Development of Versatile Low-Cost Prostheses Through Utilization of Granular Jamming

Andrew Millman, Matthew Hsu, Tiffany Perumpail, High Technology High School

Abstract

Today, over 15 million people must live with upper-limb amputations. Of these people, 12 million lack the economic means or resources necessary to access functional prosthetic technology. The purpose of this study is to utilize granular jamming to create versatile, low-cost upper-limb prostheses targeted at under-privileged amputees in developing countries. The main component of the prosthetic design is the granular jamming gripper, which is a granular mass encased in an elastic membrane. The gripper operates by conforming to an object's shape after pressing against it, applying negative pressure to vacuum-harden and create a firm grasp, and using a valve to reverse the transition and release the object. The negative pressure application is controlled by a glove worn on the opposite hand featuring two aluminum plates which, when put in contact, connect the motor pump to power and allow the gripper to vacuum-harden and enter gripping mode. The device also displays a battery level detector which warns the user when the 12V battery's state of charge decreases below 12.64V, providing the user with adequate notice to recharge his or her portable power supply before compromising device functionality. Prototype testing showed that the current design is able to successfully grip and release a wide range of objects that are typically difficult for conventional single-cable prostheses to grasp, including flat, smooth, and geometrically complex objects. The design is optimal for both under-privileged amputees in developing countries, where most cannot afford conventional prostheses, and developed countries, where the majority utilize functionally limited single-cable prostheses.The current design has a final cost of 83.68 US dollars, well within the average weekly income directly below the poverty threshold. The Granular Jamming Prosthesis currently has a patent pending, and prototypes have been shipped to Kerala, India for ongoing field testing and integration.