Advanced Navigation for PADS

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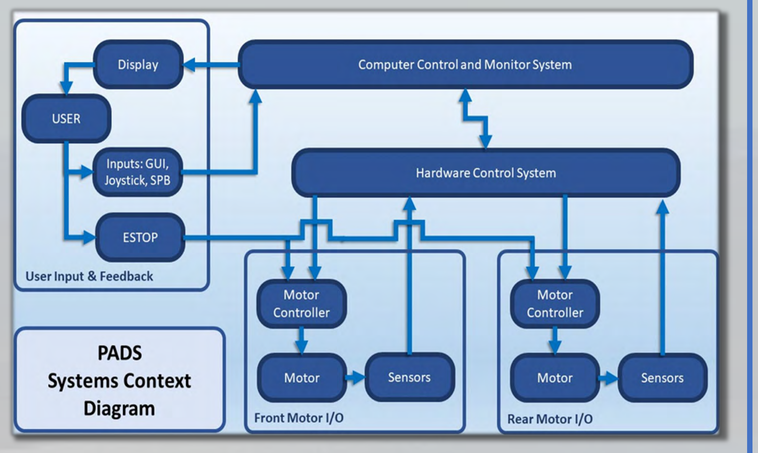
Introduction:

The Portable Accessible Docking System (PADS) is a pontoon boat provided by the Rehabilitation Center of University of Utah Health's TRAILS Program that functions as a mobile docking platform. It serves as a hub for multiple water activities for individuals with a spinal cord injury or disease. The PADS allow accessible controls that can be used by spinal injury patients, clinicians, and physicians to navigate the water craft.

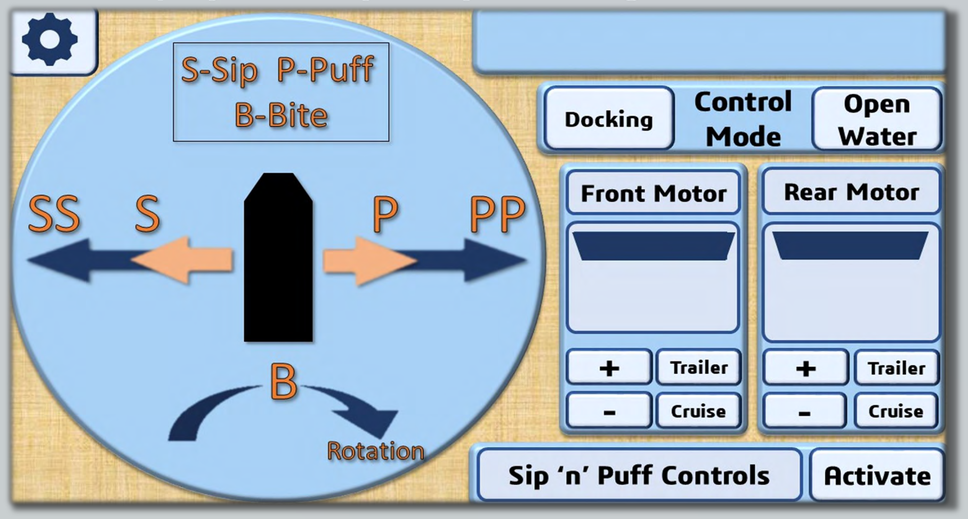
The focus of the project is on the controls and navigation of the PADS to operate two motor nodes (front and rear). Several subsystems were designed to accomplish this.

PADS at East Canyon Reservoir



PADS systems context diagram

User Display and Trajectory Planning:



User interface currently in SPB translation along X axis

Mathematical Model:

- Translation mapping:
  - $F_{xeq} = F_{m1} + F_{m2} = \frac{1}{2} C_D \rho A_x V^2$
  - $F_{yeq} = F_{m1} + F_{m2} = \frac{1}{2} C_D \rho A_y V^2$
- *F_x & F_y solved using user intended velocity vector*
- *Assumes steady state operation*

4 DOF control with 3 user inputs reduced to 3 DOF:

- Force X: $Fx_f = N_1 Fx_r$
- Force Y: $Fy_f = Fy_r$
- Moment: $Fx_f = -Fx_r$
- $N_1 = {}^{Ym1}/_{Ym2}$

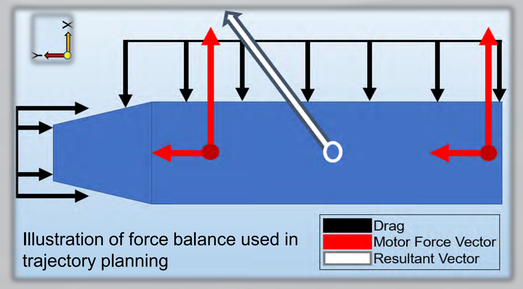


Illustration of force balance used in trajectory planning

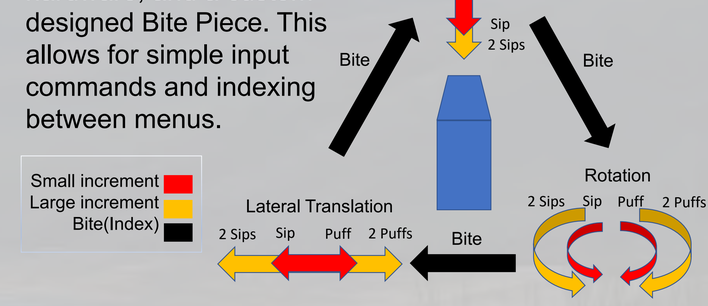
Sip N' Puff N' Bite (SPB):

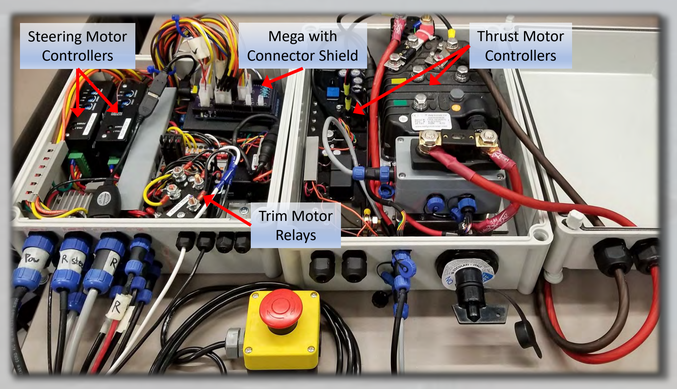
PADS control system is complex with three outputs:

- Forward Translation
- Lateral Translation
- Rotation

Sip 'n' Puff 'n' Bite Headset.

Due to the complex control system of the PADS we developed a control scheme using the Sip N' Puff hardware, and a custom designed Bite Piece. This allows for simple input commands and indexing between menus.





Motor control boxes

Motor Control Solution:

- IP67 rated
- Modular design
  - Service requires removal from PADS
  - Easy disconnection and accurate reassembly
- Safety system
  - Passive/Active components
    - Interrupts power to thrust, steering, and trim motors
    - (Passive) Emergency Stop
    - (Active) Controller interrupts systems if communication is control center lost

Customer Need	Specification	Result	
Water resist control solution	IP64 Minumum Rating	IP67 Rating	✓
Wheel chair accessibility	Control height 32" to 40"	Height Range 32"- 52"	✓
Standing accessibility	Control height 36" to 50"	Height Range 32"- 52"	✓
Responsive System	response time <500ms	412ms	✓
Easy to install on PADS	Size constraint 8" x 27"	7.1" x 11" (qty 2)	✓

Summary:

The Navigation system for the PADS enables control through: User Control Panel, Software, and Motor Controls.
Achievements:

- User controller interface including the SPB headset
- Fully functional two motor control system
- Forward motor assembly including redesign to strengthen rear motor node
- Emergency safety system

Future Work:

Additional engineering is required to fully integrate the navigation system, these include:

- Testing and tuning the PID controls
- Control box cooling system
- Update user control panel
- Revise the motor nodes to meet IP-67 environment rating

Acknowledgements

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