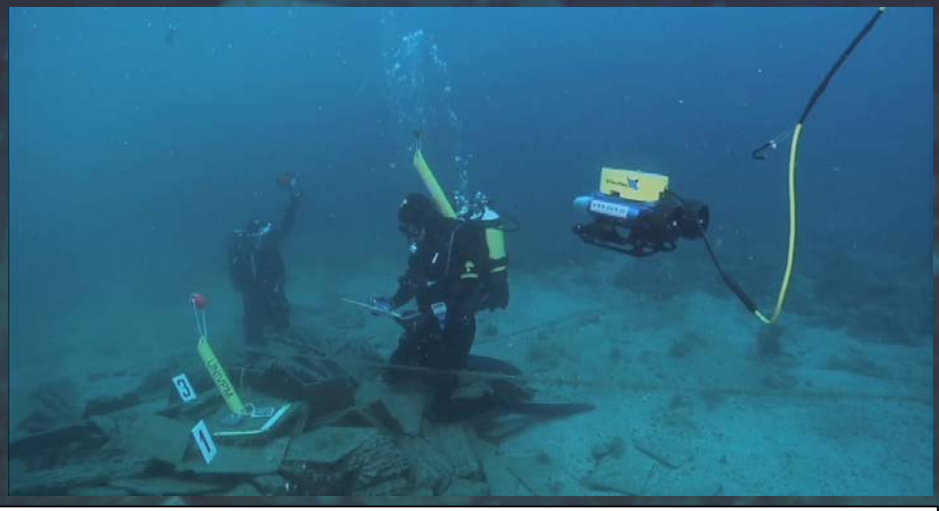
VIPS 2012 ROV Conference

An ROV-Assisted Guidance System for Untrained Pilots

Laura Sorbi, David Scaradozzi

Università Politecnica delle Marche

LabMACS
Laboratory of Modeling, Analysis and Control of dynamical Systems



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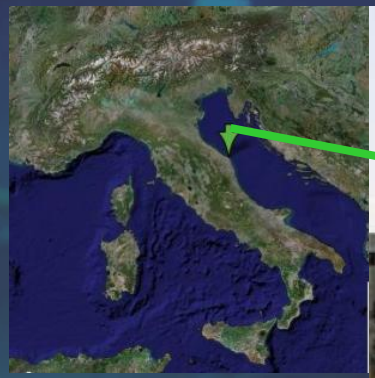
My group and research activities

Who I am

Laura Sorbi – PhD student at the Italian Institute of Technology; I have been working with Prof. Scaradozzi since last year at Università Politecnica delle Marche



My research activities

- Cooperation of multiple Underwater Robotis
- Vision in underwater robotics
- 2D photomosaicing techniques
- 3D reconstruction techniques

Competences, skills

- Development of NGC, hardware and software for robotics
- Data acquisition and processing
- 3D documentation and reconstruction

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An ROV-Assisted Guidance System for Untrained Pilots

Outline

1. Introduction and motivations
2. Architecture of the integrated system
3. Micro ROV assisted guidance system
4. Results
5. Conclusions

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An ROV-Assisted Guidance System for Untrained Pilots

- Starting point:

  We have sensors and we are able to 3D virtual reconstruct (in the optical and acoustic response sense) and document (in terms of morphological, chemical and physical values), portions of underwater volumes of interest.

- Open questions:

  Who carries the sensors on the site of interest?
  - Navigation and Control aspects: How to carry the sensors?

- Motivations:

  Underwater sites of interest in e.g. biology or archaeology often present characteristics that can be damaged by rough intrusion.

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- Motivations:

This motivates the interest in developing “low signature” robotic systems for underwater intervention.

At the present level of technology, a viable solution to reduce signature consists in keeping dimensions small.

This may limit work capability, in particular at high depth, and ultimately reduce the possibility of intervention.

We propose:

the design and realization of an assisted guidance system for a Micro ROV, which is part of a more complex integrated robotic system, developed to support unskilled pilot by implementing an assisted guidance mode

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Architecture of the integrated system

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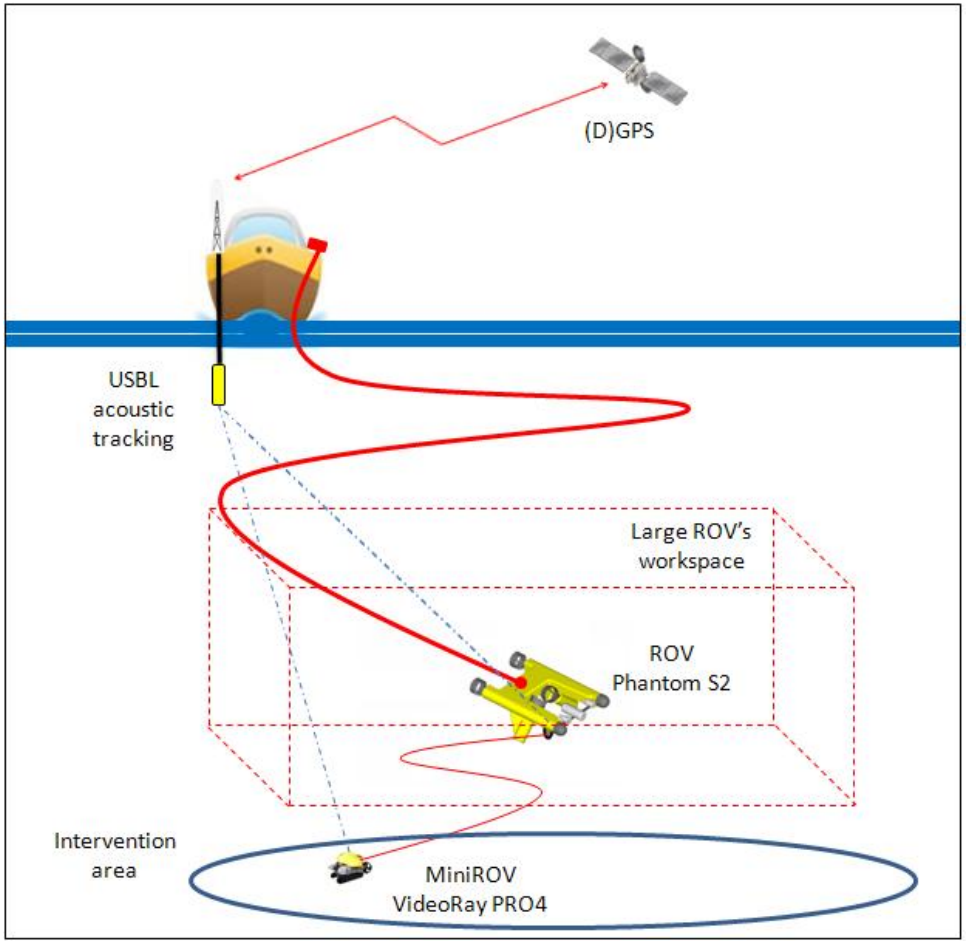

- **The MicroROV is part of an integrated robotic system for deep intervention, consisting of two coupled ROVs of different dimensions.**

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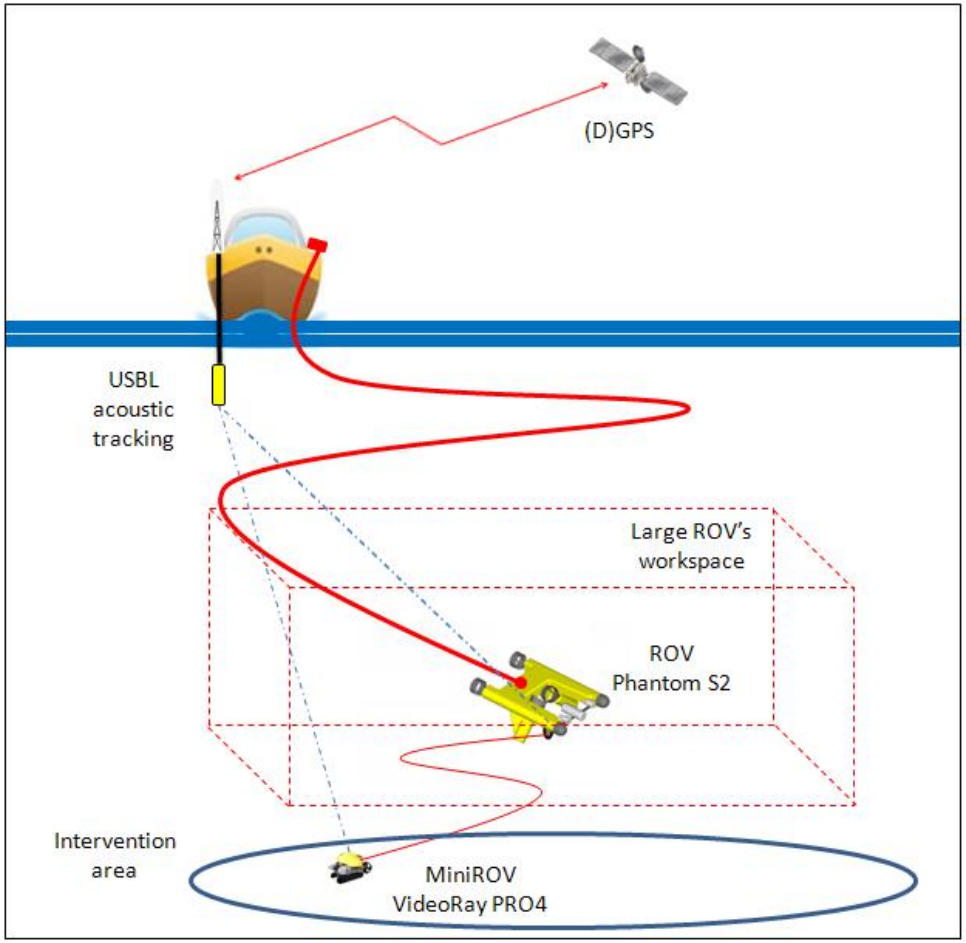

- **In that system, a Micro ROV is tethered to a large one, which, in turns, is tethered to a surface supply vessel.**

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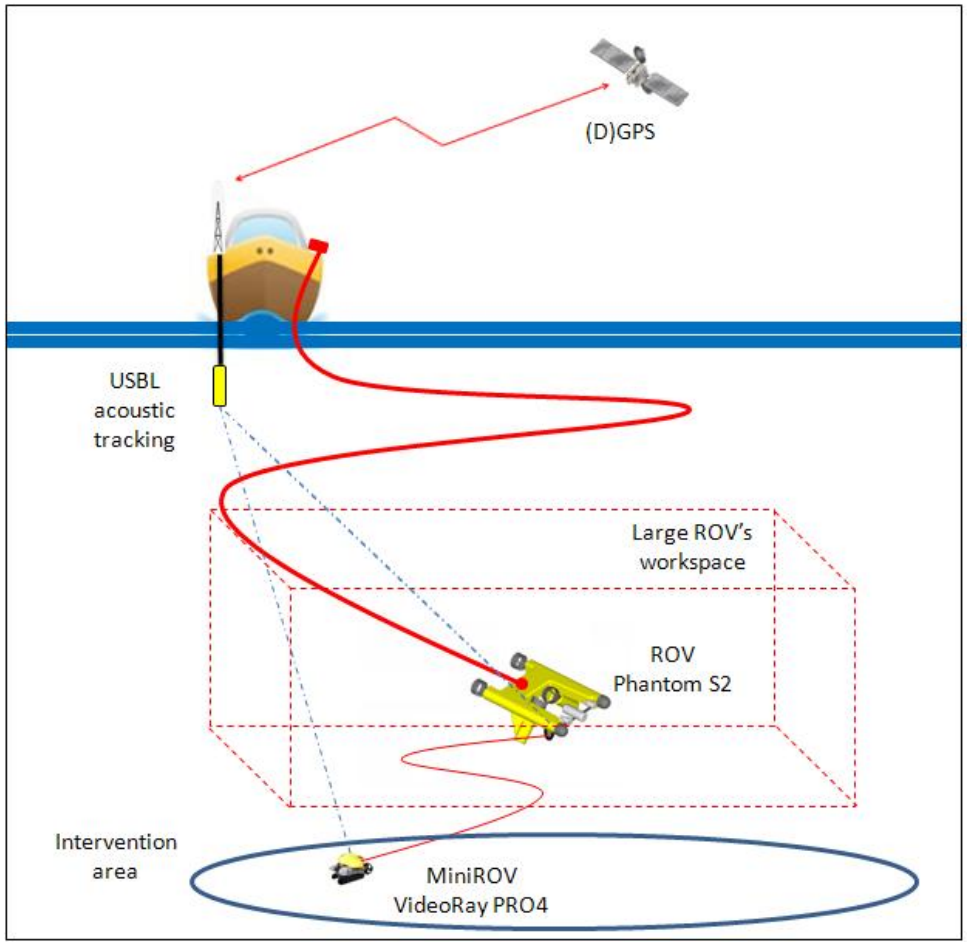

- **A supervised, automatic control system can be used to guide the large ROV while the Micro ROV is remotely guided by a human pilot on the remote vessel**

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Architecture of the integrated system

- The large ROV is maintained in a stationary position or guided along a predetermined path.
- A single operator can efficiently drive the system, focusing his attention on the interaction of the Micro ROV with the environment and on the different aspects of the survey activity.
- This is possible by monitoring the activity of the Micro ROV thanks to the use of optical or acoustic measuring devices mounted on the large ROV and by using the obtained information to assist the pilot.

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Architecture of the integrated system

- The robotic system can be employed according to **two different operational modes**

  ✓**static mode**: the large ROV is stationary and the small one moves around on a restricted area; useful when the main scientific goal is to inspect closely and to document a small area or a single spot

  ✓**dynamic mode**: the two vehicles move along a given paths, keeping a sort of formation; useful in surveying large areas

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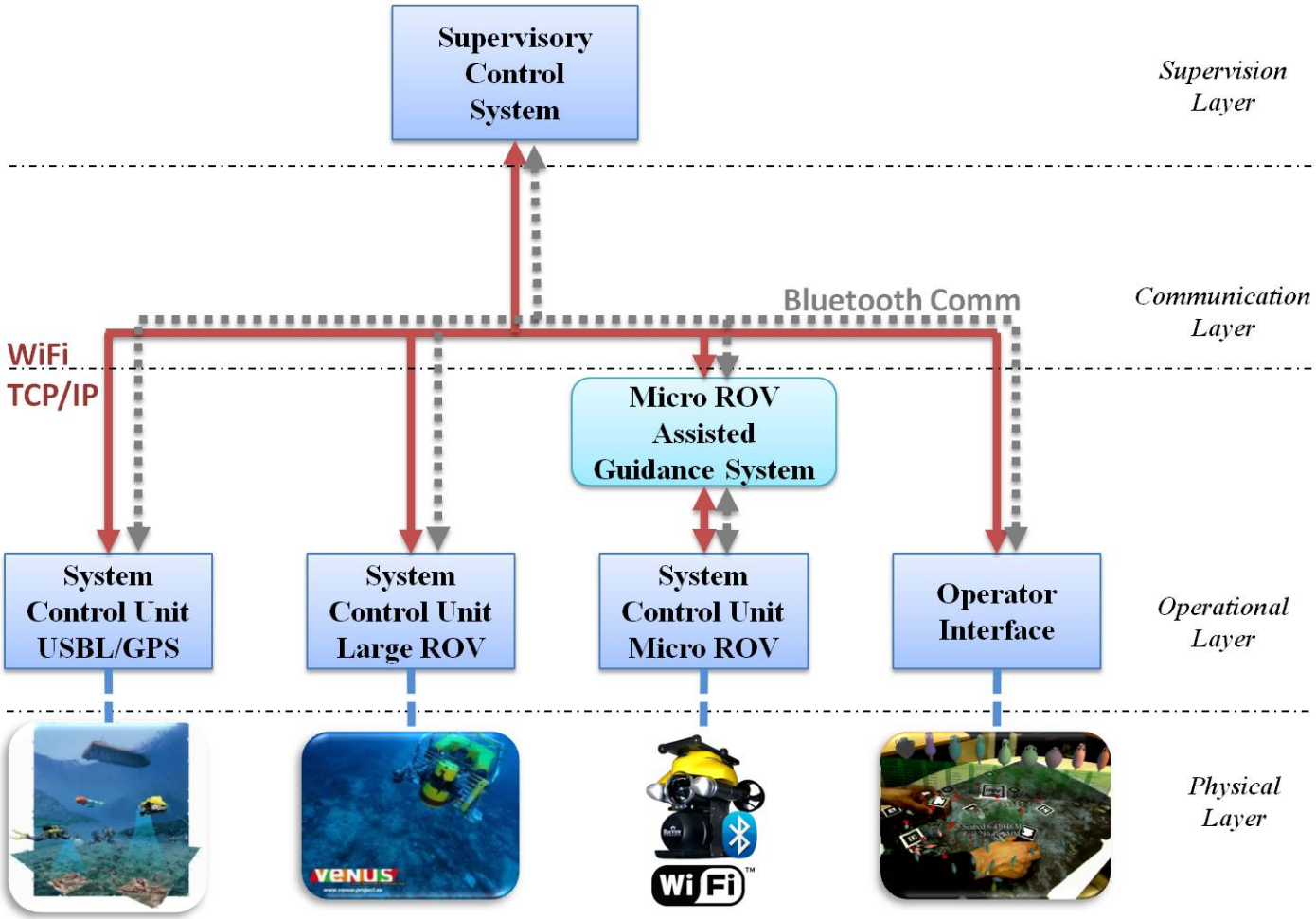

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Micro ROV assisted guidance system

- The basic task of the Micro ROV Assisted Guidance Module is to avoid the operator to drive the vehicle too far from the large ROV.

- The large ROV position on its plane defines an area on the Micro ROV's plane representing the maximum admissible work space of the latter: a rectangular region, whose center is the vertical projection of the large ROV position on the Micro ROV plane.

- It is worth noting that the last assumption can be practically satisfied using the vehicles position information provided by the USBL-DGPS tracking system or, alternatively, using a vision system which exploits a down-looking video-camera mounted on the large ROV and image processing software.

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Micro ROV assisted guidance system

• The Assisted Guidance Module works by modifying the response of the Micro ROV to the pilot's commands depending on the vehicle position with respect to the work area, forcing the pilot to keep the vehicle inside it.

•The Micro ROV is remotely operated by means of force feedback joysticks, so the reaction force on the joystick is increased as the distance from the boundary increases, generating automatically a feedback command which aims at driving the Micro ROV toward the inner part of the work area.

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Micro ROV assisted guidance system: main scheme

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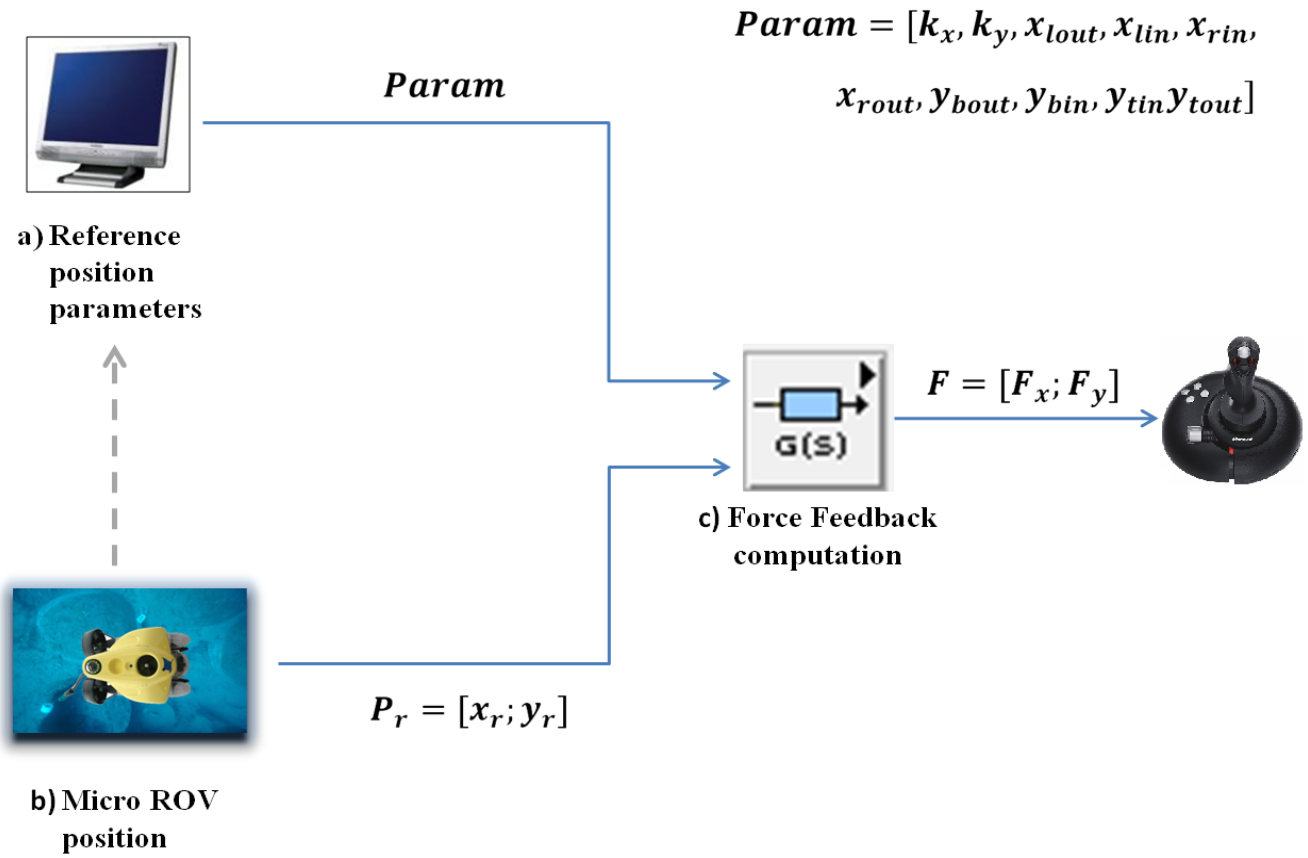

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Micro ROV assisted guidance system: force feedback computation

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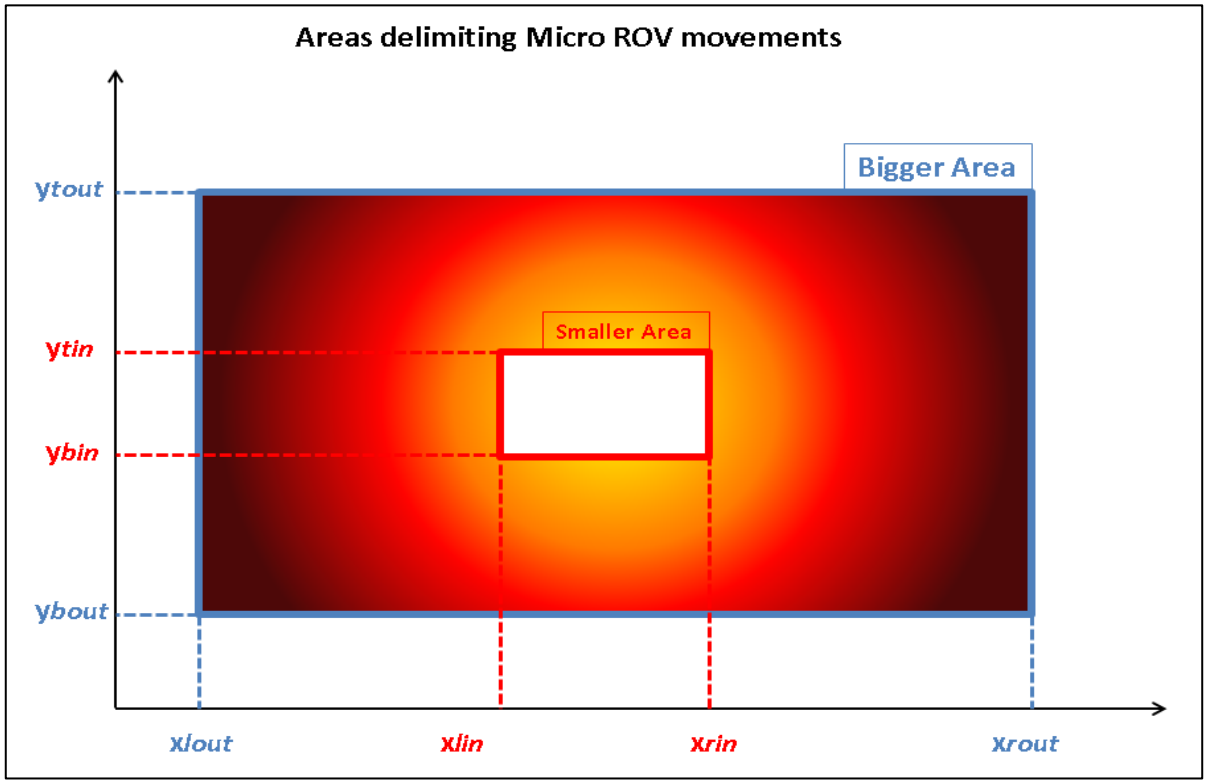

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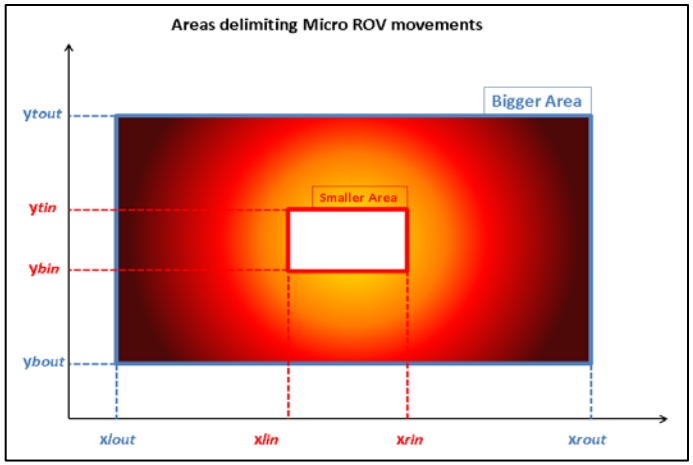

$$F = \begin{bmatrix} F_x \\ F_y \end{bmatrix} = \begin{bmatrix} k_x \dfrac{x_r - x_{lin}}{x_{lout} - x_r} - k_x \dfrac{x_r - x_{rin}}{x_{rout} - x_r} \\ k_y \dfrac{y_r - y_{bin}}{y_{bout} - y_r} - k_x \dfrac{y_r - y_{tin}}{y_{tout} - y_r} \end{bmatrix}$$

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Micro ROV assisted guidance system: operational mode

- **Static Mode**: the large ROV keeps its station, the work area of the Micro ROV is fixed.
  Rectangles are defined based on the characteristics of the robotic system (length of the Micro ROV's umbilical; performances of the vision system; response of the vehicles, skill of the Micro ROV pilot) and the mission requirements.

- **Dynamic mode**: the large ROV is supposed to move along a predetermined path and therefore the work area of the Micro ROV is varying with time. Data produced by the assisted guidance system block are updated at a fixed frequency. It is seen as a sequence of independent situations in which the static mode is active.

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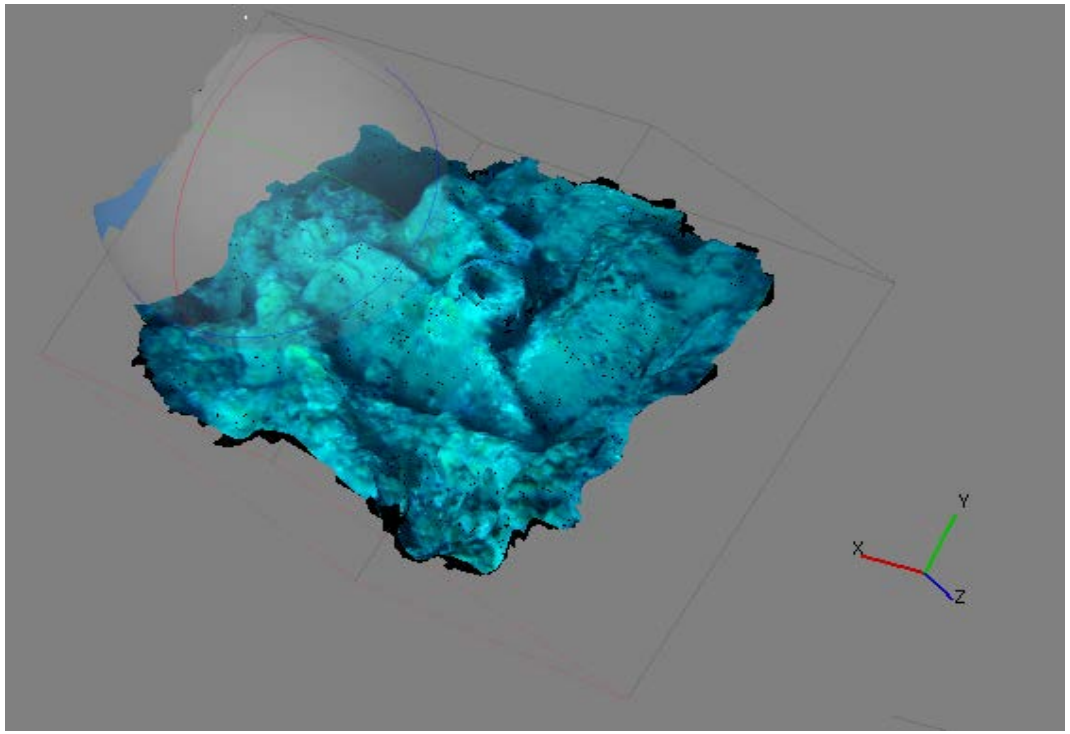
Results

Testing the force feedback implementation in simulation on already gathered data: **Kolocep – Dubrovnik - Croatia**



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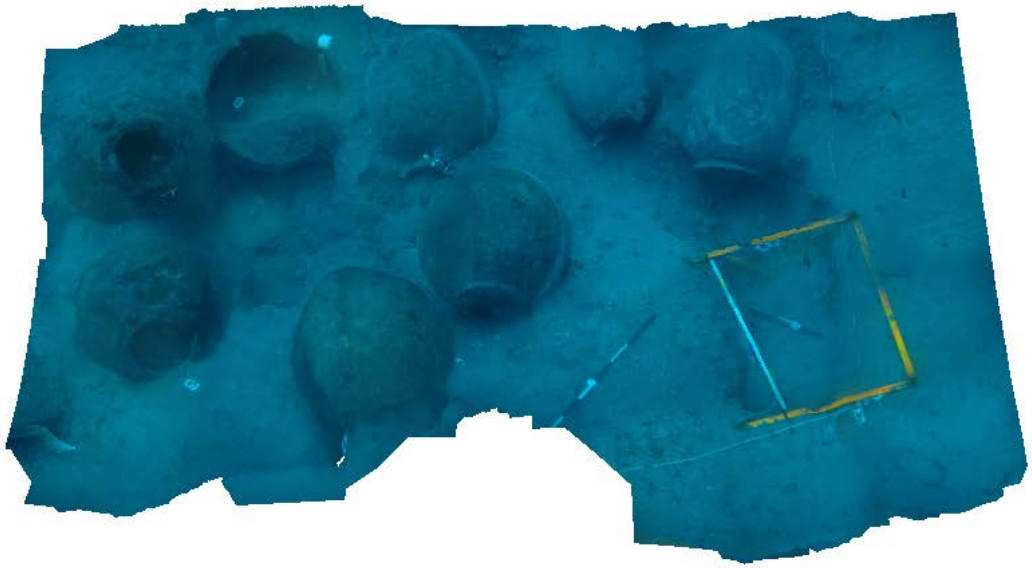
Results

Gathering data using the force feedback reaction from the Micro ROV assisted guidance system: **Elba island – Italy**



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Conclusions

• The developed system aims at making substantially simple the task of guiding the micro ROV.

• This will make possible to operate directly the micro ROV to pilots who have limited skill and experience.

• Future works will concern tests and validations of the whole structure in field missions.

•The system developed wants to be versatile: it could be used with other force profile for the feedback on the user hands.

• The joystick within the system could be used as a "**driving school**" for unskilled pilots, if coupled with simulators

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Thank you

Any questions?

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