REASONING AND SITUATION AWARENESS

WP 6

Prof Fabio Cuzzolin

OXFORD BROOKES UNIVERSITY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 779813 (SARAS).

Work package description

- **Lead beneficiary**: OBU (Oxford Brookes University)
- Prof Fabio Cuzzolin, WP Leader
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- **Partners involved and their role (in Red M1-M12)**

Partner	PM	Role
UNIVR	4	Current stage recognition, predicting future surgeon action, decision making an intervention, anomaly detection.
UNIFE	2	Current stage recognition, predicting future surgeon action, decision making an intervention, anomaly detection.
OSR	3	Online surgeon action recognition, current stage recognition, predicting future surgeon action, decision making an intervention, anomaly detection.
FSCR	1	
UPC	6	Predicting future surgeon action, decision making an intervention, anomaly detection.
OBU	42	Online surgeon action recognition, current stage recognition, predicting future surgeon action, decision making an intervention, anomaly detection.

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Gantt chart

Years	1st year				2nd year				3rd year			
Month	M1-3	M4-6	M7-9	M10-12	M13-15	M16-18	M19-21	M22-24	M25-27	M28-30	M31-33	M34-36
WP6 Reasoning and Situation Awareness												
Task 6.1 Online surgeon action recognition												
Task 6.2 Procedure stage recognition												
Task 6.3 Predicting future surgeon actions												
Task 6.4 Decision making & intervention												
Task 6.5 Anomaly detection												

- **Milestones**:
- **MS4**: the *MULTIROBOTS-**SURGERY*** platform is operative at Month 12. Experimental/clinical validations are conducted by OSR surgeons at UNIVR

- **Deliverables**:
- **D6.1 Real-time surgeon action detection and recognition** (Month18). Development of tools for surgeon action detection and recognition based on a novel deep learning architecture able to regress ‘action tubes’ in real time from incoming videos

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Title: **Online surgeon action recognition** [M1-M18]

Participants: OBU, OSR

- **Activities**:
- The real-time detection (in time), localisation (within the image) and classification of multiple actions and events
- Actions are performed either by the main surgeon or by the assistive robotic arms
- Actions can be: dissecting a tissue line, sucking up blood, manipulating anatomical structures, changing camera view, etcetera
- Events can be: excessive bleeding, accidental cuts, etc

- **Challenges**:
- We do have a real-time pipeline already in place: **what we need is domain-specific data the system can learn from (data scarcity)**
- **Resolution/quality of the endoscope images**
- **To detect anomalous events we need real data**

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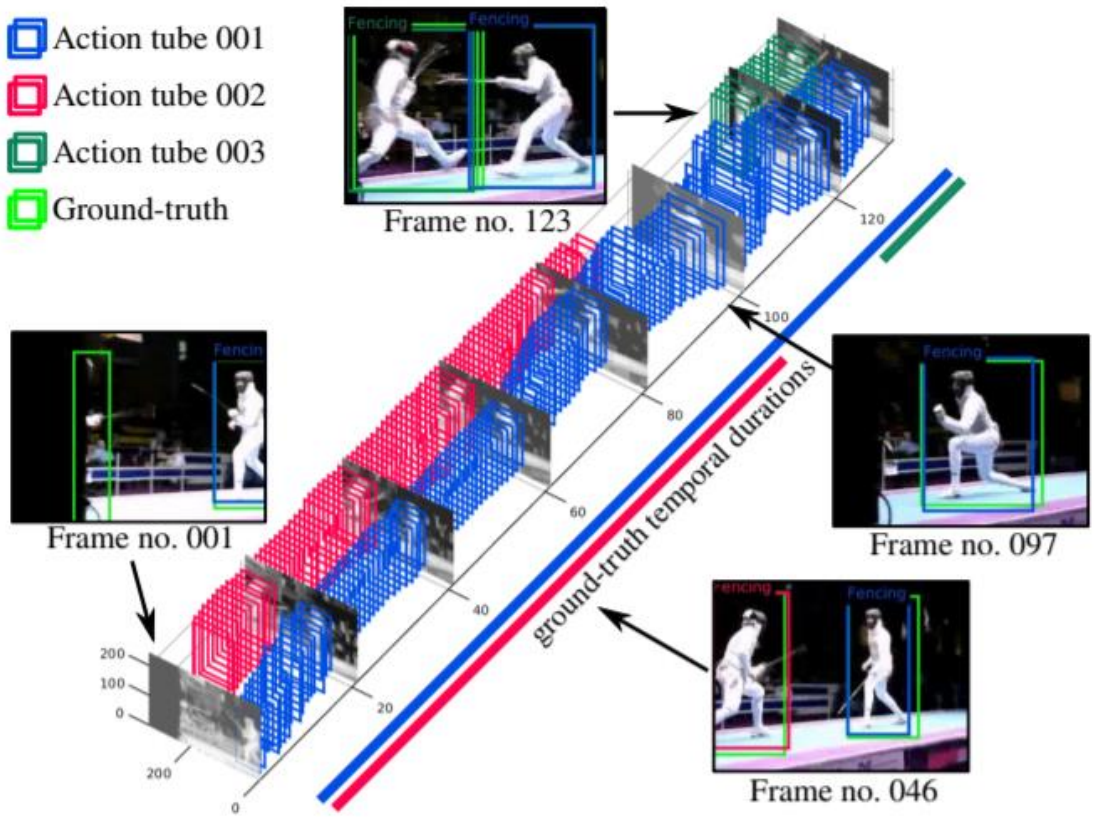
Task 6.1 - Method

- Works by detecting actions of interests in each frame, in real time
- Then linking them together, to form coherent ‘action tubes’



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Task 6.1 - Illustration

- The system learns from ‘annotated’ videos: somebody draws a bounding box around actions of interest
- And ‘labels’ them (e.g. this is jumping, this is dancing)
- **We need something similar for surgical data**
- **The more/better annotation we have, the better the results**
- May come from **verbal annotation** during the procedure
- Plus a simple graphical interface to draw the boxes
- A doctoral student from OSR could do this?

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Title: **Current procedure's stage recognition** [M1-M24]

Participants: OBU, OSR, UNIFE, UNIVR

- **Activities**:
- Based on prior knowledge on the temporal structure of a laparoscopic procedure, and on (training) examples of similar procedures ..
- .. the AI core recognises, at any time instant, what stage of the procedure it is in
- Arranges individual actions (see Task 6.1) into a graph encoding the spatial and temporal structure of the procedure
- Makes use of both examples (as in Task 6.1) and of **prior clinical knowledge** (experts describing the structure of a procedure)
- **Challenges**:
- **Scene context is needed** (coming from WP5), config. of surgical cavity
- **Not implemented yet** (but we have a clear architecture in mind)
- **Real time can be challenging** (but lots of prior knowledge)

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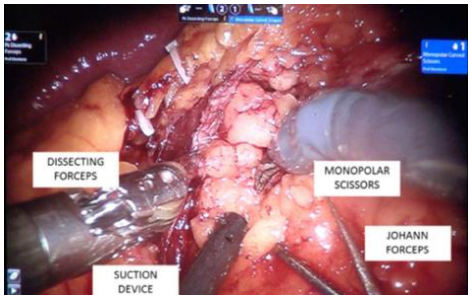

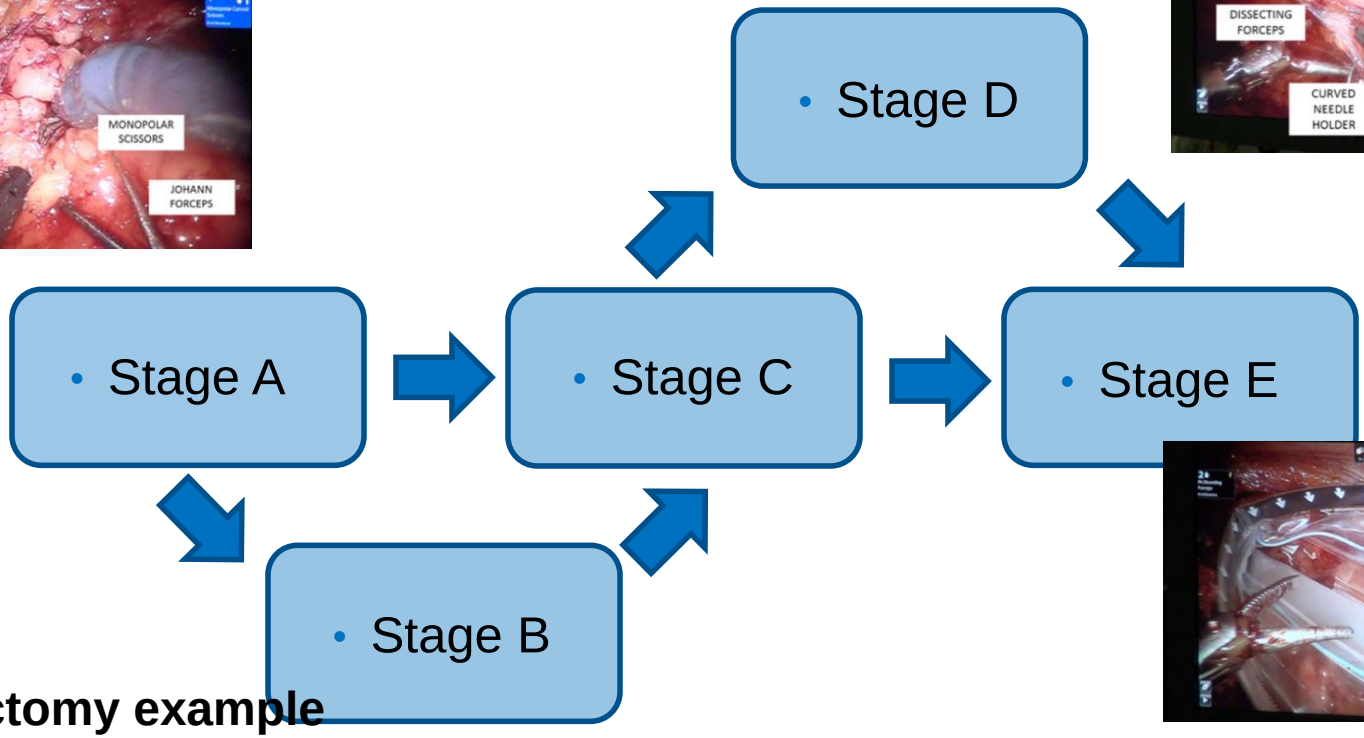

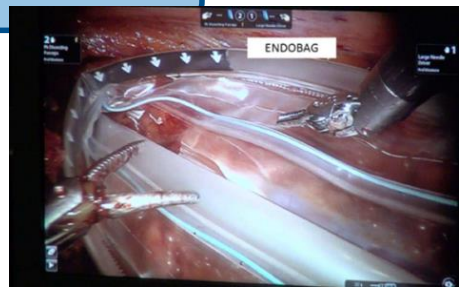

- **Nephrectomy example**
- The same intervention can happen in different variants
- Stages are identified based on what is happening (T6.1), tools present (T5.3) -> **need to associate visual info with procedure stages**
- Prior clinical knowledge on possible temporal structures is crucial

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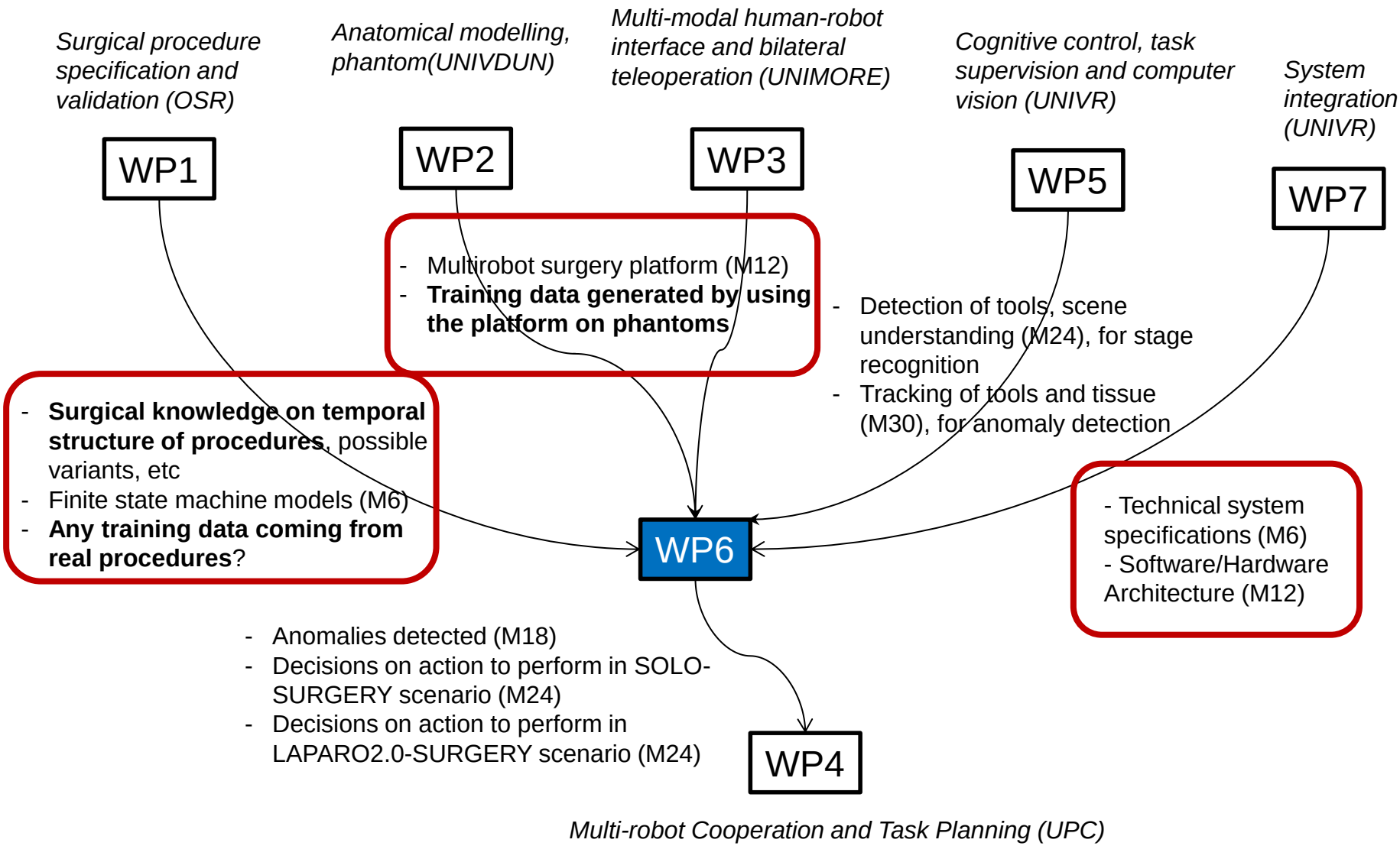
WP relationship (M1-M12)



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Facilities @ AI and Vision lab

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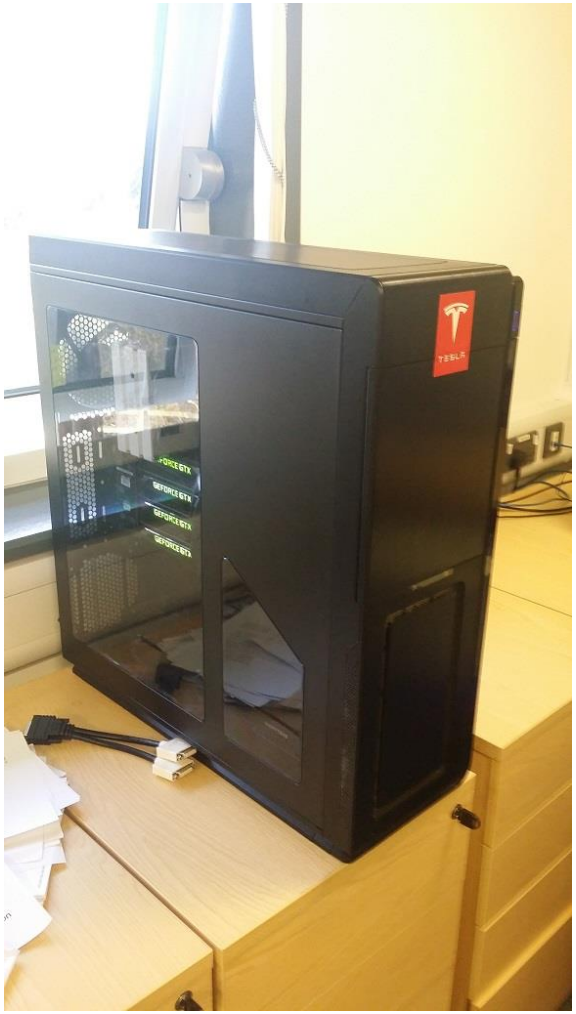
- **Already available**:
- 1-GPU workstation, 4.2TB HD (Jupiter)
- Dell Precision Tower 7910 Workstation equipped with two NVIDIA TITAN X GPU cards, 12.5 TB HD (Sun)
- OcUK Tech Labs Haswell-E X99 Pro Gaming PC Configurator with 4 GeForce GTX 1080Ti "Blower Edition" GPUs, 19.5TB HD (Mars)
- Two Latitude laptops for visitors
- Annotated datasets: UCF-101, JHMDB-51, Oxford RobotCar
- **Funded by SARAS**:
- A new 4/8 GPU workstation for deep learning processing



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Risks and criticalities

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- **Major risks**
- Data of insufficient quantity and/or quality is collected to train the deep networks performing Tasks 6.1 and 6.2 -> **MULTIROBOTS-SURGERY needed asap, appropriate data collection protocol to be agreed on, clinical support by OSR UNIVR**
- Inaccurate or slow recognition of procedure stage -> The workflow of the R-MIS procedure is much constrained by clinical knowledge, so easing the design of complex procedure models. Efficiency by fast deep neural nets
- Anomalies go undetected -> **the system must be tilted towards preventing false negatives**, at least initially

- **Specific needs**
- Clinical knowledge encoded into **temporal structure of procedures and variants**
- **Training data from example procedures**: endoscope videos, robot signals, from the MULTIROBOTS-SURGERY platform
- **Training data from real laparoscopies** conducted at OSR or elsewhere
- For each example procedure: **annotation (what is happening, what objects are present, and where, what stage are we in)** – part of this we can do (object detection), **most needs to come from clinical experts** (verbal annotation while operating?)

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