NRI: FND: Natural Power Transmission through Unconstrained Fluids for Robotic Manipulation

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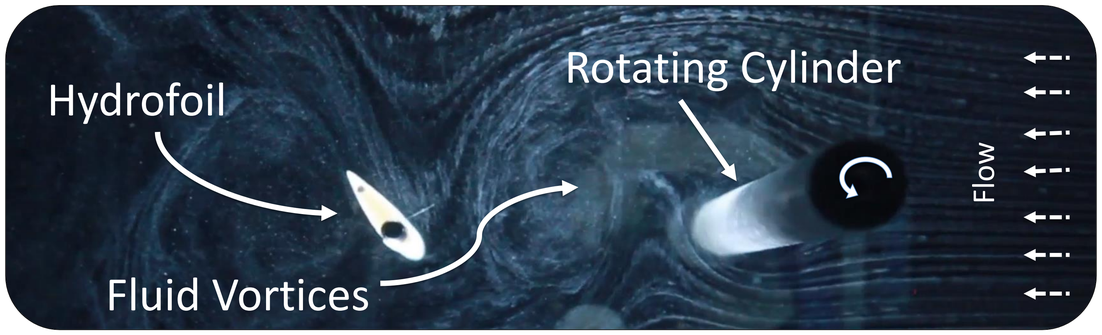
OVERVIEW

MOTIVATION: Exoskeletons have evolved from rigid systems to more compliant cable-driven systems to better match the impedance of the human body. This work aims to extend this progression to a new fluid-based immersive method for natural assistance while walking.

PROJECT GOAL: Enable closed-loop control transfer of momentum and power through an unconstrained fluid as a new class of robotic power transmission and apply it for gait training.

PRINCIPLE

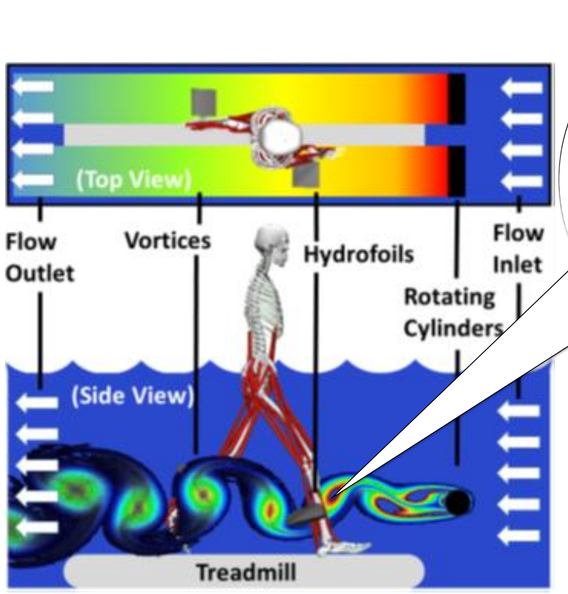


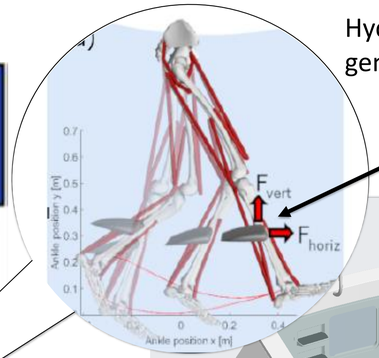
- Leverage the open-loop natural response of vortex shedding from a rotating cylinder to control in closed-loop the limit cycle oscillations of the system.
- Scaled experiments successfully establish that controlling the cylinder's geometry and rotational velocity, the frequency and amplitude of the alternating vortices can be used to control the hydrofoil's trajectory.

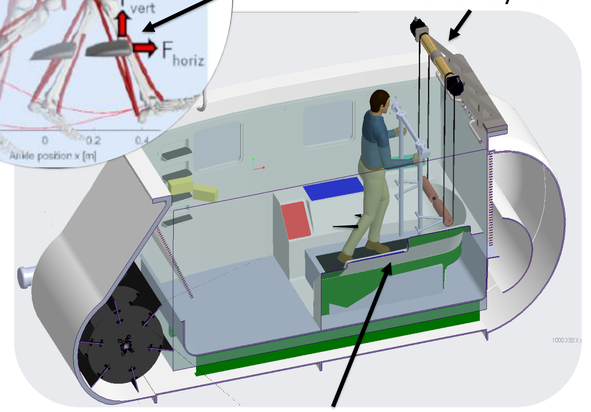
AIMS

AIM 1: Investigate the response of a hydrofoil in the wake of a cylinder forced to rotate in a controlled environment
AIM 2: Control the motion of a hydrofoil to follow a desired path through controlled rotations of a cylinder placed upstream
AIM 3: Control a multi-body system through wake-induced oscillations
AIM 4: Simulate an augmented human gait in a fluid environment
AIM 5: Transfer the principles to the human-scale, real-world environment

APPROACH







- Create an immersive fluid-based gait trainer which can provide compliant assistance to an individual while walking.
- Biomechanical simulations using musculoskeletal modeling tools help identify the desired force profiles that need to be generated on the hydrofoil attached to the person to achieve a walking gait pattern.
- Force profiles can be shaped by controlling the fluid flow and rotational oscillations of the cylinders placed in upstream flow by external actuators.

IMPACT

- Enable a new type of manipulation strategy, which does not involve direct contact or coupling with the object being manipulated.
- A novel method for natural gait training for persons recovering from stroke or injury.
- Realize applications in manufacturing and underwater robotics for fluid-based non-contact material handling and manipulation.
- Develop and deliver an innovative underwater robotics outreach program for K-12 students to demonstrate the physics as well as the beauty in engineering systems.

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