Technical Overview

FUNCTIONAL ELECTRICAL STIMULATION FOR HAND REHABILITATION

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The problem

Loss of hand function is among the most disabling consequences of stroke and spinal cord injury. The hand is where independence lives: eating, dressing, writing, holding a phone. Rehabilitation that restores even partial voluntary grasp changes what a day looks like.

Functional electrical stimulation has been used in rehabilitation for decades, and the principle is sound. Stimulate the peripheral nerve, evoke the contraction, pair it with the person's own intent to move, and you drive the motor relearning that recovery depends on. The limitation has never been the principle. It is the electrode.

Conventional surface FES uses a small number of large electrodes. A large electrode recruits whatever lies beneath it, and in the forearm that means several muscles at once. The result is a gross, undifferentiated contraction: the whole hand closes, or the whole wrist extends. Individuated movement, the thing that actually matters for function, is out of reach.

Placement is the second problem. Forearm anatomy varies enough between people that a position which works well for one person is mediocre for the next, and a position found last week is hard to reproduce this week. Clinicians spend appointment time hunting for motor points by trial and error, and that is time that should have gone to therapy.

Our approach: spatial selectivity

Instead of a few large electrodes, we use an array of many small ones.

Every element in the array can be addressed independently, which turns electrode placement from a mechanical problem into a software one. Rather than moving a pad around the forearm searching for a motor point, the system energises subsets of the array, observes the response, and builds a map of which elements recruit which muscle in this particular person's arm.

That map is the product. It gives us three things conventional FES cannot:

- **Selectivity.** Recruiting a small region rather than a whole compartment makes it possible to target individual muscles, and therefore individual movements.

- **Repeatability.** Once mapped, a session can be reproduced. The array is placed roughly and the software finds the same elements again, instead of depending on a clinician reproducing a pen mark on skin.
- **Adaptation.** The map is not fixed. As the person recovers, or as the array shifts during a session, the addressing is updated in software without touching the hardware.

The underlying trade is straightforward: precision moves out of the clinician's hands and into the system, where it can be measured, stored, and repeated.

The system

The device has three parts: a surface array of independently addressable elements worn on the forearm, a battery-powered stimulator that generates the waveform and routes it to selected elements, and a companion application that runs the mapping procedure and stores each person's map between sessions.

Safety

Stimulation is delivered as charge-balanced biphasic pulses, so no net charge accumulates at the tissue interface.

The architecture places every stimulation limit — amplitude, pulse width, duty cycle — in the stimulator's firmware, below the levels the application is able to request. The ordering is deliberate: a fault in the application layer cannot produce an output beyond what the stimulator itself permits.

The device software is developed under IEC 62304, with the software safety classification, architecture, and traceability records maintained from the start rather than reconstructed for an audit later.

Where we are

FiRe ehf is an early-stage company in Reykjavík, Iceland, and the device is in development. We would rather show you where we actually are than describe it on paper.

We are looking for clinical partners interested in evaluating spatially selective stimulation in a rehabilitation setting, and we are glad to talk with researchers working on adjacent problems.

Get in touch at helgi@fireehf.is.