From Interaction to Integration: Advancing Optimal Human-Robot interfaces for Underwater Manipulation

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Introduction

- Underwater operations involve interaction with the environment, but such interactions can be **hazardous** or **detrimental** to the underwater ecosystem. Therefore, it is essential to develop teleoperation systems that prioritize **user comfort** while **minimizing environmental impact**.
- Previous work showed that a natural user interface is not only comfortable and easy to use but it is also **optimal**.

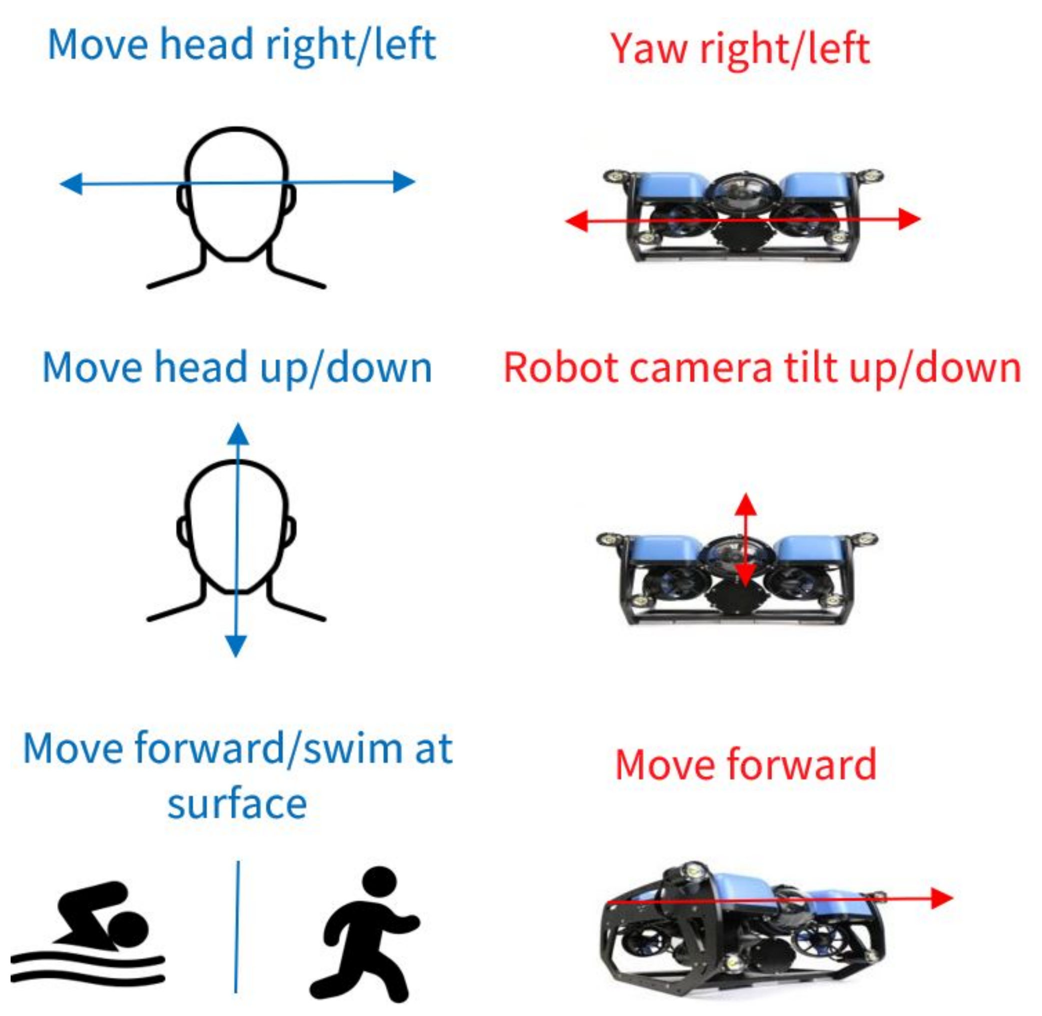

Figure 1. Natural user interface found in last work

Methodology

- The problem of developing is described as finding a mapping between the user's actions and the robot's actions.

$$g : \underbrace{\mathcal{A}}_{\text{user's actions}} \longrightarrow \underbrace{\mathcal{U}}_{\text{robot's actions}}$$

- g usually comes from a tailored functional designed to enforce the function to have some properties. We constructed a functional so we obtained the mapping given by Fig. 1. Its general form is:

$$g = \arg\min \int_0^t L(g(a(t), x(t)), a(t), Dg(a(t), x(t)))dt$$

- On top of previous results we added an image recognition AI assisted user tool in order to manipulate the robot's gripper. It allows identifying whether the user's hand is open or closed.

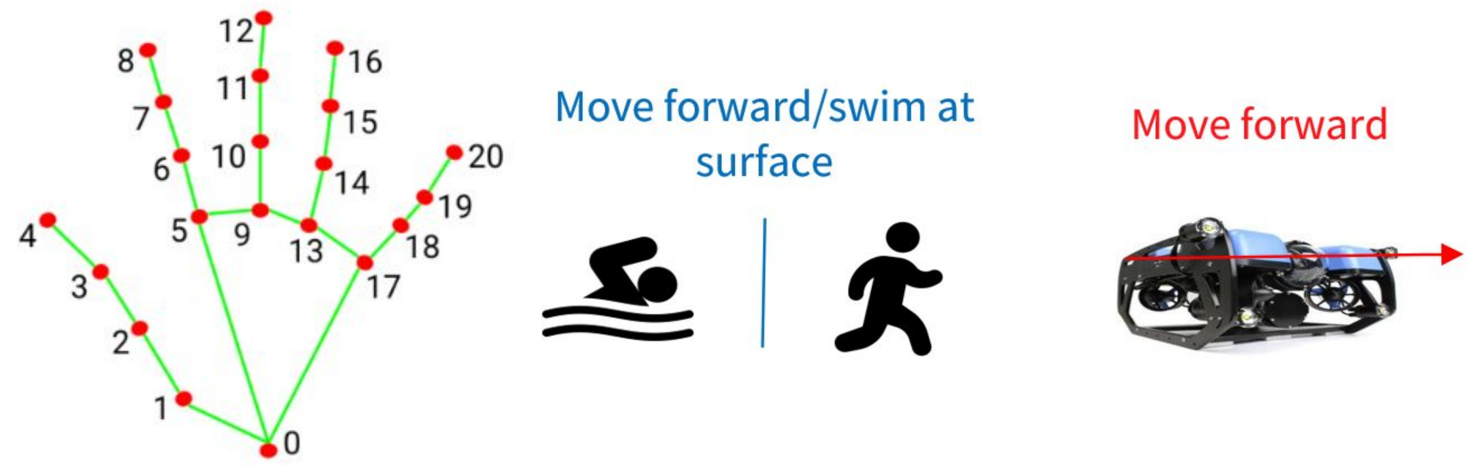

Figure 2. Hand landmarks used to identify closed and open gestures (left), new action mapping (right)

Results

- An extensive approach for manipulating a BlueROV2 in a simulated environment.
- Soft gripper control through hand gestures.

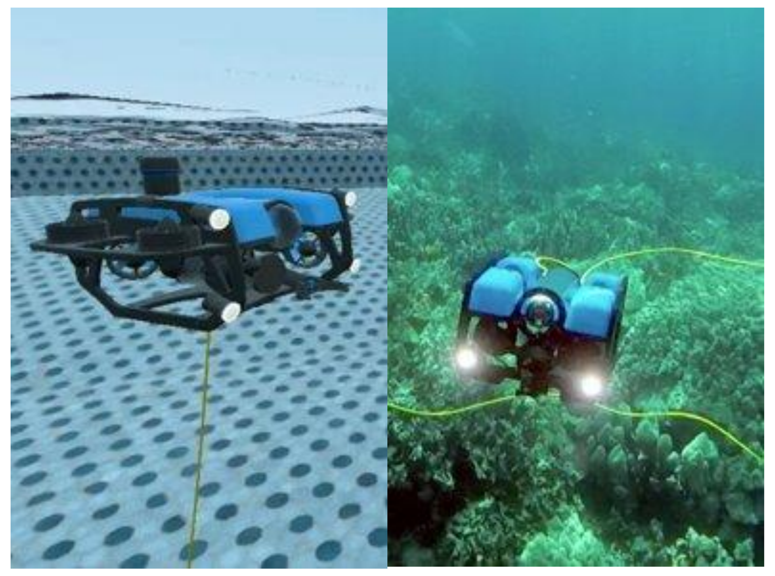

Figure 3. Real robot underwater (left), robot's digital twin (right)

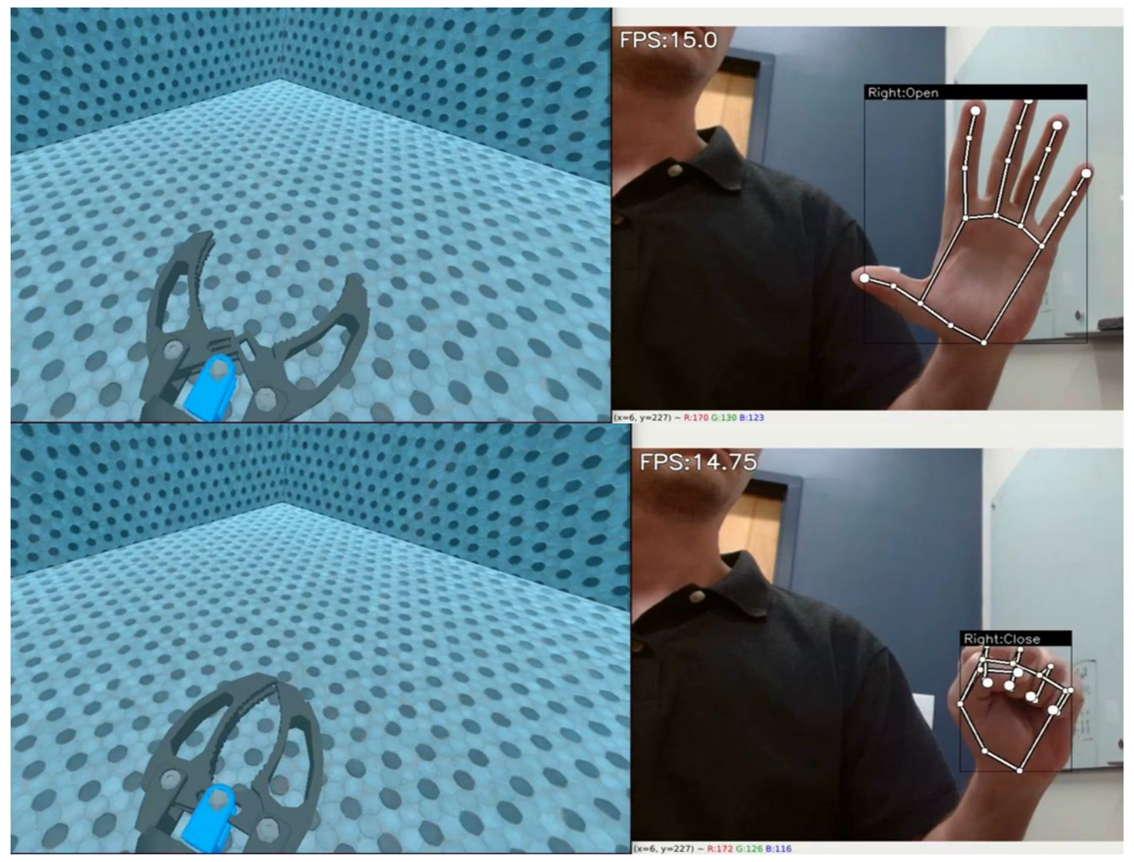

Figure 4. Open hand gesture recognition (left), closed hand gesture recognition (right)

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Conclusion & Future Work & Acknowledgements

- We seek to enable physical control of the entire ROV. This would offer a realistic experience
- This approach can also be employed to manage other binary control systems

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