2128895: Human-Robot Sensory Transfer for Worker Productivity, Training, and Quality of Life in Remote Undersea Inspection and Construction Tasks

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BACKGROUND

- **Subsea engineering and exploration represents great economic, environmental and societal opportunities.** According to the National Oceanic and Atmospheric Administration (NOAA), about 95% of the world's oceans and 99% of the ocean floor are unexplored.
- **It is extremely dangerous and highly difficult in subsea operations.**
- Many subsea operations rely on Remotely Operated Vehicles (ROV). Piloting a ROV takes years of training and requires engineering knowledge such as marine engineering, mechanical engineering, and robotics etc.
- The difficulty of ROV piloting and the corresponding requirements on engineering knowledge set a **high barrier for people who are interested in the marine industry**.

OBJECTIVES

The overarching goal of this project is to explore the opportunities for broadening participation of the general population in the future subsea engineering works via a human-robot sensory transfer approach.

- **Objective 1:** Explore Human-Robot Sensory Transfer that Lowers Barriers of Underwater Robot Controls to Democratize Human Presence in Subsea Works
- **Objective 2:** Quantify Functional, Motivational and Educational Impacts of the Proposed Subsea Human-Robot Interaction on Workers in Various Subsea Work Contexts
- **Objective 3:** Investigate the Viability and Sustainability of Future Subsea Works with the Proposed Underwater Human-Robot Interaction

PROPOSED HUMAN-SENSORY TRANSFER SYSTEM

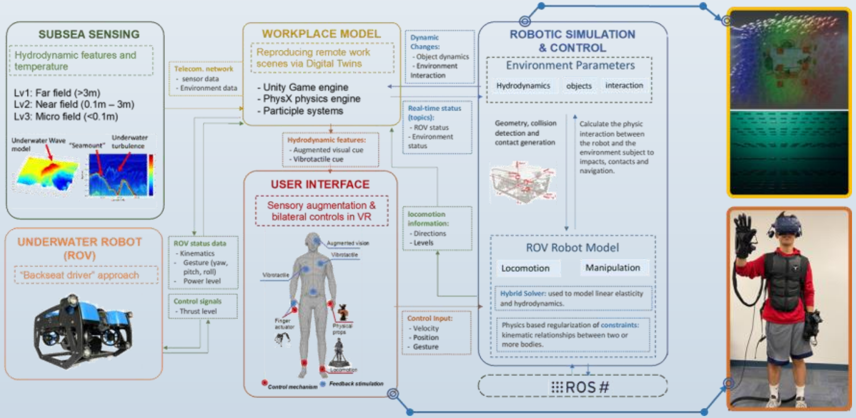


Fig.1 System structure for sensory augmentation for subsea robot teleoperation

FIVE MODULES in the system:

Subsea Sensing Module: multi-level sensor network to collect real-time subsea environmental data pertaining to the hydrodynamic features; **ROV Module**: a platform based on BlueROV2 with a heavy configuration; **Robotic Simulation and Control Module**: data synchronization among ROV, Robot Operating System (ROS) and Virtual Reality (VR) platform; support natural body-motion control; **Workplace Model Module**: three levels of flows (micro, near and far field) generated by PhysX game engine; multi-sensor data fusion and Deep Convolutional Generative Adversarial Network (DCGAN) prediction; **User Interface Module**: including **Unity Data Augmentation System** and **Haptic Feedback System**; Human operator receive multi-level feedback corresponding to that generated in Workplace Module with VR headset, haptic suit and haptic gloves.

Fig.2 Subsea environment reconstruction in Workplace Model

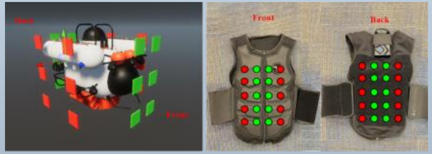


Fig.3 Haptic device connection and binding in User Interface Module

CASE STUDY

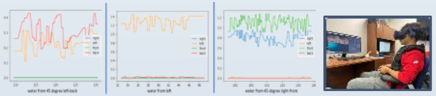
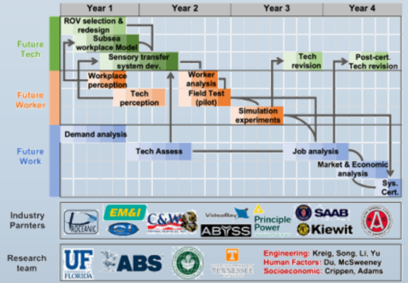


Fig.4 Case study experiments and results

Three areas with subsea currents are designed in different directions on the inspection route. The operator need to keep the original route and finish inspections in three inspection areas without losing direction and keep the minimum drift. The plots demonstrate the changes in average intensity values generated on the haptic suit zones in each current area.

The result showed that the difference in vibration patterns was significant and the participants could easily identify different ROV positions and locomotion conditions based on the information provided by the multi-level sensory feedback system.

PROJECT TIMELINE AND TEAM



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