Biomedical Signals
Lab 7 - Adaptive Filtering

Marcos Oriol & Raid Höms

December 16, 2025

Universitat Politècnica de Catalunya

ADAPTIVE FILTERING WITH LMS ALGORITHM

1 Introduction

The accurate recording and analysis of bioelectric signals, such as the Electromyogram (EMG), are **fundamental to physiological monitoring and clinical diagnostics**. However, these signals are frequently contaminated by significant non-biological interference, making accurate analysis challenging. Effective filtering techniques are therefore **essential to isolate the signal** of interest from unwanted noise.

One of the most pervasive sources of interference in EMG recordings is the **power line artifact**, typically oscillating at 50 Hz or 60 Hz. Since the power line frequency falls within the operational bandwidth of the EMG signal, its removal is critical, yet challenging, as traditional **linear time-invariant (LTI) filters** can inadvertently remove desired biological signal components alongside the noise.

This document explores the application of **Adaptive Filtering** using the **Least Mean Squares (LMS) algorithm** as a dynamic solution to interference cancellation. Unlike fixed-coefficient LTI filters (such as the Butterworth Notch filter), the LMS algorithm adjusts its filter weights iteratively to track and minimize the interference component in the primary signal.

The work is structured in two main parts:

1. **Filtering Power Line Interference**: We apply the LMS algorithm to remove 60 Hz power line noise from EMG signals. The performance is evaluated using the **Energy Spectral Density (ESD)** and compared against a fixed-coefficient LTI filter to assess the trade-offs in noise reduction and signal preservation.

2. **Filtering ECG Interference in EMG Signals** : We address the more complex issue of removing cardiac activity (ECG) artifacts from EMG signals. Since a separate ECG reference signal is not available, we synthesize the required reference by extracting an **"average ECG beat"** and using cross-correlation to generate an impulse train.

Ultimately, this study aims to analyze the **convenience** and performance of adaptive filtering in handling both simple (sinusoidal, 60 Hz) and complex (morphological, ECG) interference components in biomedical signals.