ROB599 Project Pitch
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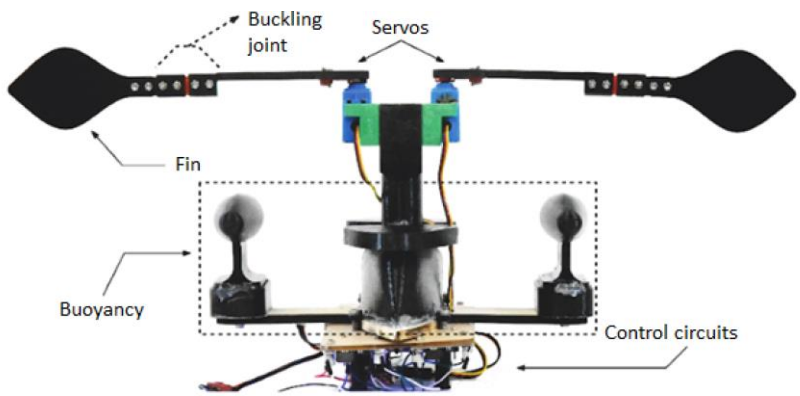
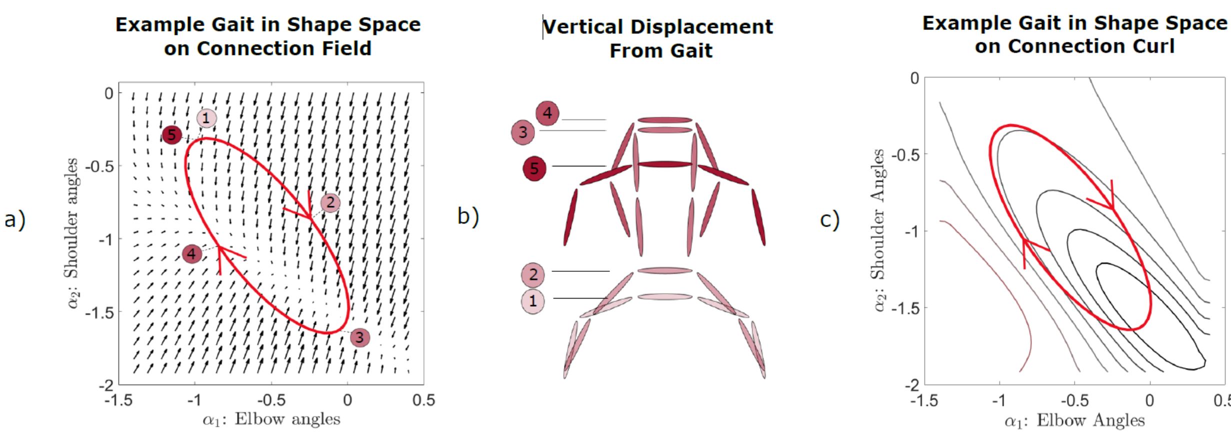
So far in my PhD, I've been working with Ross Hatton on analyzing the movement of robots with "swimming" locomotion mechanisms. We are using geometric mechanics techniques to relate joint motion of robot swimmers to lateral and rotary motion of the robot in water.



The above illustration shows a prototype swimming robot developed by the IdeaLab at Arizona State University, who we are currently collaborating with on this research project. The 'elbow' joints consist of passive curved mechanisms that allow for anisotropic motion through water, creating gaits that look like a swimmer's stroke. We can mathematically model the robot's motion through water using geometric techniques, as shown below. For now, I'll ignore the passive joint mechanisms and pretend that we have full control over all of the joint angles.



Part a of the above figure shows joint motion of a symmetric 5-link robot swimmer parametrized through "shoulder" and "elbow" joint angles overlaid over the y-connection field, which relates joint motion to vertical movement of the robot in water. Joint trajectories along a vector move the robot up, trajectories opposed to a vector move the robot down, and perpendicular motions cause the robot to remain still. Part b illustrates the displacement of the robot over the course of one of these gait cycles. Part c illustrates the same gait on the connection curl function, which provides an intuitive way to visualize which gaits provide the highest displacement.

As part of my PhD work, I would like to investigate how geometric mechanics techniques can be applied to swimming robots to provide path planning methods for short term goals. Current geometric mechanics control strategies are piecewise in nature: for example, to get to a far off point you would develop a “turning” gait that focuses on rotating the robot, and then a “translation” gait that focuses on covering distance. A simple path planner would alternate between these two gaits to get to a given point. I believe that we can construct better strategies by combining geometric mechanics with learning techniques that would allow a robot to accomplish shorter-term locomotion goals that require simultaneous rotation and translation, and that can create effective controls strategies to counteract current drift from the water and movement error caused by robot asymmetries and uncertainties in our knowledge of the connection field.

To that end, I’d like to use my maturing ROS skills develop a controls/path planner testbed for swimming locomotor robots. I’d like visualization of a robot swimming around due to the inertial connection between joint movement and robot motion, along with a way to command new joint trajectories, and maybe an implementation of the ‘rotary->translation’ path planner to get all of the pieces working in tandem. This will make it easier for me to later develop geometric/learning strategies for swimming robot control and path planning.

Requirements/Rubric:

- Load connection field/connection curl generated through sysplotter (Ross’s software)
  (5 points)
- Load joint gaits generated through sysplotter
  (5 points)
- Visualize 5-Link robot swimmer somehow (likely Gazebo)
  (15 points)
- Commanding joint movement causes appropriate configuration change in visualization
  (10 points)
- Commanding joint movement causes lateral/rotary robot motion from connection in visualizer
  (20 points)
- Rudimentary joint path planner can swim robot within 1 body-length of a designated location
  (5 points)

Likely ROS Structure

Launch/RobotDefinition – Launch Gazebo in empty “swimming pool” environment with swimming robot model

Services – Load connection field, load joint gait

Nodes – Publish joint angles from choice of control strategy/preloaded gait/custom gait, turn joint trajectories into lateral/rotary motion trajectories

Actions – Take desired global coordinates of robot as movement goal, run rudimentary path planner strategy to move robot to that location