GENESYS
ELECTRONICS DESIGN

Case Study: Exoflex

Award winning Exoflex transforms hand rehabilitation therapy with innovative technology, improved data.

Originally created to provide basic hand functionality for people with quadriplegia, Exoflex is now being used to revolutionise the hand therapy market.

Exoflex delivers therapeutic controlled movement to each finger joint in a patient's hand, controlling and measuring the speed, force and range of movement.

Using a simple web interface, practitioners create tailored therapy routines for a patient. These routines are transferred to the device's electronics control unit via Wi-Fi or a connected smartphone. Data collected from Exoflex enables monitoring of a patient's recovery and further customisation of therapy routines.

The Exoflex system consists of five components:

1. The Exoflex arm worn by the patient;
2. An electronic control unit (ECU);
3. Up to five drive modules (one per finger);
4. Finger nodes that attach the drive module to the patient's hand;
5. A web interface for control and data collection.

The Challenge

Exoflex is the brainchild of Peter Abolfathi. Peter first started work on the concept in 2003 as part of his PhD in Biomedical Engineering. After developing an initial prototype, Peter partnered with BES Rehab Ltd to commercialise the product. Although originally designed to provide enhanced movement for quadriplegics, BES Rehab saw an opportunity to use the technology as a hand rehabilitation tool.

"Creating a product fit for use as a hand rehabilitation tool was significantly more difficult than our original concept," explained Peter. "Exoflex uses motors to control the movement of each joint. The original concept only used two motors; but in order to control the extension and flexion of each joint separately, we needed to use 14 motors, each with independent and precise control capabilities."

"Another challenge was the ability to accurately measure the force applied to each joint while the patient performed their rehabilitation routine. This had never been done previously, so the team had to come up with a completely new technology to make this happen."

By measuring this force the practitioner is able to view a patient's progress overtime and modify their therapy accordingly.

Designing the Firmware

Genesys Electronics Design was engaged to develop the circuit boards, firmware and software for the Exoflex drive unit, and assist with regulatory compliance, validation and testing.

Jesse Kovac, Senior Design Engineer at Genesys took the lead on this project.

"Coming on-board part way through the project, our first task was to review the existing design schematics and identify any areas that required modification or improvement."

During his review, Jesse identified two concerns with the Exoflex control unit:

1. There was no in-built synchronisation between the different joints. This meant the movement of each joint would be slightly off-synch with other joints, based on the time it took for the movement message to travel from the control unit to the individual motor. To fix this, Jesse designed a synchronisation routine to ensure that every joint was ready to go with pre-loaded routine data before the movement started.
2. The original system had a control loop that was causing the joints to overshoot and produce unwanted oscillation. Jesse implemented a PID control loop tuned to enable the joints to reach the desired target in less than one degree.

Measuring Joint Force

Genesys oversaw the implementation of an innovative solution in partnership with engineering business Spatial Freedom, that used infrared technology to measure the force applied by each joint.

To do this, an infrared beam was passed through a mask at the back of the motor and the amount of light getting through this mask was measured using a sensor. By designing a mechanism that coupled the obstruction of light by the mask to the tension and compression applied to the axis a novel method was created for sensing force.

Remote Connections

Exoflex uses a simple web interface to input therapy routines and view patient reports.

Connecting to the device's ECU through Wi-Fi or smartphone provides freedom and flexibility to both patients and practitioners, who no longer need to be in the same place to upload new routines or view results. This opens up a range of opportunities for telemedicine and increased at-home care.

> "Not only did Genesys find innovative solutions to the most difficult technical challenges, but also fully supported the project in a number of other ways including compliance, testing and technology validation."

The Result

After many years of hard work and dedication, Peter is thrilled see the product ready to take to market.

"Production samples are now being used to demonstrate Exoflex's capabilities to hand rehabilitation practitioners," explained Peter. "It's exciting to see this technology making it's way into the market to improve outcomes for hand rehabilitation patients."

"Genesys was a vital partner in this project. Not only did they find innovative solutions to the most difficult technical challenges, but also fully supported the project in a number of other ways including compliance, testing and technology validation."

"I am still working closely with Genesys for any further requirements and modifications, and they have fully supported our needs throughout the process."

Awards

Exoflex has won three major awards for innovation in medical technology:

1. British Council Eureka Prize for Inspiring Science – 2004.
2. National Disability Awards for Excellence in Technology - 2016.
3. Good Design Awards - Museum of Applied Arts and Sciences Selection and Award - 2017.