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Haptic-GeoZui3D: Exploring the Use of Haptics in AUV Path Planning

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Rick Komerska, Colin Ware, Matthew Plumlee and Roland Arsenault

Our Goal

Our research goal is to utilize the sense of touch and force feedback to enhance our ability to interact with 3D data in real time and across multiple scales and frames of reference.

As AUV missions become more complex, the need to plan these missions in a safe and efficient manner will increase. We believe Virtual Reality (VR) and haptic technologies can support this requirement by providing an intuitive and compelling environment for interaction.

Haptic Design Principles

Constraints and Visual Integration

- Haptically represent constraints rather than objects
- Display constraints both visually and haptically
- Visually emphasize potential for interaction
- On contact, visually reveal additional constraints
- Make state information visually and haptically available

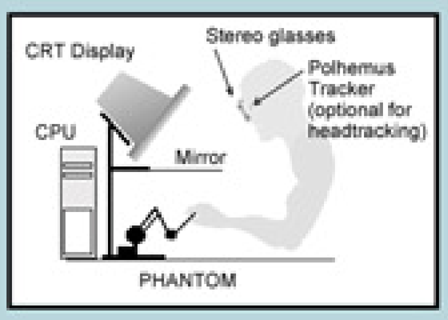
Center-of-Workspace Interaction Metaphor

This metaphor mimics a typical physical workspace, such as an office desk or technician's workbench. It employs a central fixed point in space, conceptually within arm's length of the user. Objects are brought to the center of the workspace and operated on by contextually appropriate tools.

An Integrated Workspace

Haptic widgets provide a mechanism for combining task-related constraints with a direct manipulation environment.

Our fish tank virtual reality combines force feedback, stereo vision and headtracking technologies with center-of-workspace interaction to provide a small yet high fidelity testbed for evaluating haptic widgets and interface concepts.



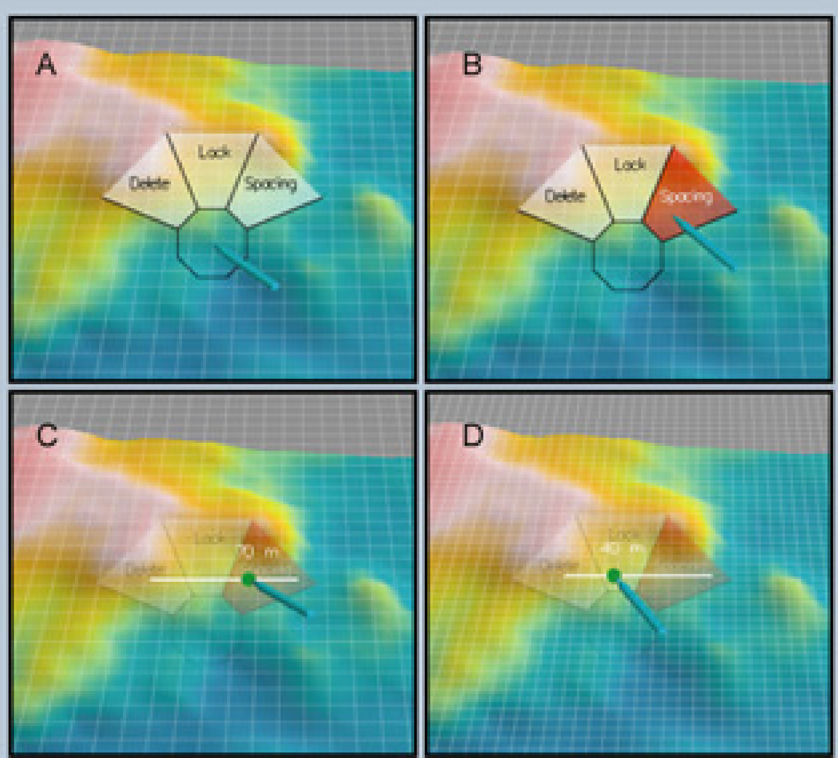
System Specifications

- PC-based
- OpenGL graphics, Stereo vision
- PHANTOM 1.0 haptic device
- Polhemus headtracking
- Modified GeoZui3D visualization software

Haptic Elements to Support Path Planning

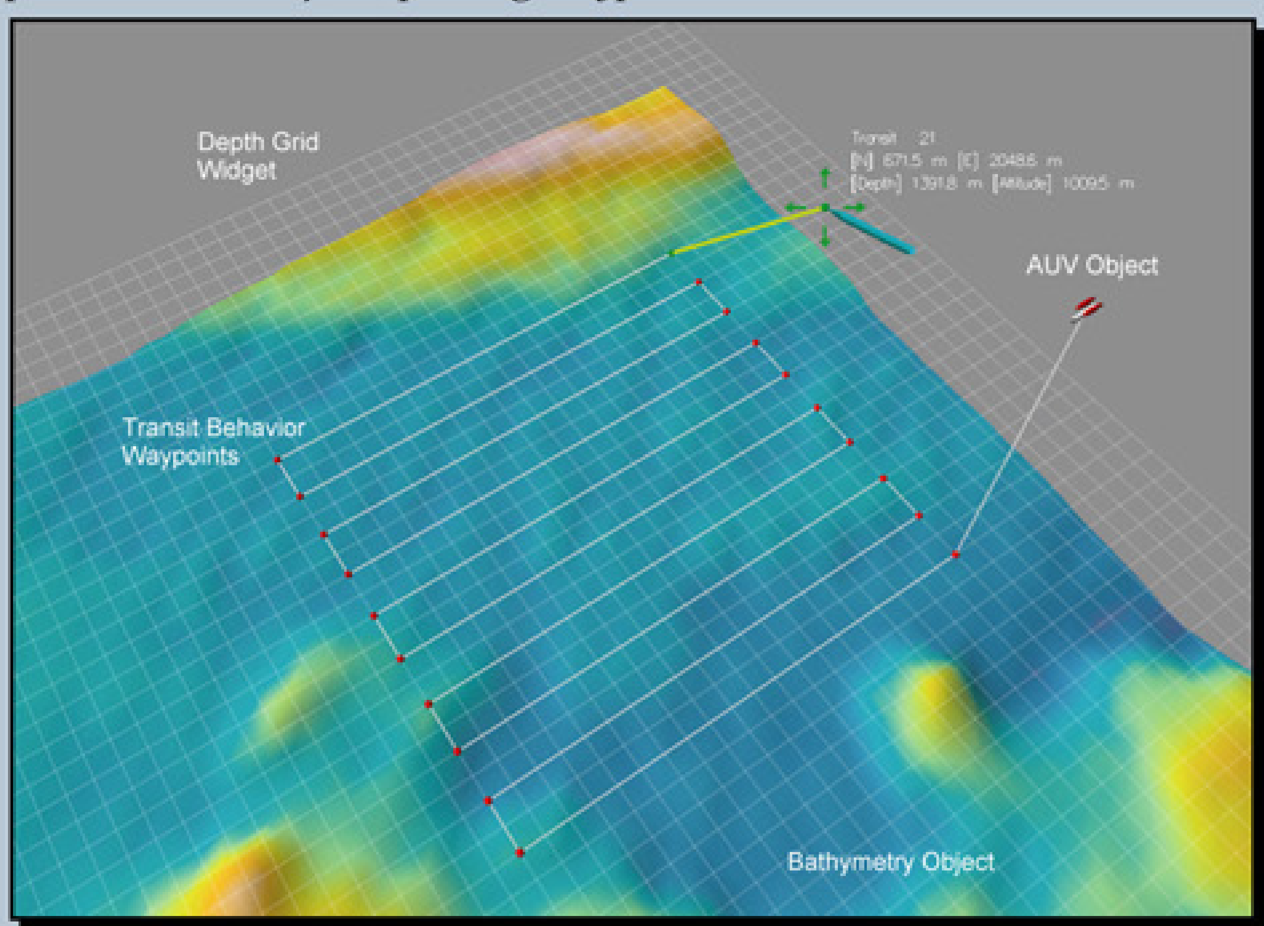
We have developed various interaction elements that rely upon haptic constraints to guide the user's actions in carrying out specific tasks. We divide these elements into four major categories:

- AUV and environment data objects
- Scene navigation widgets
- Object placement widgets
- Mode and parameter selection controls

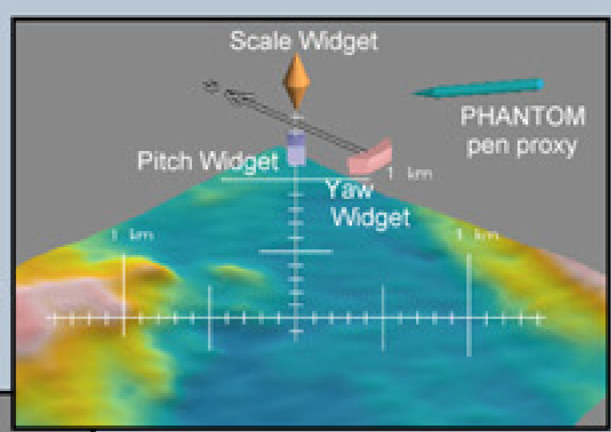


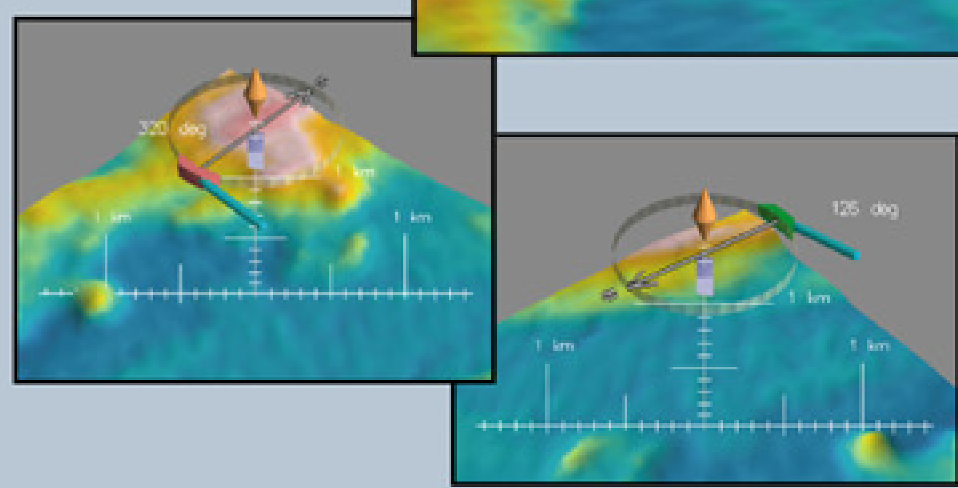
In-situ contextual pie menus allow for quick mode selection. Slider controls permit modification of parameter values, such as adjusting the grid spacing shown above. Haptic forces support these operations.

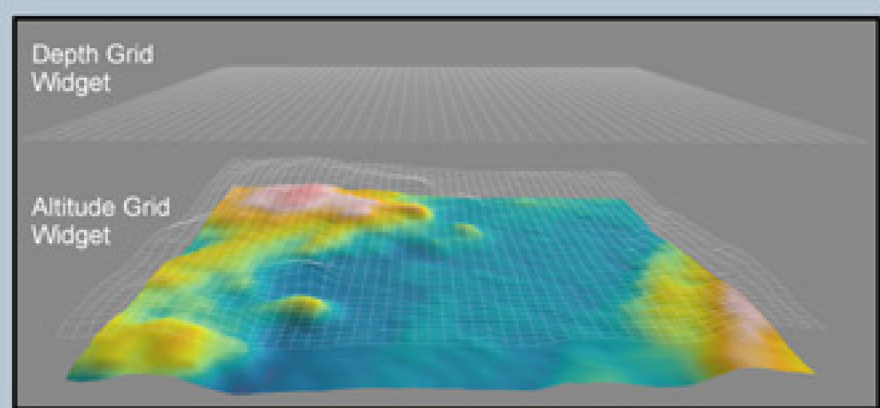
Data objects include AUVs, vehicle path segments and bathymetry. Path segments can be generated for waypoint transit and lawnmower survey behaviors. Snap forces permit easy selection of AUVs and their path segment control points. The bathymetry is haptically rendered as a constraint surface as a placement guide and safety surface to prevent the user from placing waypoints beneath the sea bottom.



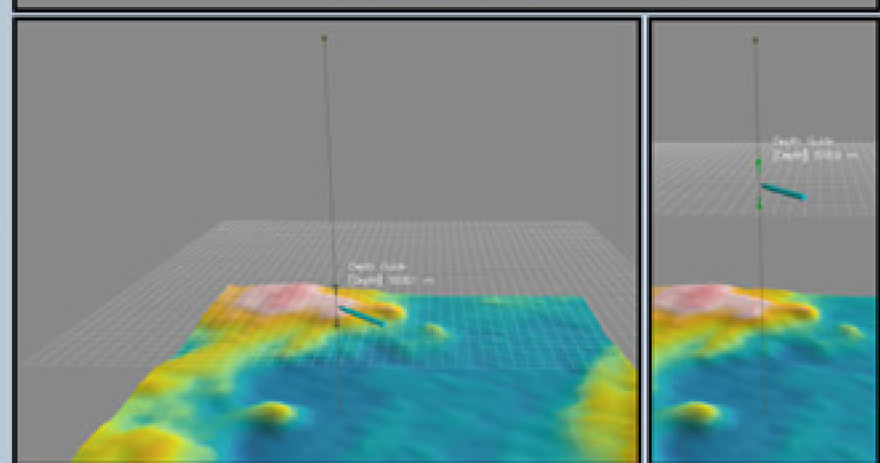
Scene navigation widgets allow the user to quickly and intuitively translate, rotate and scale the virtual environment about the center of the workspace. Visual and haptic constraints are employed, in the example of the yaw widget shown below, to constrain the user's motion to the ring.







Widgets such as the constant depth and constant altitude snap grids support precise placement of AUVs and path segments. Grid height can be adjusted directly; haptic line constraint forces guide the user in this task.



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