Armature Joint Module

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Client:
MechAdept

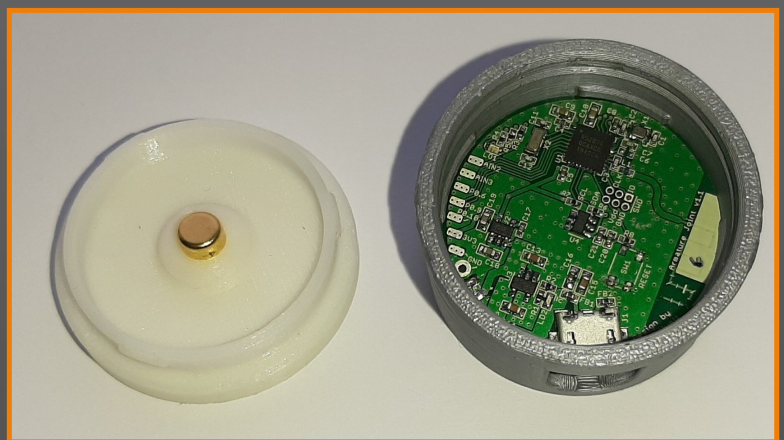
LinkedIn

WelTec
Te Whare Wānanga o te Awakairangi

Overview

Prototyping large robots at a miniature scale is a great way to validate a robot's design. It allows the engineer to test a robot's kinematic structure design and its range of motion in the real world, at a low cost. MechAdept employs this method for their high-performance mechatronic systems, but they do not give useful joint position feedback without manual measurement.

The aim of this project was to develop a functional prototype of a single joint module to prove the concept of a puppeteering armature which would be manipulated by hand and stream out position information to a user terminal via Bluetooth. This is for MechAdept to prototype robotics and present to clients a virtual puppeteered armature. The design had to be compact, battery powered, modular and simple.



Prototype 4, disassembled

Latest Prototype

Link 2: Holds the magnet with a press-fit and the male snap-fit tabs to interface with link 1.

Magnet: Diametrically magnetised for easy interface with the magnetic sensor on the PCB

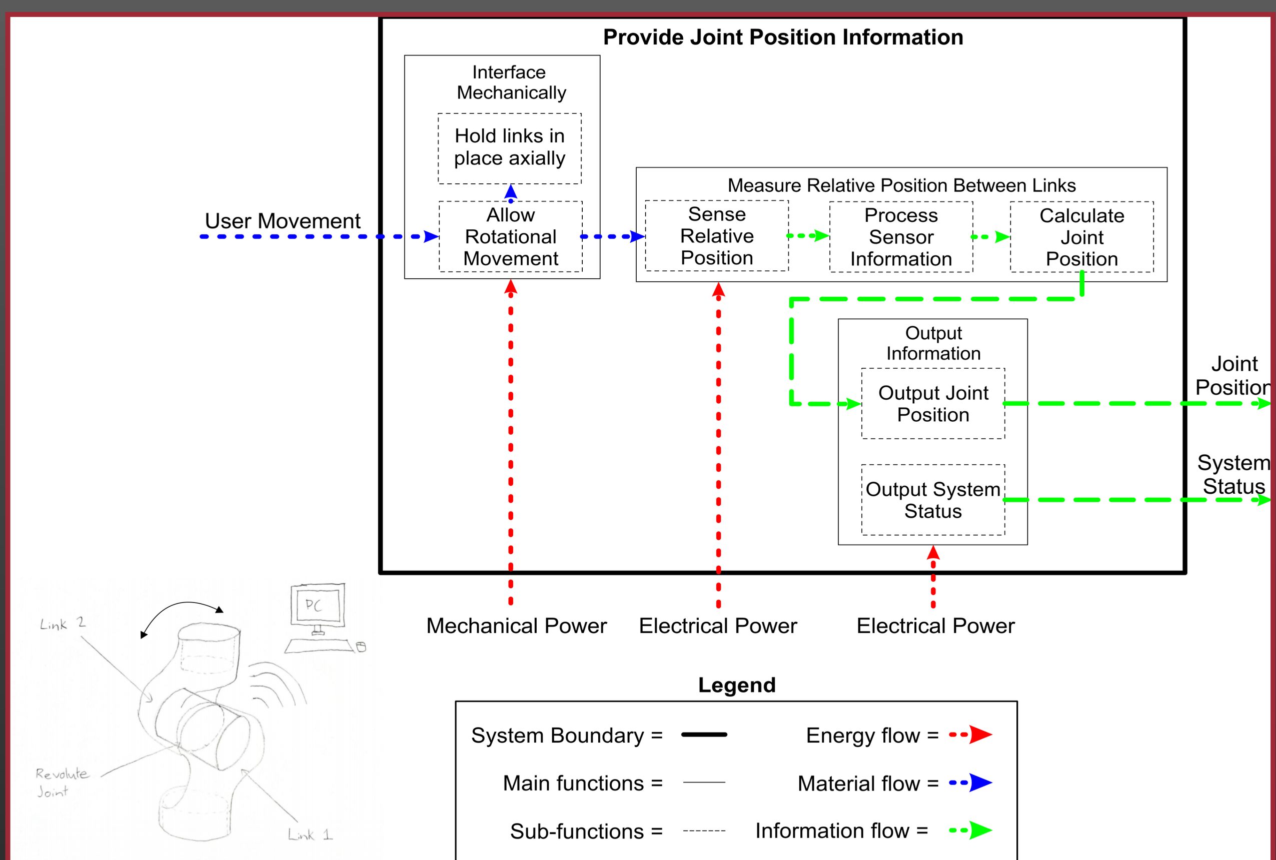
Link 1: Provides the female slot for the snap-fit connection and an enclosure for the PCB and battery. The slot allows rotation of link 1 and provides friction and hence a holding torque.

Custom PCB: Powered by a Lithium-Polymer battery, the custom PCB features a Bluetooth-capable System on Chip (SoC), PCB trace antenna, 3D hall sensor for field position measurement, battery charging circuitry and a 3.3V voltage regulator.

Link 1 cap: Closes the enclosure and secures the PCB and battery.

Latest prototype assembled, indicating BLE advertisement with green LED

Development



Function Structure Analysis for Problem identification

This project required the development of systems of three different types; mechanical, electronic, and embedded software.

Embedded Software

The Segger Embedded Studio Integrated Development Environment (IDE) was used to write software and program the custom board and nRF52 development dongle. Segger's J-Link debugging probe was used with the IDE for code debugging.

Nordic Semiconductor's Software Development Kit (SDK) was used to learn the microcontroller platform and provide a base for the embedded software using the method of studying and modifying example code.

Electronic System

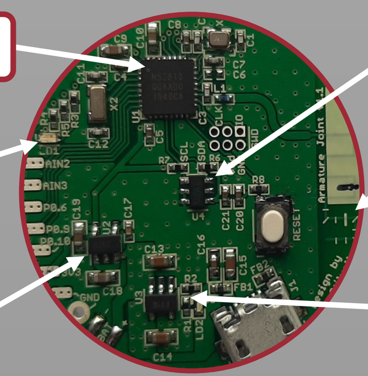
The electronic system elements were prototyped on a breadboard to validate the magnetic position measurement system. High speed signal Printed Circuit Board (PCB) design considerations and electronic components were researched for implementing the design on a PCB. This was designed electronically using Autodesk Eagle, manufactured by PCBZone in NZ, and assembled with the help of MechAdept.

Reference circuitry from Nordic Semiconductor was used for the Bluetooth-capable System on Chip (SoC) section of the PCB to help ensure its sufficient Radio Frequency (RF) performance.

nRF42810 SoC

RGB indicator LED

3.3V Voltage Regulator

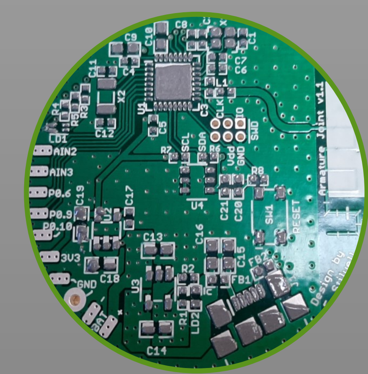


3D Hall Sensor

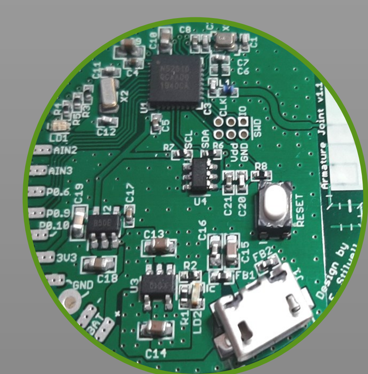
PCB trace antenna

Lithium Polymer/ Ion battery charger

Assembly Process

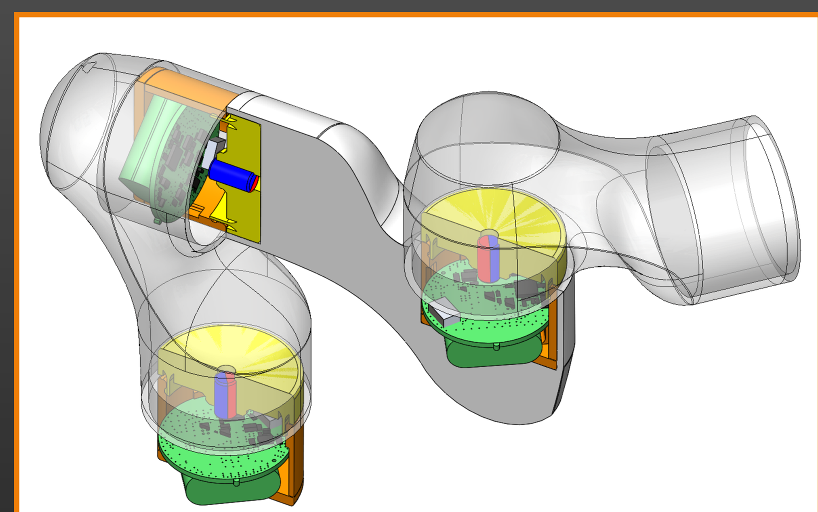


Solder paste applied



Components Placed

Reflow soldering process



Envisioned armature implementation by Frank

Kinematic Structure

3D printing was used for its fast turnaround time of mechanical prototypes and its availability. 3D printing design considerations were then researched before designing concepts were produced.

The kinematic structure was rapidly prototyped using Solidworks 3D CAD software for the modelling and 3D printing for the manufacturing. Two main concepts were produced and evaluated, and the preferred one was iterated upon to experimentally validate design decisions. The first concept relied on the magnetic pull of a magnet to hold the links together and provide field position to the magnetic sensor, however the prevailing concept was a snap-fit type which relied on a clip-on profile to interface the two links. This offers a rigid connection, a holding torque due to friction in the joint interface and a simple solution.

Concept 1—magnetic interface

Concept 2—Snap-fit interface

Conclusion

Multiple mechanical test iterations have been produced and the best mechanical interface was found to be a snap-fit design with a balance of actuation friction, simplicity, and ease of assembly/disassembly.

Six of the PCB's have been produced, all of which have passed power cycle tests, and one has been programmed with a basic Bluetooth application which verified the operation of the electronic system. The connection was maintained over a distance of >10m.

The functionality of the joint remains unproven due to the complexity of the embedded software. The level of knowledge required was beyond the scope of this programme, but this project has presented the motivation for future learning.

This project involved the development of a single joint module. It provided the hardware platform to build upon. However, the vision is to have multiple of these connected to interchangeable links to provide a hand manipulated virtual model and miniature robot prototyping platform.