

TERM PROJECT ASSIGNMENT

Name of candidate: Katla Maria Gudmundsdottir

Topic: Engineering Cybernetics

Title (Norwegian): Et Lukket-sløyfe Funksjonell Elektrisk Stimuleringsystem til Gangrehabilitering etter Hemiparetisk Slag

Title (English): A Closed-Loop Functional Electrical Stimulation Control System for Gait Rehabilitation following Hemiparetic Stroke

Assignment text:

Functional Electrical Stimulation (FES) is a technique used to restore motor function in individuals with neurological impairments, such as those resulting from stroke. While FES has shown promise in gait rehabilitation, current systems face significant challenges in delivering comfortable and effective stimulation. Despite technological advances, most commercially available systems still rely on open-loop control, which lacks adaptability, leading to issues in recreating the gait cycle, excessive muscle fatigue and discomfort. As a consequence, the full potential of this valuable rehabilitation technique remains underutilized.

This project aims to address these limitations by developing a closed-loop FES system that integrates real-time feedback from Inertial Measurements Units (IMUs) to dynamically adjust stimulation in order to recreate a natural, comfortable gait cycle. The work is structured into the following tasks:

1. **Refactor Code Base:** Refactor and modularize legacy software to create a maintainable and scalable code base for FES gait control.
2. **Determine FES Parameters:** Define the stimulation waveform parameters, validate and adjust code to ensure expected output behavior.
3. **Design Stimulation Sequence:** Select the muscles, their stimulation timings and durations in order to create an open-loop stimulation sequence that successfully recreates a step. Test the generalizability by validating on several subjects.
4. **Integrate Wireless IMUs:** Replace wired IMUs with newly developed wireless versions.
5. **Implement Knee Angle Estimation:** Develop and validate knee angle estimation using IMU data and sensor fusion algorithms.
6. **Implement Gait Phase Detection:** Implement the existing Python gait phase detection algorithm in C++.
7. **Implement Closed-Loop FES:** Design, build and validate a closed-loop FES system using IMU feedback and the open-loop stimulation sequence.

Assignment given: 09. September 2024
Submission deadline: 13. Januar 2025