Improved Sense of Touch for Prosthetic Hand

Degree programme: BSc in Micro- and Medical Technology | Specialisation: Sensor technology
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In this bachelor thesis, an attempt was made to enable a prosthetic hand to detect slippage. With the help of magnetometers that measure the magnetic flux density of a magnet embedded in an elastomer at its centre. The elastomer mimics a fingertip that deforms when an object slips, according to the shear forces acting on it. The embedded magnet shifts and the magnetometers record this shift.

Motivation

Detecting the slip of an object in the hand enables the safe grasping and holding of objects with minimal necessary effort. Objects slip when the opposing forces, tensile force and static frictional force, no longer balance each other out. It is desired to mount the developed sensor on the fingertips of a prosthetic arm, which will solve the tasks of the Cybathlon competition. The Cybathlon is a competition, a project of ETH Zurich, in which people with disabilities compete in everyday tasks. A related Bachelor thesis by Simone Gagliardi has the same goal with a different strategy.

Approach

Different methods to detect a slip were researched and evaluated. Following criteria applied: Object independence, size/shape, number of axes, robustness, temperature resistance, availability, complexity of implementation and price. The decision was made in favour of detection by magnetic field measurement. As shown in the picture the strength of the magnetic field depends on the distance, the deformation of the elastomer depends on the force, which means that the force effect is measured indirectly. Calculations showed that a magnet of 1mm in height and diameter or one of 0.5m height and a diameter of 1.5mm made from NdFeB should be used. Other magnets flux density is too high at this close distance. Three Printed Circuit Boards have been designed and mounted. Two of them contain four squarely arranged magnetometers, representing two fingers. The third contains multiplexers with integrated level shifters. Multiplexers allow the polling of all measured values despite the same device address. The level shifter allows a 5V communication line to the Arduino while the others are on 3.3V. For the elastomer, a negative mould is pressed into plasticine and filled with liquid rubber.

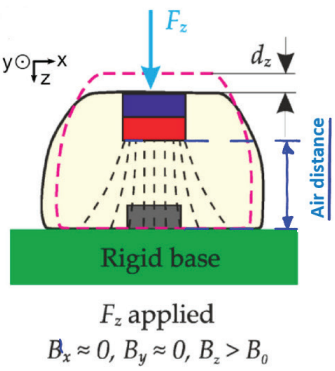
Results

First measurements, like the ones in the diagram below, show that smallest displacements of the magnet can be measured in a repeatable way. However, the measurement data does not behave exactly according to the expected Biot-Savart law.

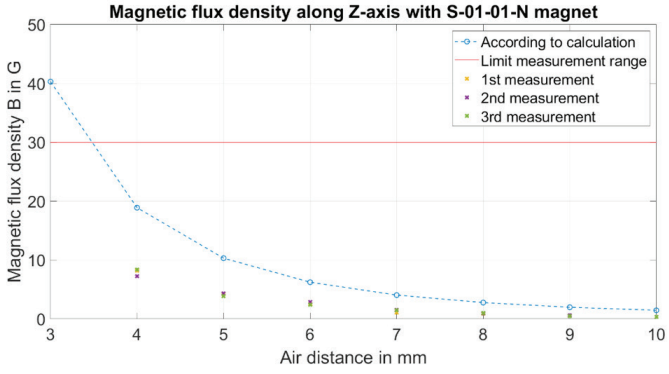
Outlook

It would be interesting if the data could be used to draw conclusions about the weight and surface properties of the object. This might be possible because the static frictional force equals to the product of the normal force and the static friction coefficient.

Literatur: [1] T. Le Signor, N. Dupré, G.F. Close: A Gradiometric Magnetic Force Sensor Immune to Stray Magnetic Fields for Robotic, Proc. IEEE



[1, modified] Cross-section of Sensor



Example of measurement data from a single magnetometer

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