FORCE SENSING PROSTHETIC FINGER TIP USING ELASTOMER-EMBEDDED COMMODITY INFRARED PROXIMITY SENSOR

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ABSTRACT

The field of upper limb prosthetic design seeks to recreate what was lost after amputation including the loss of sensation. In order to accomplish this feat, prosthetic devices require compact, stable, and clinically robust sensors in order to measure interaction with the external environment. These types of sensors are more important now since dramatic progress was made to provide stable natural touch perception using implanted neural interfaces. We developed a force sensing prosthetic fingertip using elastomer-embedded commodity infrared proximity sensor to enable sensory restoration after upper limb amputation,.

The fingertip sensor integrates a commodity infrared proximity sensor (VCNL 4010, Vishay Semiconductors) which is embedded in a soft polymer, polydimethylsiloxane or PDMS (Dow Corning Sylgard 184). The infrared sensor was chosen due to its small form factor (3.95 x 3.95 x 0.75 mm3) which includes all digital electronics to produce a I2C communication output signal. The polymer was chosen due to its ease of manufacturing/molding and resistance to chemical and mechanical abrasion. The sensor operates by emitting infrared light (890nm) through the PDMS layer and measuring the net reflected intensity of the reflected signal. A layer of copper was deposited onto the PDMS material in order to reflect IR light and create a measurement which is independent of the reflectivity of the object in contact with the sensor. The intensity is approximately inverse of the square of the distance traveled and therefore can be used to determine displacement of the PDMS layer. Then, Hooke's law indicates the force and thereby creates a compact, stable, and clinically-robust force sensor for prosthetic fingers.

The mechanical design of the fingertip involved reverse engineering a commercially available prosthetic finger (Bebionic 2, RSL Steeper) into a computer-aided design (CAD) file. The CAD file was then modified in order to embed the printed circuit board of the sensor as well as pathway for the four-line ribbon cable. The fingertip was then manufactured using a plastic rapid prototyping printer (Objet Connex 350). Afterwards, a molding process created the PDMS layer which ensures that any contact force (i.e. - oblique or non-normal forces) will be detected by the sensor.

A force sensing prosthetic finger was developed in order to create a compact and stable measuring method to promote the restoration of tactile sensation for people with upper limb amputation.