

# Hybrid Intelligence

## (MICRO)SURGERY MODEL

DiMiRoS team

Dalibor Vasilic, ErasmusMC

Jenny Dankelman, TU Delft

Maryam Gholineyad, ErasmusMC/TU Delft

HI-team coordinators

Kim Baraka [k.baraka@vu.nl](mailto:k.baraka@vu.nl)

Catholijn Jonker [c.m.jonker@tudelft.nl](mailto:c.m.jonker@tudelft.nl)

# Long-term Objective

---

**Coupled system** (human-machine) capable of learning high quality task performance in (micro)surgical environment

Successful surgical procedure = successful patient outcome

# Setting of the Case Study: Operating Room

---

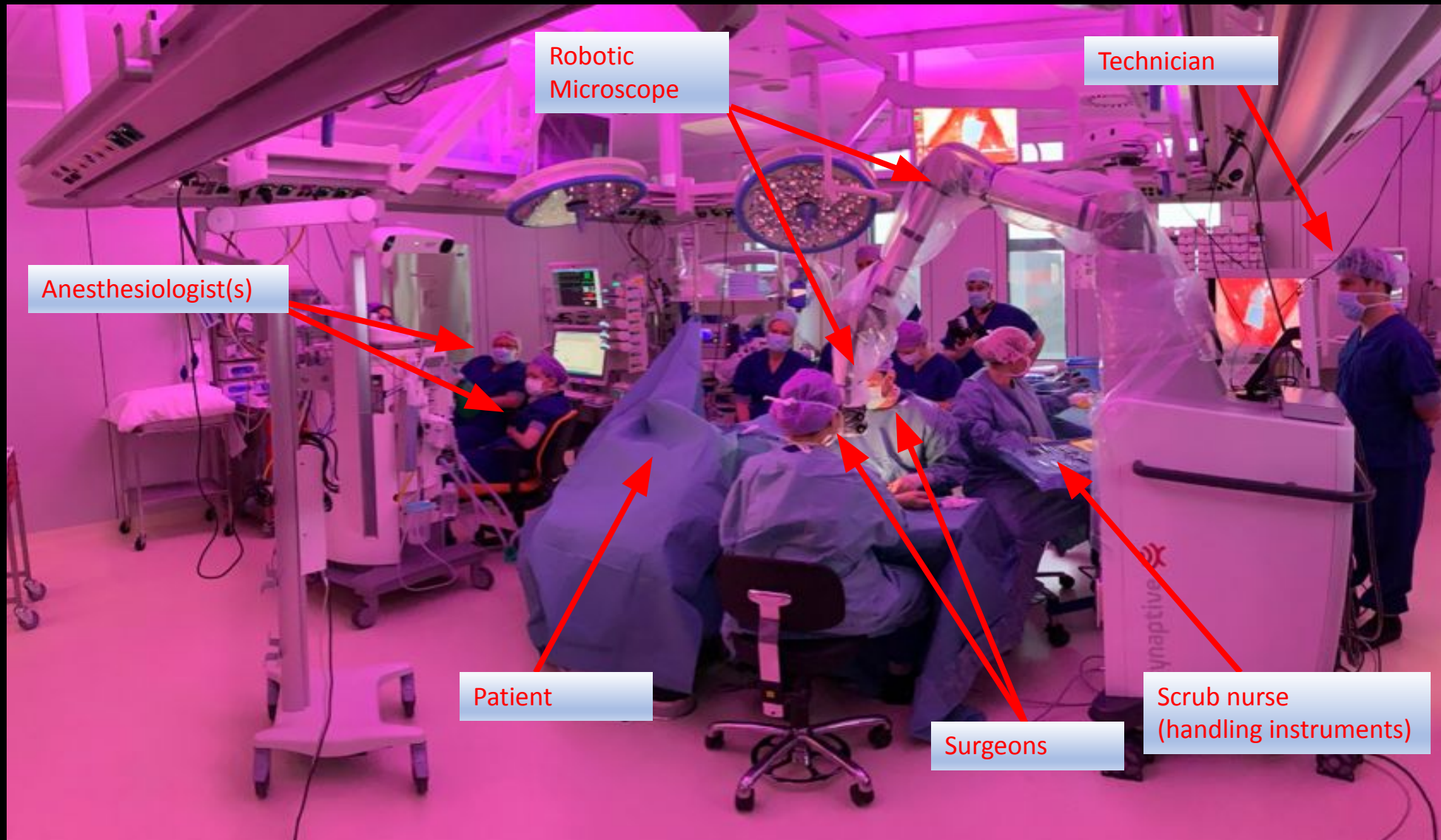
## Description:

- complex decision making and execution within contained space of OR (no rippling effect on outside world).
- (e.g. formulated in a mathematical problem as **assistance game** model)

## Actors:

- **Microsurgeon**: skilled human with cognitive and physical limitations
- **Robotic Microscope**: microscope on a robotic arm
- Other people: another surgeon, technician, scrub nurse, Anesthesiologist(s), patient

# Current Surgical Universe = OR



How can we create a Hybrid Intelligent system in which robot and surgeon complement each others skills, to the benefit of the humans?

- human has an incentive to teach the robot
- the robot learns from the human and experience
- the robot asks questions
- the robot asks permission
- the robot defers to the human



# HI-team potential contributions (more welcome)

- Deliberation
- Shared mental models
- Conversational agents
- Ontologies
- Co-active analysis and co-active design
- Reinforcement Learning
- Machine learning

# Deliberation & Conversation

- Scenario building per operation
  - A: default situation
  - B: potential situation x...
  - C: potential situation y...
- Create a shared mental model between robot and surgeon about
  - plan A, B, C...
  - ontology for this type of operation
- Ontology building for types of operation to speed-up
- Typical dialogue determination
  - during training & preparation sessions
  - during surgery

# About the robot: Input

- audio (speech but also other sounds)
- video (about the instruments, body, the surgery itself, but also about the behaviour of the people in the room)
- haptic/touch controls
- communication with other machinery – additional agents
- Comprehension: what can it observe, recognize, understand?



# Robot: What type of output?

Abstract:

- positioning of the camera
- audio?

Currently:

- according to prespecified instructions?
- manual relocation
- suggest a surgical plan and navigation plan for the surgery
- basic versions of the components are in place
- database of surgeries (with videos and information), with recordings of surgical training.
- Analysis is done using user annotated material, moving towards automatic annotation. Object (tools) and hand-position detection.

# What collaborations? Options

- Co-activity analysis and co-active design method (Johnson, 2012)
- Innovate to fill the gap with Hybrid Intelligence
- Decision making on surgical actions
- Hybrid Intelligent annotation
  - Step/Phase recognition
  - Identification of surgical pitfalls
- Evaluation of surgical actions
  - angle/posture of surgeon's hands and arms
- Robot: Angle/position of robot arm and camera

# HI-research

first steps:

## CO-ACTIVITY ANALYSIS

### Hybrid Intelligent annotation

- Step/Phase recognition
- Identification of surgical pitfalls
  - Gesture recognition
  - Tool recognition

Tasks	Hierarchical sub-tasks (repeated 4x)	Required capacities	Team member Role Alternatives			
			Alternative 1		Alternative 2	
			Performer Surgeon	Supporting team member Microscope/GSAP	Performer Microscope/GSAP	Supporting team member Surgeon
Perform vessel anastomosis (phantom)	Locate the vessel for anastomosis	Sense vessel				
		Recognize/locate vessel				
		(Re)focus/(re)magnify microscope				
	Pick up needle	Sense needle				
		Recognize/locate needle				
		Know how to pick up the needle				
		Pick up needle				
		Sense errors in sub-task performance				
	Pass needle through vessel (part A)	Know how to pass the needle through vessel				
		Position hands with instruments to pick up needle				
		Pass needle through vessel				
		Sense errors in sub-task performance				
	Pass needle through vessel (part B)	Know how to pass the needle through vessel				
		Position hands with instruments to pick up needle				
		Pass needle through vessel				
		Sense errors in sub-task performance				
	Pulling the thread	Know how to pull the thread				
		Pull the thread				
		(Re)focus/(re)magnify microscope				
		Sense errors in sub-task performance				
	Tying the first not	Know how to ty the knot				
		Tie the knot (pick up thread, make loop, grab end and pull)				
	Tying the second knot	Sense errors in sub-task performance				
		Know how to ty the knot				
		Tie the knot (pick up thread, make loop, grab end and pull)				
		Sense errors in sub-task performance				
	Tying the third knot	Know how to ty the knot				
		Tie the knot (pick up thread, make loop, grab end and pull)				
		Sense errors in sub-task performance				
	Cut the thread	Know how to cut the thread				
		Cut the thread				
		Sense errors in sub-task performance				

# GENERAL FUTURE OBJECTIVES to be taken from get go – (philosophy/ethics)

---

Misuse

Enfeeblement = deskilled human