HYDRAULIC LOCOMOTION

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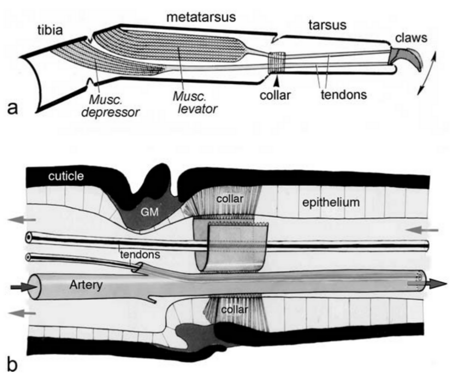
INSPIRATION

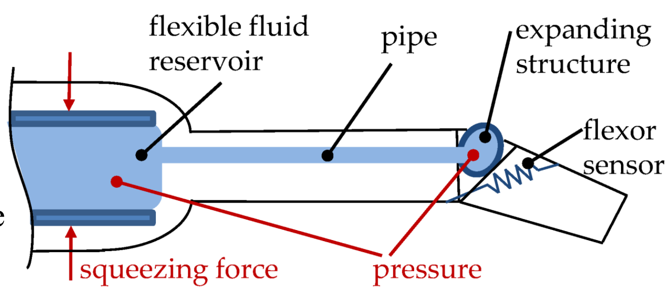
Through billions of years of evolutionary history, Earth has produced wonderous systems and mechanisms to functionalize its inhabiting lifeforms. Of particular interest is the aspect of locomotion, or mechanics-based movement, of which nature has accumulated an impressive roster of innovative concepts. This project will aim to replicate the hydraulics-based locomotion adopted by arachnids – specifically, in spiders.



PRINCIPLES

·Regulated blood pressure fluxes in arteries
·Expansion of joints under hydraulic pressure
·Contraction of joints using controlled muscle tendons
·Expansion and contraction form movement

By increasing blood pressure in the arteries, a pressure induced force is applied in the expanding structure of the leg joints, shown through the equation $\Delta F = \Delta P \times A$. This force drives the joint expansions.

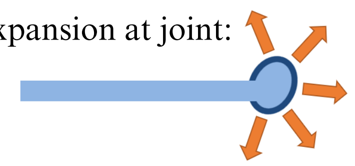


MECHANISM

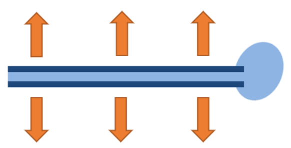
The center piece of a spider's hydraulic locomotion is thus an expanding structure that can outlet a force to a targetted leg joint when pressure increases and lose its force/resistance when pressure decreases.

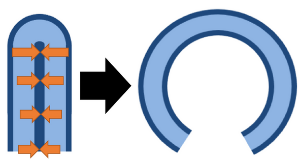
-System (organ) to regulate pressure fluxes
-Inelastic transport of pressure to joint
-Expanding structure to hold low internal forces and expand upon pressure increase
-Expanding structure to outlet forces on joint
-Sensors to detect orientation of joint
-Muscle tendons to contract upon pressure decrease and loss of expansive forces

Expansion at joint:



Expansion at pipe:

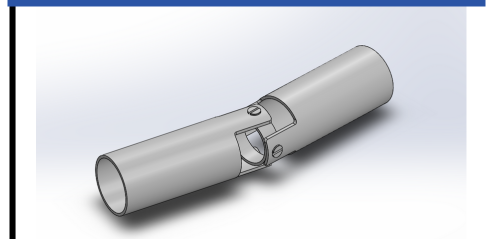




The expanding structure in a spider's leg joints focuses its pressure-induced forces in the region of the joint, acting as a growing wedge to push apart two leg segments. Another design would be to utilize the pressure-induced forces throughout the length of the pipe to stretch out any bends or angles into a straight orientation. Thus reversing the expanding structure's function from producing a bend in the leg segments to straighening them. This alternative design principle is the basis for my product's functionality.

IMPLIMENTATION

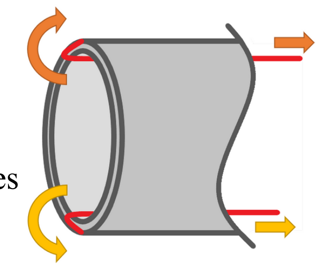
JOINT



-360-degree coverage of radial orientation
-Hollow tubular interior for passage of fluid conduits
-Vertical slits at connector pins for 'tendon' support
-Low surface to surface contact and friction

TENDON

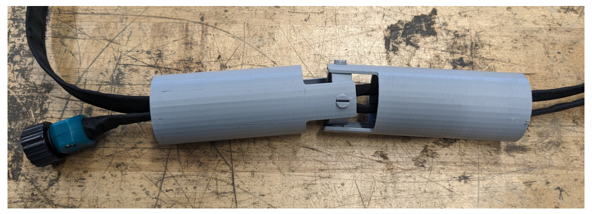
Different tendon materials were installed using adhesives and screws onto the lip of a joint segment, then passed through the connector pin slots and pushed through the opposite segment opening. Pulling on the tendons produces an external rotational torque for directional control.



Material Type:	Pros:	Cons:
Brake Cable	Strong, organizable, consistent	High resistance, sluggish, stiff
Fishing Line	Low resistance, efficient, light	Messy, hard to install
Polypropylene Twine	Strong, easy to install and grip	Inconsistent, friction, jamming

CONDUIT

Two types of conduit tubing were tested: a flexible nylon-sleeved hose (top right) and low-density polyethylene bags (middle right), using water and air as their respective fluids.

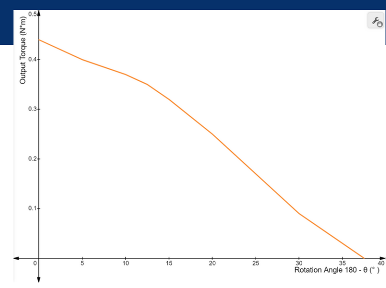


Increase in pressure resulted in expansion of joint from a bent position into a straight orientation for both conduits (bottom right).

Findings from repeated testing:

$$Work\ (W) \begin{cases} \propto \dfrac{1}{Density\ of\ fluid\ (\rho)} \\ \propto Bend\ angle\ (\theta_i) \end{cases}$$

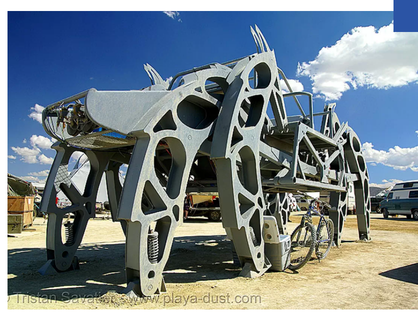
Where W is the work done by the fluid pumps and the Bend angle is the initial angle the joint is bent to away from the axis



Graph of the joint output torque in units of Newton Meters over the Rotation angle - the supplementary angle of the Bend angle - in units of degrees. The fluid measured is air in plastic bag conduits.

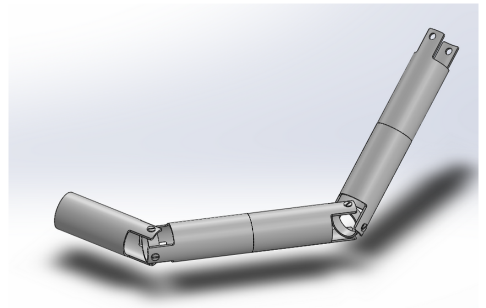
APPLICATION

NEW TECHNOLOGIES



Spiders are characterized by their jolty, agile, and lightning-fast movement. With the hydraulic principles that underlie their locomotion implemented into controllable components, new forms of vehicular, equipment, and civil designs can be innovated.

Features of hydraulic expansion components include:
-Scalability of size (concept implementable for both large and small scale components)
-Simplicity of design
-High torque and power output per unit mass of system
-Efficiency and ease of use



SUSTAINABILITY

This project's hydraulic locomotion is achieved through controlled fluxes of fluid pressure running through conduits inside the joint components. This design is an alternative to the use of fuel combustion to propel movement, providing a substitute to fossil fuel and helping decrease carbon emissions.

Additional sustainable features:
-Low fluid type constraints, can use recycled forms of liquid and gas
-For smaller scaled equipment use, can be operated manually without electric systems
-Low complexity means low material requirements and resource demand

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