Shared Autonomy for Unstructured Underwater Environments through Vision and Language

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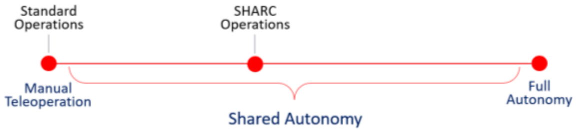
Challenge

Manipulation tasks using robotic arms in unstructured underwater environments are slow, labor intensive, and cognitively demanding for human operators.

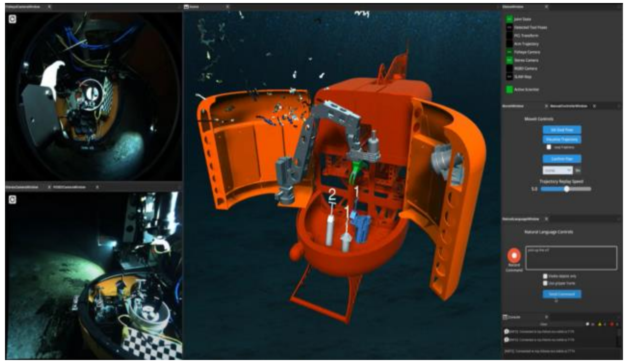
Solution

Shared Autonomy for Remote Collaboration (SHARC) provides a scalable method for safe and efficient collaborative human-machine operation.



Key aspects:

- Virtual Reality interface enables a safe, intuitive mechanism for human interaction with the 3D work space.
- Low-level automated motion planner eases cognitive burden (and training requirement), enabling earth scientists to focus on high-level science objectives.
- Natural language input provides an intuitive process for issuance of goal commands within a given environmental context, increasing the operations efficiency while also improving the situational awareness of humans who are collaborating within the workspace.

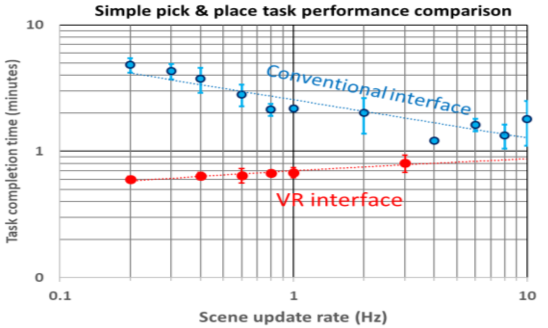


Screen capture of SHARC desktop interface while issuing natural language commands remotely (from Chicago) during a science sampling operation using a robotic arm on a remotely operated vehicle at 1km deep in the Eastern Pacific Ocean.

Collaborative (3rd person) view of real-time 3D workspace scene reconstruction during human directed manipulation operations using SHARC-VR interface.

Scientific Impact

SHARC couples the advantages of automated low-level motion planning and control with an immersive real-time 3D reconstruction of the work space, while enabling human supervisory (goal directed) control. This minimizes human cognitive burden while also providing scalability for human-human cooperation within the workspace and parallelization of tasks.



Plot comparing task completion time as a function of varying scene update rate. Results indicate that the SHARC VR interface enables lower task completion time also decreasing required bandwidth by nearly 100X.

Broader Impact

- SHARC's performance relative to conventional control indicates that it enables order-of-magnitude efficiency gains when operating with high latency or limited bandwidth telemetry. This has major implications for advancing the mission complexity and marine and space-based robotic systems without increasing bandwith requirements.
- It is directly transferrable for other applications, such as for underwater maintenance of NSF's OOI infrastructure (potentially saving $M/yr in maintenance and repair costs), as well as for increasing the operations tempo for marine and terrestrial disaster response missions requiring robotic intervention.
- Its scalability enables real-time engagement by potentially large numbers of remote citizen scientists and observers (order thousands) from anywhere in the world using a standard internet connection and consumer-grade VR headset or personal computer.

Map of NSF Ocean Observatory Initiative study sites.

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