MECH 6V49.005 Soft Robotics

Jaw Force Sensor for Medical Applications

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Report

In dental research, bite force has become an important curative effect evaluation index for tooth restoration, periodontal treatment, and orthodontic treatment. Bite force can be defined as “the force exerted by the masticatory muscles upon the occlusal surfaces of teeth”. This bite force is by virtue of the pressure applied by the mandible (lower jawbone) and the temporal bone that are connected via the masticatory muscles. The joint between the temporal bone and the mandible is known as the temporomandibular joint. A decrease in the magnitude of jaw force compared to that of a healthy adult is a possible indication of temporomandibular joint disorder (TMJD).

In order to detect and avoid the early onset of TMJD it is imperative to measure the jaw force. While there already exist a few technologies to do so, the objective of this project is to design and test a prototype for a soft sensing device that can be used by dentists to measure jaw force over a period of time.

For the design of the soft device, the basic idea was to sandwich a piezoelectric pressure sensor within a cast of hyperelastic material. The prototype of the soft device is made using EcoFlex 00-10 and the CAD model for the same is made using Solidworks. The soft device was tested for a force of 10N with the help of ANSYS Workbench to obtain and interpret the results for stress, strain, and deformation based on a Neo-Hookean model, for which the material data was acquired through literature review.

The primary method of prototyping the soft device was casting EcoFlex 00-10 in a mold. The mold was designed on Solidworks, converted to a .stl file and uploaded to a slicer. The .gcode file was then uploaded to a FDM (Fused Deposition Modeling) 3D printer for additive manufacturing. There were a total of 2 iterations of the mold, as the first design was not suitable for mold reusability, so we improved upon that.

For the operation of the soft device, we used an Arduino UNO board as the controller, a 220Ω resistor, a breadboard, and wires soldered to the piezoelectric pressure sensor that was placed inside the EcoFlex cast. The Arduino UNO controller was connected to a laptop using a USB 2.0 A/B cable for data transfer and power supply. The code for signal plotting in Arduino IDE environment was used to display the corresponding graph with changes in pressure applied on the soft device.

This project intends to introduce a basic framework for design of soft sensing devices for medical applications through demonstrated testing. For future scope, the piezoelectric sensor shape could be optimized for better accuracy and a more rigid yet hyperelastic material could be used to increase durability. This would also help to design better night-time dental guards for patients to combat bruxism. Furthermore, the scope of this study could expand into veterinarian sciences and pediatric care, too