The smart handle is designed as a human-machine interface to be used to provide an intuitive way to control actuators of robotic exoskeleton devices. By collecting data from key sensor locations, each motion applied to the handle produces a unique data pattern. Using these patterns, a neural network can be trained to correctly predict the intended motion of the user which can be then used to drive the actuators of the exoskeleton.

The second-generation smart handle aims to achieve the same success of the first-generation while removing the limitations in its design. These designs use load cells to detect forces applied to the stationary handle and then send the force data to the neural network.

**Methods and Materials**

**Strain Gauge Design:**

This design utilizes strain gauges positioned at key points on the branching parts of the top and bottom base pieces. These strain gauges detect how the material in those areas deforms under stress. The purpose of this design was to maintain the functionality of the first generation while simplifying the design and manufacturing process.

**Pre-made Load Cell Design:**

This design utilizes three single-axis load cells on either end of the handle arranged in a triaxial alignment to simulate a single tri-axial load cell.

The goal with this design is to determine just how much data is necessary to allow the neural network to deduce intended motion–reducing the number of data channels from 12 to 6 compared to the alternative design.

**Electrical Design:**

The circuits for each of these designs are quite similar, both make use of Wheatstone bridges, to analyze force changes, amplifiers and Arduinos.

**Discussion**

By using data gathered from strain gauges and comparing them to each other, the motion enacted on the handle can be found. In the case of a pushing force, the connector along the push would give a positive strain value while the other two are negative. A lifting force would give positive strain readings for all gauges.

This is the principle behind how both designs achieve the same functionality as the first-generation in unique ways.

**Conclusions**

These two designs explore different ways to expand the concept behind the first-generation smart handle. The load cell design shows promise in its simplicity and lower amount of data while the strain gauge design offers greater functionality at a greater cost to construct and an excessive amount of data.

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