Mesofluidic Actuation

Pioneering the Next Generation of Actuators and Prosthetic Devices

Purpose:
- Increase the energy efficiency of fluid powered systems.
- Reduce U.S. consumption of oil (e.g., in diesel-dependent hydraulic machinery used in agriculture, construction, mining, etc.).
- Enable compact systems with very high force and power density.
- Eliminate wasted energy in fluidic actuation control.

Sponsors: Oak Ridge National Laboratory's Laboratory Directed Research and Development program, DARPA, U.S. Navy.

Potential Uses:
- Prosthetic and orthotic devices.
- Physical rehabilitation.
- Robotic surgery.
- Safely disabling explosive devices.

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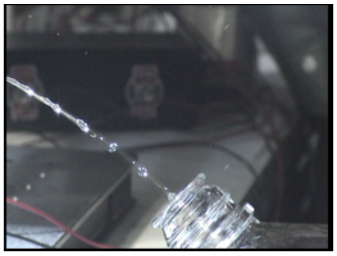
Mesofluidic actuators are fluid-based actuators that range from a few millimeters to centimeters in size (characterized as sugar cube to fist size) and use pressurized fluid for the motive force, with flow rates ranging from less than a milliliter per second to tens of milliliters per second. Mesofluidic actuators provide high force density (>1,000 psi), low friction, direct drive, and high mechanical bandwidth and can use a variety of working fluids, ranging from oil to water or saline solution. A number of key components have already been constructed and demonstrated: (1) hydraulic power units, (2) miniature actuators with integrated position sensors, (3) miniature flow control valves that can control high pressure fluid one drop at a time at a very high frequency, and (4) a complete prosthetic finger.

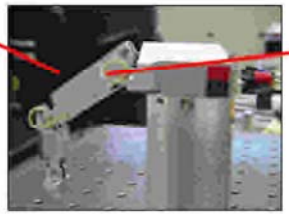


Fluid flow composed of multiple individual drops is shown with the help of a strobe light.

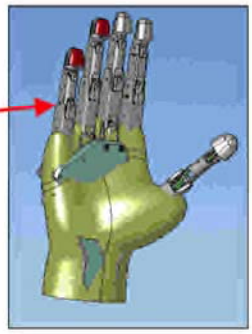
This type of actuation technology has 10 × the power density of electric motors in the mesoscale size regime and is an enabling technology. The flow control valves are the key component. These valves can be combined in a multistage design to greatly amplify flow rates (>> gpm) and have the additional advantages of (1) low cost of construction, (2) zero internal leakage flows due to the poppet style of valve (i.e., it is very energy efficient), (3) low electrical power requirements, and (4) flexibility (valves can be combined for individual control of each flow port, allowing regeneration of hydraulic energy).

Electrohydraulics, using pressurized fluid for power and control, are pervasive in a variety of industries, with component sales in 2005 exceeding $33B. There are many potential applications where the primary energy source is limited and fine motion control is required. New potential application areas include prosthetics, mobile robotics, and medical robotics.

Finger load test at 60 lb.



Actuators inside finger and valves inside MCP. Finger pinch force = 20 lb (flex).



Transradial hand design based on mesofluidics. Target is 50% female.