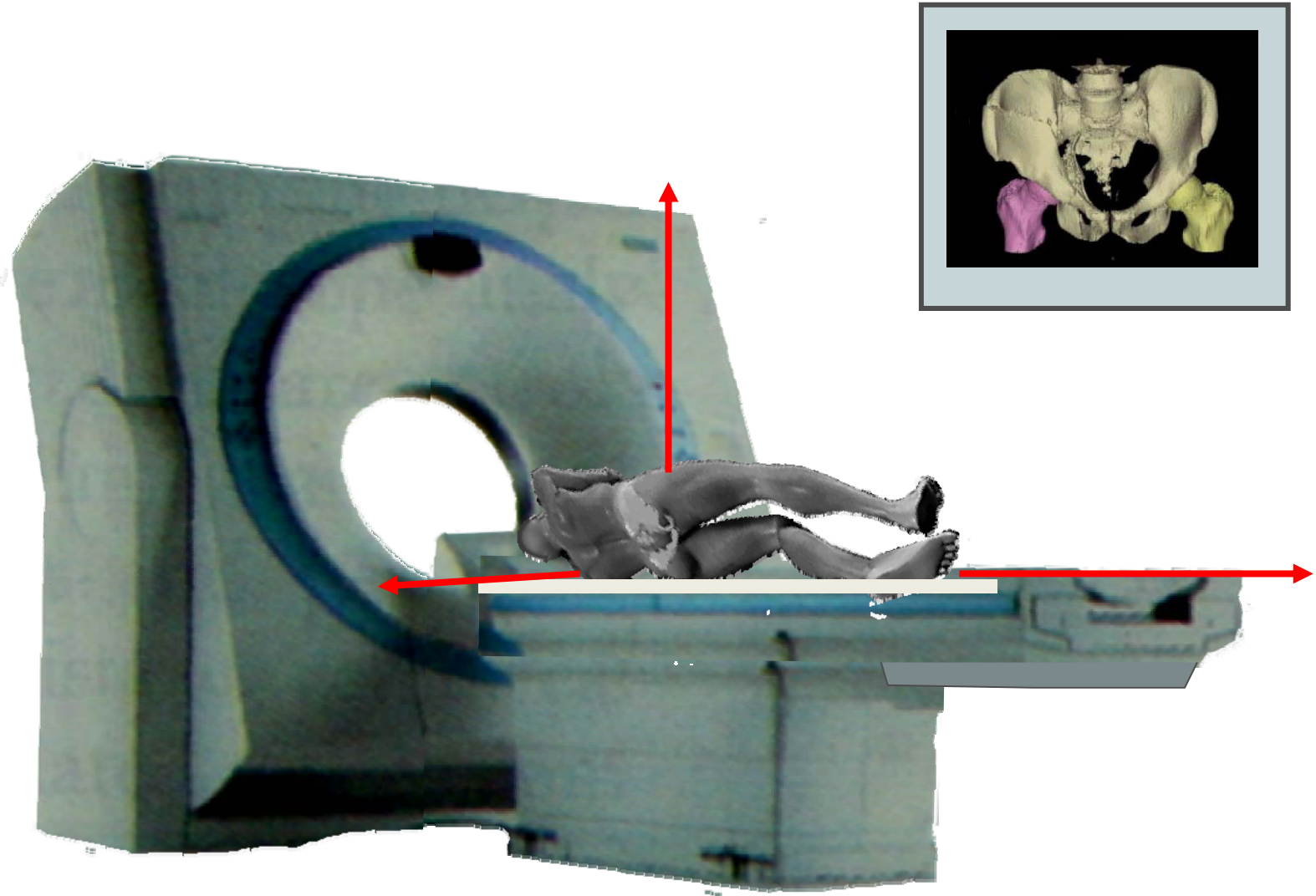


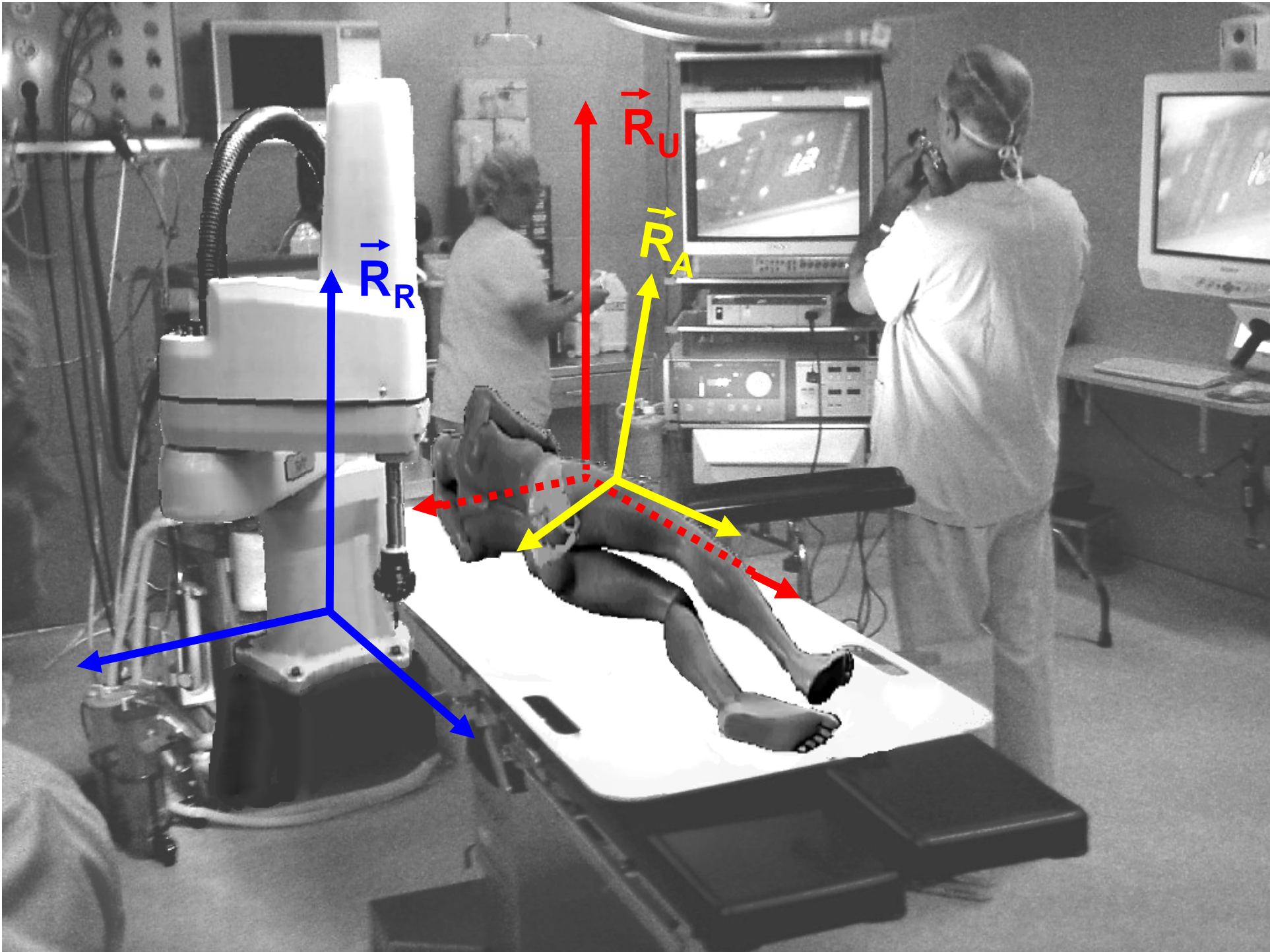
Intervention  
Planning &  
Supervision



Monitoring







# Therapy Planning and Control



IMAGE ACQUISITION

3D RECONSTRUCTION

SEGMENTATION

INTERVENTION PLANNING

REFERENCES DETECTION

TRAJECTORY PROGRAMMING

IMAGE REGISTRATION

ROBOT CONTROL

DATA ACQUISITION

3D RECONSTRUCTION

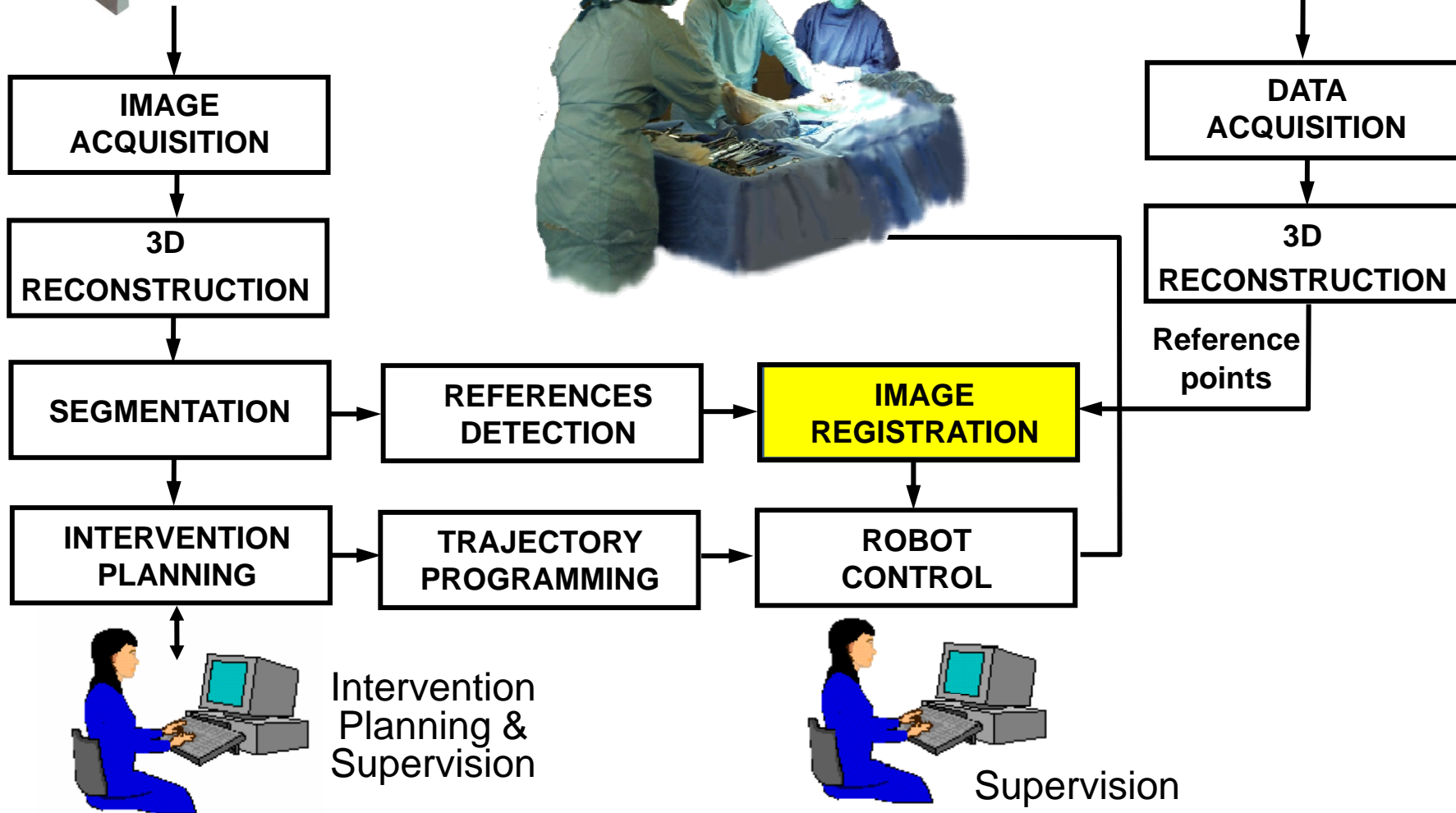
Reference points

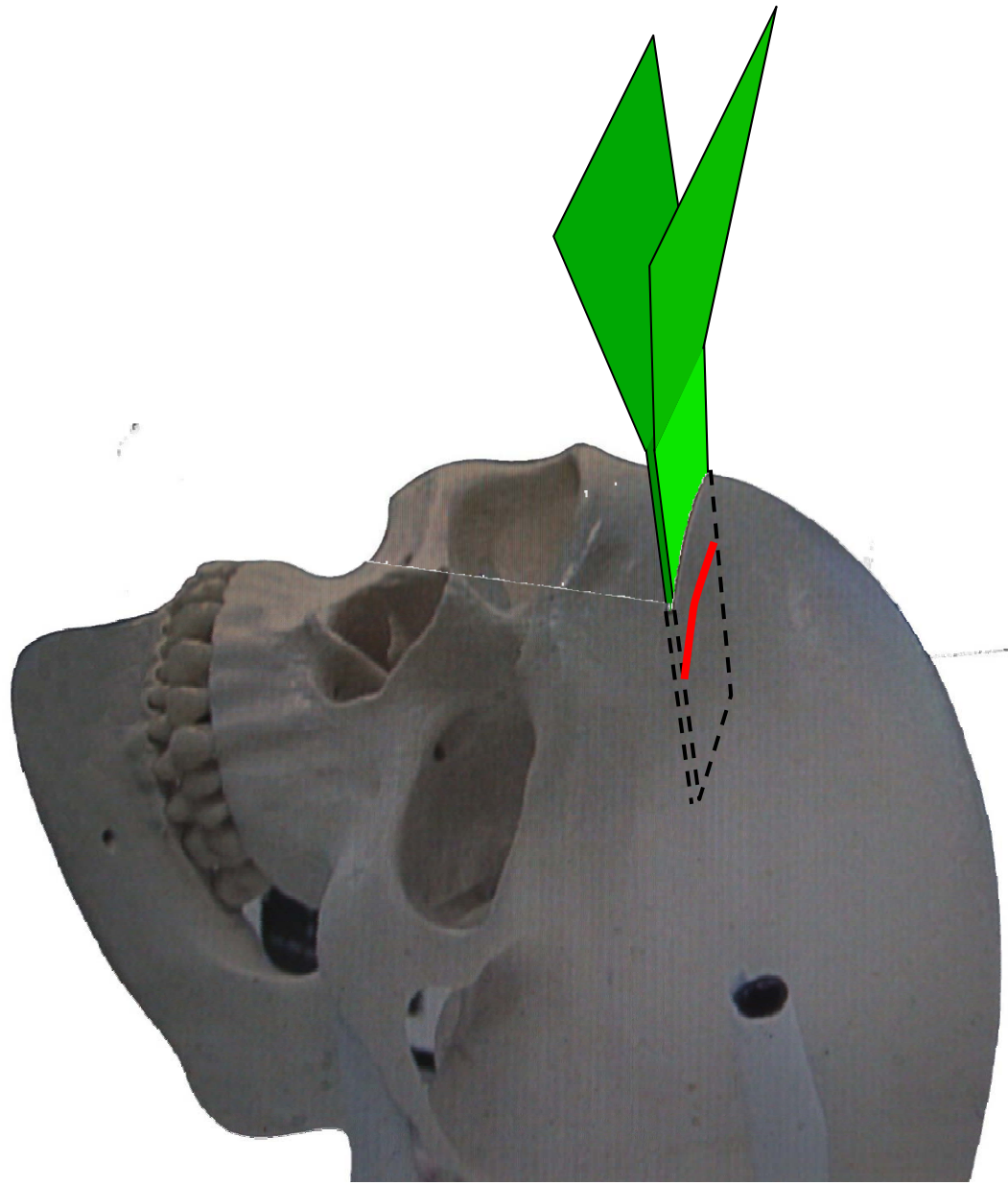


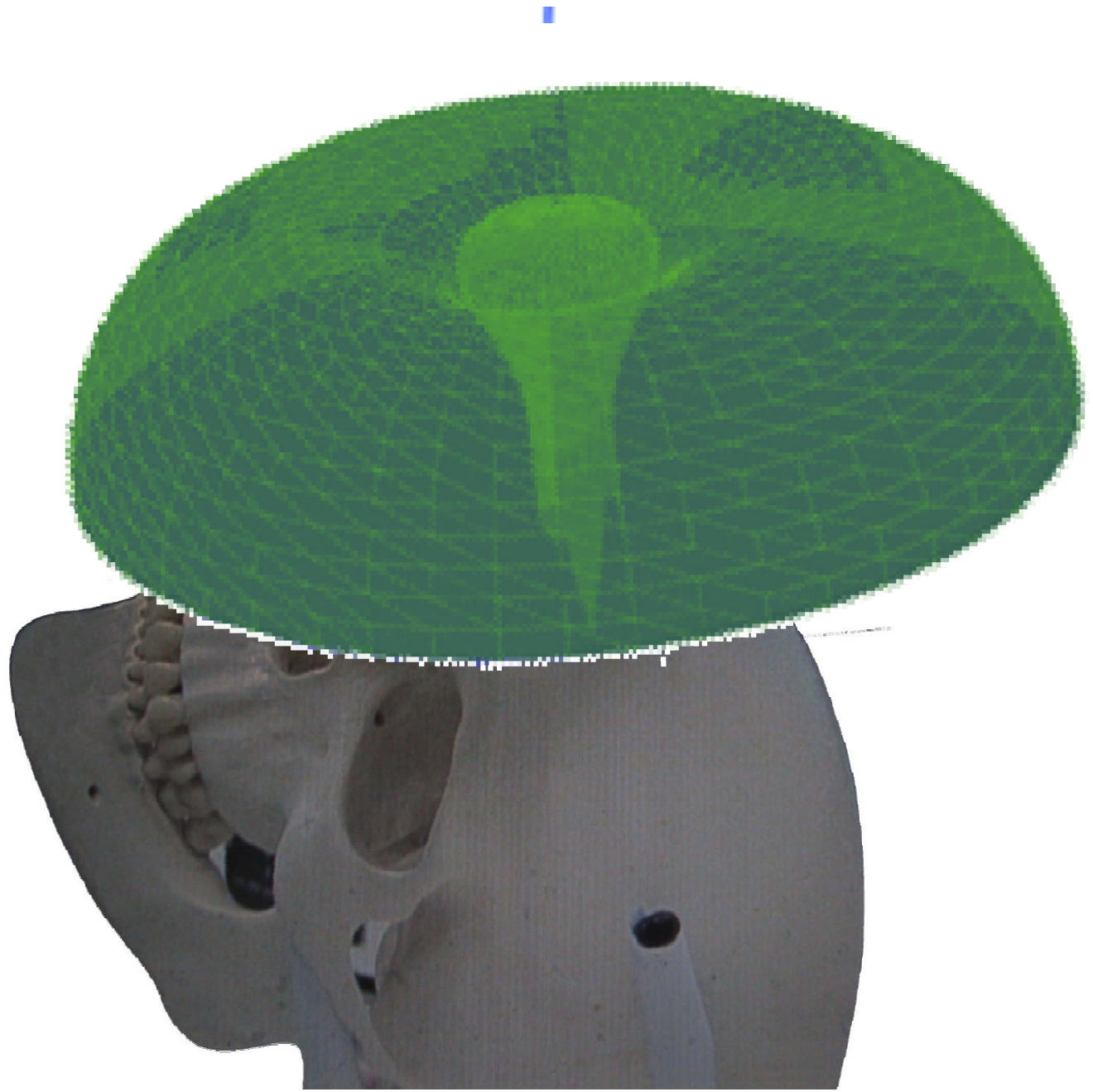
Intervention Planning & Supervision

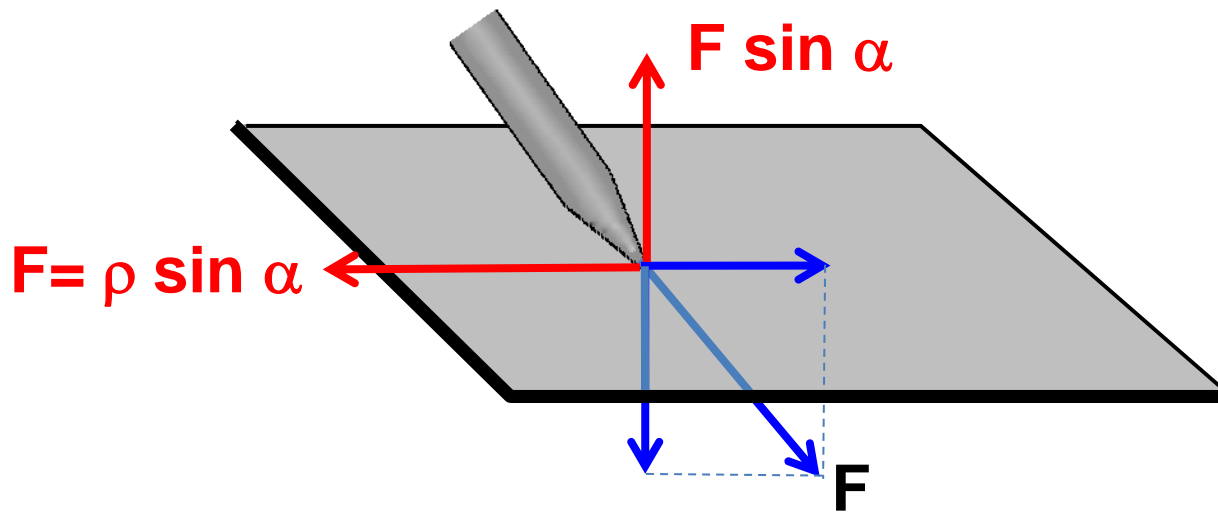


Supervision









Physical reaction


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Orthopedic	Precision, complex fitting, CAD/CAM	

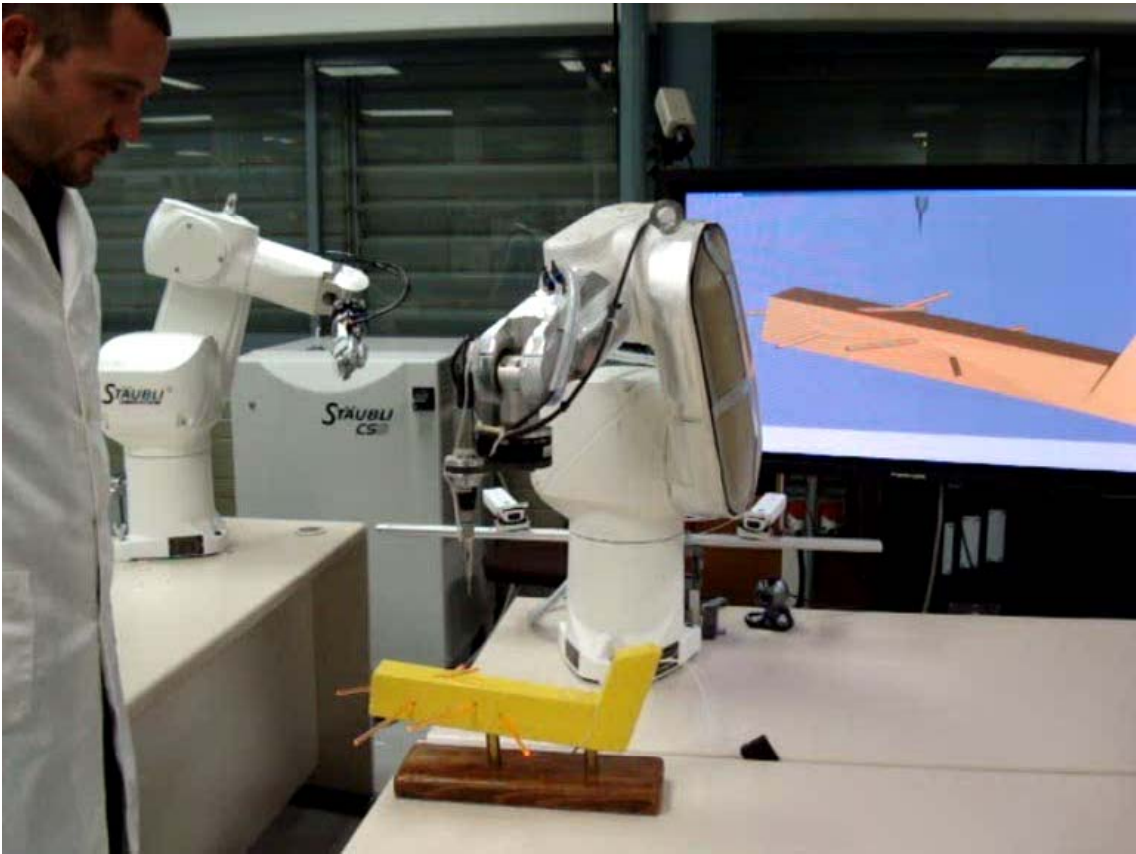




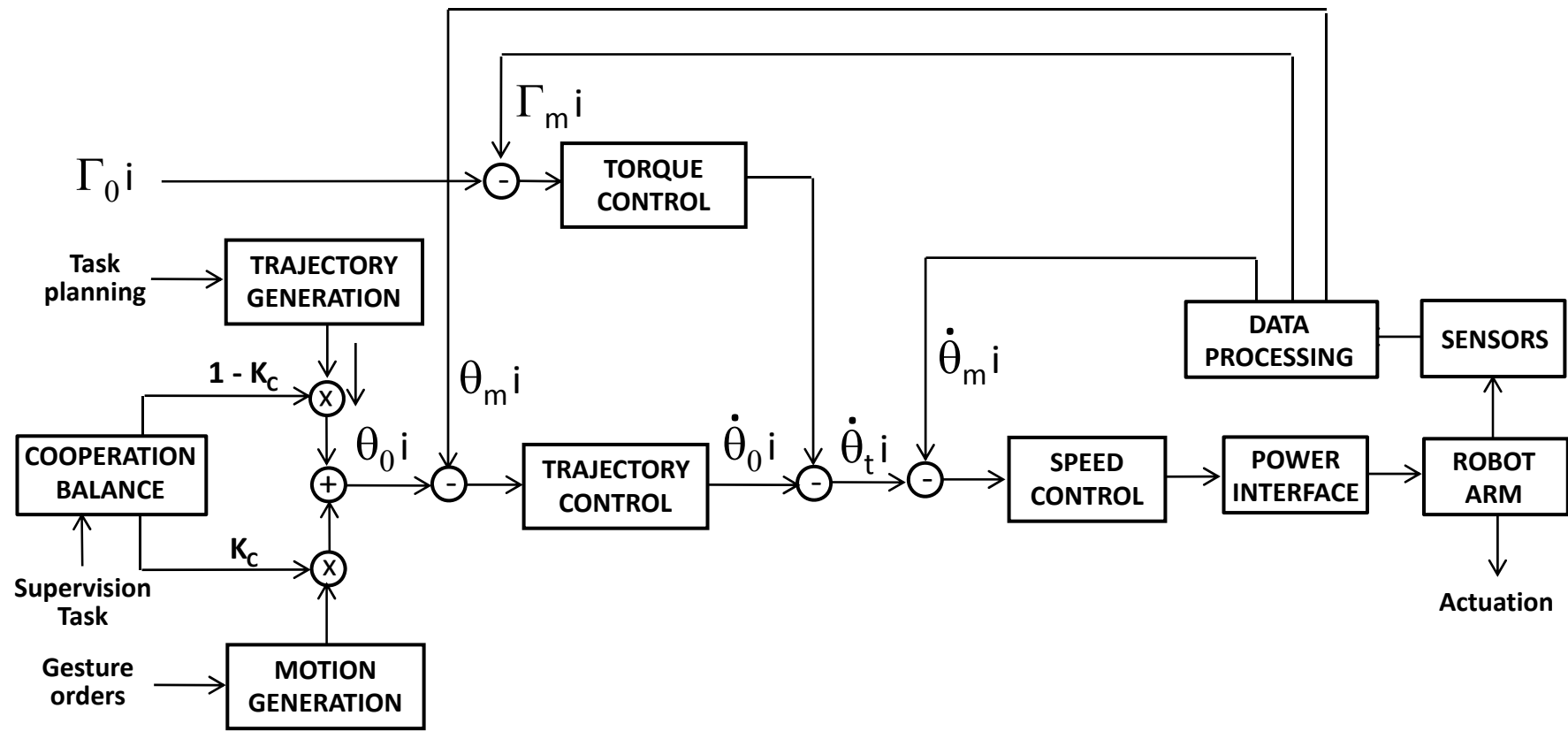
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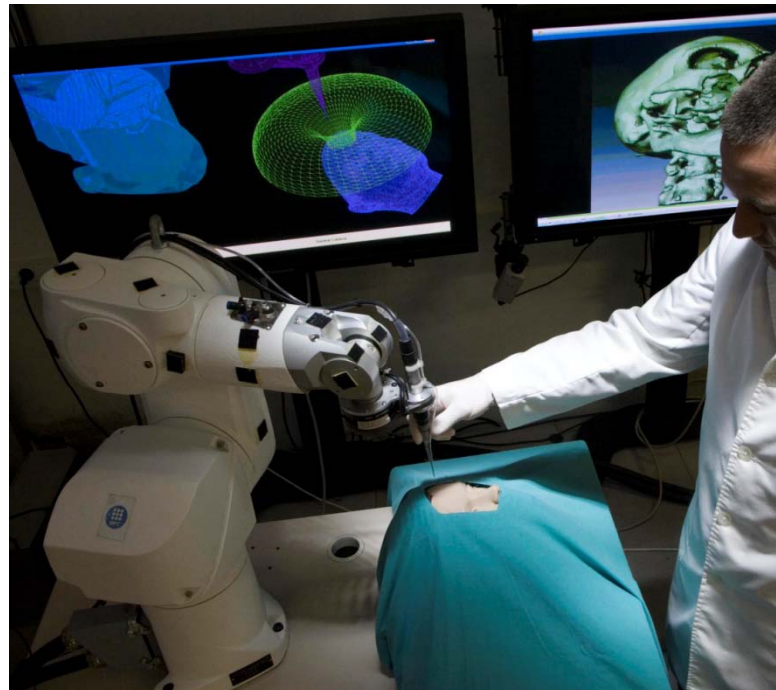
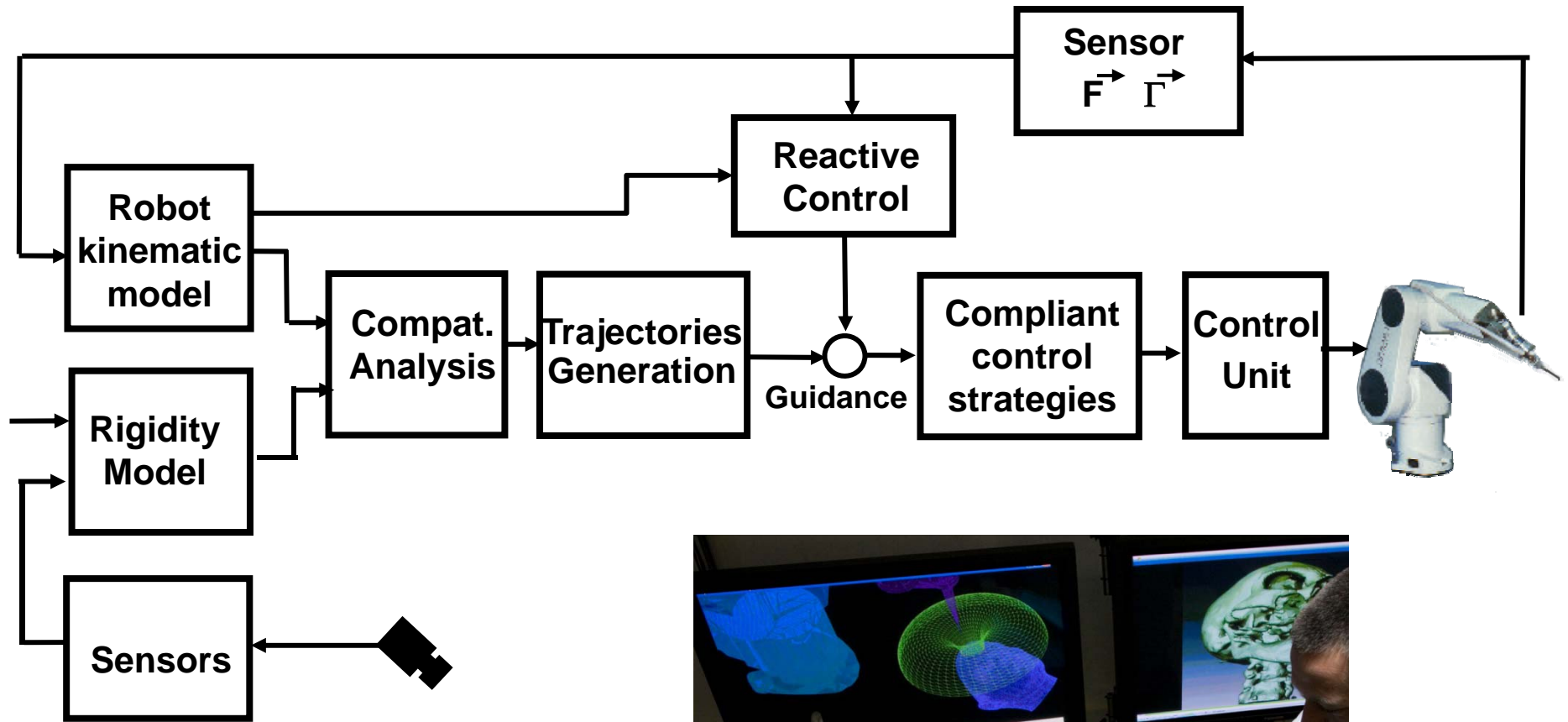
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Orthopedic	Precision, complex fitting, CAD/CAM	





Proposta de "ciència" en l'estratègia de cooperació (en vectorial)



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Intracavity	Ergonomical dexterity, anti stress operation and precision	Manual guidance, multiplexed arms
Orthopedics	Precision, complex fitting, CAD/CAM	Tempos control, registration adjustments