Synthetic Muscle

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04/28/03

Function of Natural Muscles
Provide precise articulation
Scale invariant
Provide large amounts of Support
Durable, a lot of stress *and* strain
How do they work?
"Row"-like interaction of actin and myosin
How do we develop such things?
The actual muscles and operation
Implant technology (for replacement)
Robotic applications
Historical limitations
Pneumatic and Electrical Servos (1940's - now)
*New* Materials include:
Synthetic Polymers
Carbon Bucky-Tubes
Basically anything that accomplishes actuation under specific stimulation is a muscle
electrical servo
pneumatic piston
biological tissues
Natural muscles
Transform ATP into Motion
Artificial muscles
Transform Electricity into Motion
Artificial Focus is the Skeletal Muscle
Easiest form of contraction to replicate
Categorized into Simple motions
Voluntary, and thus simple to implement into the Human Body
History:
1780~ Galvani noticed that frog muscles would contact under electrical stimulus.
1968~ First Pneumatic Rubber 'muscle'
Compressed Air is injected into Rubber tube that is coated with string to force it to contract
There are many different types of artificial muscle being developed here are a few.
PAN
Chemical Muscles, controlled by pH change
IPMC (Ionic Polymer-Metal Composites)
Voltage difference causes bending
Piezoelectric / Electrelastomers
Elastic Capacitors

IPMC
How They're Made:
Polymer Matrix coated with Platinum/ Silver
Made in sheets, able to cut into different shapes as needed by the task at hand
How they work:
By applying a voltage across the surfaces of the sheets, one side (positive terminal) will contract and bend the sheet of Polymer
Advantages
Light & Compact
Low-Voltage and Low-Power costs
Comparison to Natural Muscles
Large Actuation Strain
High Fracture Tolerance
Responds to electricity in a relatively step-invariant way as normal tissue

PAN
Chemically controlled Actuators
Composed of Gel and Plastic. Tough.
Contracts under pH change, no electricity required for usage
Advantages to PAN
Similar to Human Muscle in Acceleration and Velocity
Over double the amount of force of human muscle per square cm.
Disadvantages to PAN
Must be surrounded by solutions at all times which are toxic to humans

Piezoelastic
Composition
Basically a capacitor with an elastic dielectric
This allows the device to stretch and contract unlike most normal electrostatic devices when a voltage is placed across the two plates
Advantages of Piezoelastic Muscles
Incredible range of motion
The ability to turn mechanical energy *back into* electrical energy
They have a wide variety of uses outside of the human body
Robots (micro and macro)
Pumps
Sensors
Speakers

References:
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