NitinArm: Using Shape-Memory Alloy Actuation to Engineer a Lighter, Cheaper, More Dextrous, Trans-Radial Prosthetic

Vatts, Shreyas (School: College Park High School)

Approximately 50 million people globally rely on technology to replace a missing appendage, 80% of whom cannot afford current solutions and are left with costly, immobile, bulky prosthetics. Among the most prevalent are trans-radial prosthetics; these devices intend to capture the arm’s nuanced movement but grossly fail, achieving only 9 of the 27 degrees of freedom (DoFs) at upwards of $100,000. This inability to adequately imitate the hand and wrist is a product of the cost, size, and weight of the motors used. Hence the quality of life of amputees is significantly hindered. This research engineers a novel trans-radial prosthetic to utilize Nitinol, a low-cost, lightweight, shape-memory-alloy instead of motors. Nitinol has three phases—twinned martensite (trained), detwinned martensite (deformed), and austenite (transition)—and changes shape with temperature. To recreate 19 DoFs, Nitinol wires are trained in sets of two: one mimics muscle contraction, and the other expansion. By connecting the wires’ ends, one is always in its detwinned phase, and by passing a current through the wire, it warms and transitions to its twinned phase, simultaneously deforming the paired wire, mimicking the expansion and contraction of muscles. These wires are then inlaid in a custom 3D-printed PLA-carbon fiber prosthesis which enables the replication of the abduction and adduction of the fingers and the isolated actuation of the phalanges, feats not accomplished in commercial prosthetics. This design displays a 110% increase in DoFs than current solutions at only $3000, 10% of the industry average. NitinArm’s increased dexterity, lower costs, and lower weight improve millions of amputees’ lives as it betters trans-radial prosthetics, and proves Nitinol applicability to all prosthetics.