MiNT08

Early Feasibility study of using Immersive Gamified Functional Electrical Stimulation for upper limb neurorehabilitation

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REHABWEEK 2025 MiNT MASTERCLASS IN NEUROTECHNOLOGY

Introduction

Extended Reality (XR) has been used both for fitness and for stroke rehabilitation[1-2]. XR & **gamification** has a potential to enhance patient adherence, improving rehabilitation outcomes for stroke rehab while being accepted by patients. **Functional Electrical Stimulation** (FES) is an established technique for muscle training [3] and muscle re-education which has been used in stroke rehabilitation [4].

The combination of these techniques has a potential for furthering the improvement of stroke survivors [5].

v-health is a novel upper limb neurorehabilitation system combining Functional Electrical Stimulation (FES), Extended Reality (XR) and gamification created by Valkyrie Industries.

The system's unique approach:
- Connecting **FES**, movement and **XR** in real time
- **Gamifying** FES exercises
- **Tracking** and analysing the movement
- Designed for one hand operation, even for people with reduced mobility.



Real-time · Movement-aware · Wearable · Wireless · Easy-to-use · For upper limb

v-health by VALKYRIE

- An immersive experience combining virtual reality (VR) and functional electrical stimulation (FES).
- Valkyrie wearable FES hardware **eir bands**
- Applied to user's muscles in the upper limb
- BLE communication protocols for communication with <15ms latency
- **FES**:
  - Pulse width: 30 – 200 usec
  - Amplitude: Up to 120V p2p
  - Pulse duration: 50 to 100 Hz
- Third-party untethered VR hardware, such as Meta Quest 3 with hand tracking
- Android phone for clinician's control



Study Protocol

- 4 neurological patients (3 spinal cord injury, SCI, patients and 11 stroke survivors)
- Four clinics: the University of Ghent Hospital in Belgium, Hobbs Rehabilitation, Neurokinex and Relive in the UK

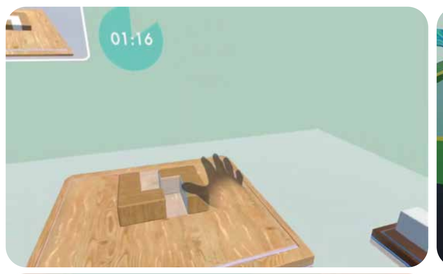
FES mobile game
- "Raccoon rush" (endless runner, any FES application point)

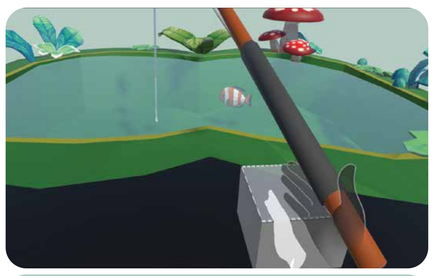
FES XR games
- "Fishing game" (wrist flexion / wrist extension)
- "Building blocks" (finger extension / finger flexion)
- "Phoenix game" (wrist & finger extension)
- "Air hockey" (elbow joint, analytics)

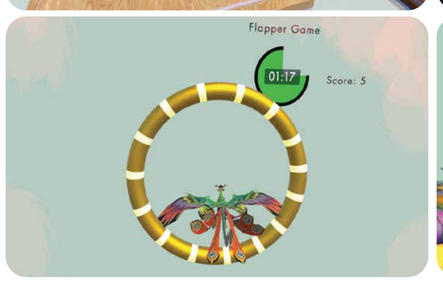
XR games (no FES)
- "Bubble game" (range of movement, analytics)

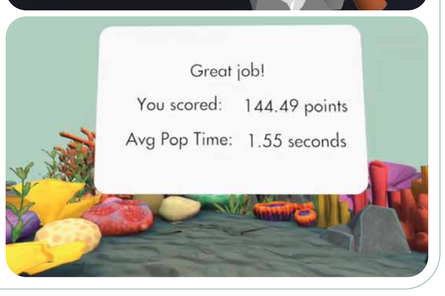












Results

Our system was shown to be **easy to use, immersive, engaging and exciting.** 11 out of 14 patients liked the games and wanted to have this technology in the clinic or at homes in addition to existing rehabilitation methods.

Most patients **preferred XR** over mobile games, citing the direct feedback between the patient's intention to move in XR, and electrical stimulation. Different patients preferred different games, highlighting the diversity of v-health platform.

Conclusion

Combination of XR and real-time FES reacting to the patients' movement has a strong potential to be used for stroke and SCI rehabilitation.

Valkyrie Industries

London-based startup specializing in immersive electrical stimulation for variety of applications; Founded in 2017

Experiences:
- **Eir training Lite**: VR fitness on Meta Quest
- **EIR TrainingTM**: VR fitness + Muscle Stimulation
- **ASICS VR Fitness**: Competitive VR fitness experience
- **Argil**: Immersive 3D creation
- **Bifrost**: Muscle Stimulation Upper body suit

Acknowledgements

Ulrike Hammerbeck, Marco Davare: King's College London
Laura Marriott, Helen Hobbs: Hobbs Rehabilitation
Lode Sabe: University of Gent
Lucy Redman: UK
Whole Valkyrie Industries Team

Partners

GHENT UNIVERSITY · hobbs rehabilitation Neurological Specialists · KING'S College LONDON · London South Bank University EST 1892 · asics · LUXSHARE ICT

References:

[1] Hoolahan, K., et al (2024). An Investigation into the Effects of Virtual Reality and Electrical Muscle Stimulation on Mood, Exertion and Muscular Fatigue. International Journal of Virtual Reality, 24(1), 46–78.
[2] Soleimani M, Ghazisaeedi M, Heydari S. The efficacy of virtual reality for upper limb rehabilitation in stroke patients: a systematic review and meta-analysis. BMC Med Inform Decis Mak. 2024 May 24;24(1):13
[3] National Clinical Guideline for Stroke for the UK and Ireland - c/o Sentinel Stroke National Audit Programme (SSNAP) King's College London
[4] Khan MA, et al(2023) A systematic review on functional electrical stimulation based rehabilitation systems for upper limb post-stroke recovery. Front. Neurol. 14:1272992
[5] Norouzi-Gheidari, et al. Feasibility and preliminary efficacy of a combined virtual reality, robotics and electrical stimulation intervention in upper extremity stroke rehabilitation. J NeuroEngineering Rehabil 18, 61 (2021)