HERIOT WATT UNIVERSITY

Gesture Control of an Underwater Manipulator

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Background

- Teleoperation allows underwater manipulators to be remotely controlled from the surface
- Currently many different styles of controllers are used for teleoperation
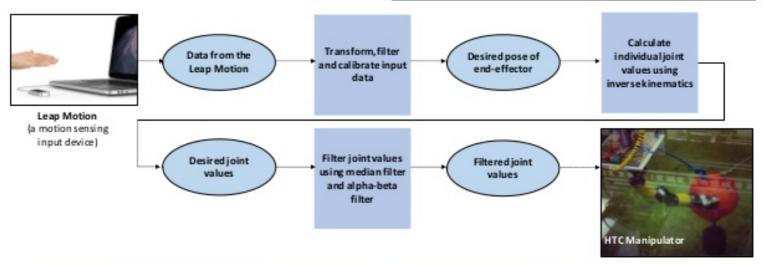- Extensive training is required to operate current controllers

Hypothesis: A gesture control input device, such as the Leap Motion, would provide a more intuitive method of controlling the HDT Adroit Underwater Manipulator compared to the current joystick based Hardened Operator Control Unit (HOCU)

Aims and Objectives

- Develop a working simulation that allows the Leap Motion to control the motion of the underwater manipulator
- Control the physical HDT Adroit Undersea Manipulator by mimicking human gestures captured by the Leap Motion sensor
- Contrast the performance of the Leap Motion controller to the Hardened Operator Control Unit

Hardened Operator Control Unit (HOCU)

Leap Motion
(a motion sensing input device)

Data from the Leap Motion → Transform, filter and calibrate input data → Desired pose of end-effector → Calculate individual joint values using inverse kinematics

Desired joint values → Filter joint values using median filter and alpha-beta filter → Filtered joint values →

HTC Manipulator

Key Technical Challenges

Frame of Reference
Problem: The Leap Motion and the HDT manipulator have different frames of reference.
Solution: The Leap Motion data axis was converted to manipulator frame of reference.

Calibration
Problem: Converting Leap Motion data to the relative end effector pose
Solution: The required pose of the manipulator was given by the relative position and orientation of the operator's hand over the Leap Motion. As a result, the operator had to start with their hand over the device in order to set the origin values.

Filter
Problem: The manipulator runs the risk of being damaged if the joint state values are erratic.
Solution: Both the Leap Motion input signal and the joint state output signal were smoothed using mean, median and alpha-beta filters.
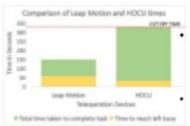
Pause mechanism
Problem: The operator's hand and the end effector need to be in the same relative position when resuming a paused system. Otherwise the system runs the risk of the two becoming out of sync.
Solution: The controller is locked until the operator positions their hand at the required position. A sphere appears in the simulator guiding the operator to the correct position.

Evaluation

The task was to touch two buoys in the fastest possible time:
- Trials taking longer than 5 minutes 30 seconds marked as a failed attempt
- 3 trials on each device
- Arm is reset to the default position between trials

- HOCU quicker at reaching the left buoy as it was quicker to maneuver in a straight line
- Operators managed to complete the whole task nearly every time when using the Leap Motion
- Operators never managed to complete the whole task using the HOCU
- HOCU kept hitting joint limits when trying to reach right buoy

- Leap motion proved to be more intuitive, caused less pain, allowed for greater precision and provided more control
- HOCU excelled at pausing the system as it involved the operator letting go of the joystick