BME 544 Assignment 6

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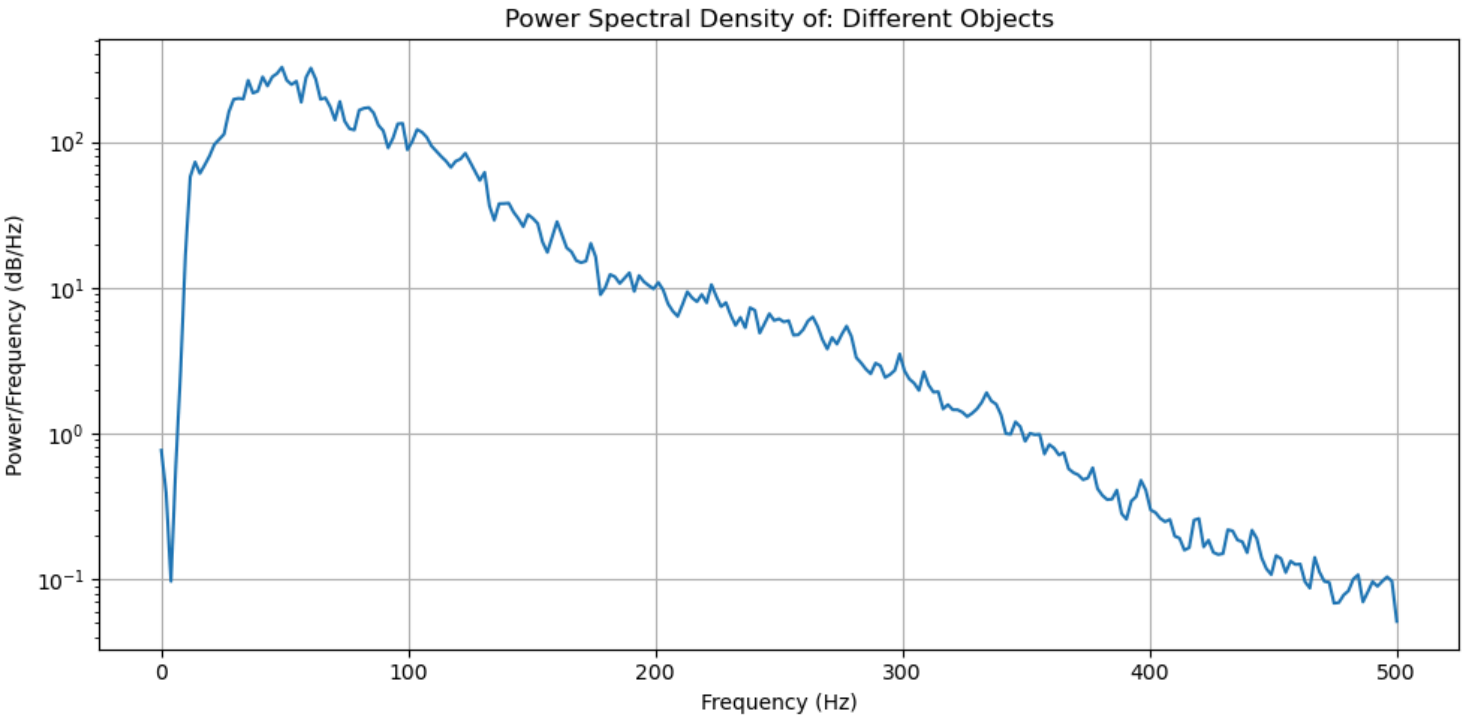
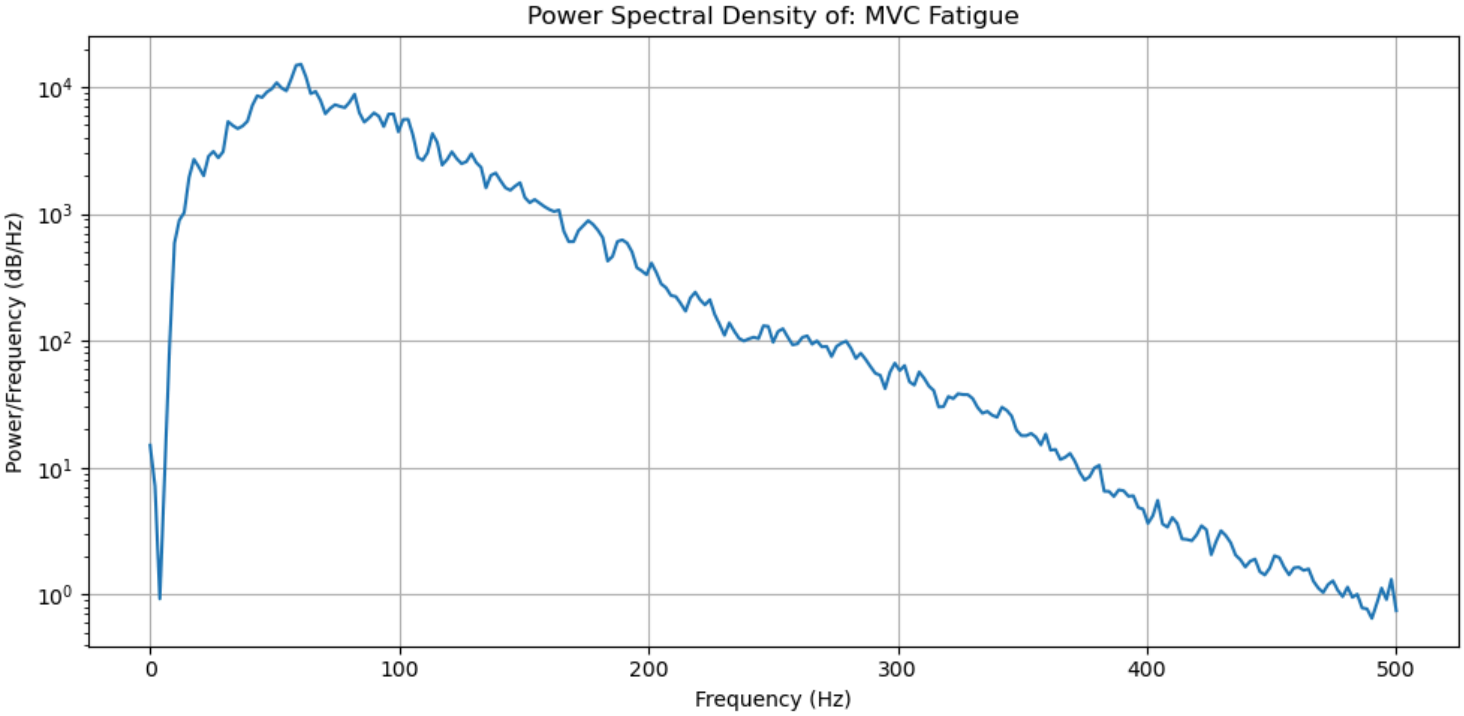
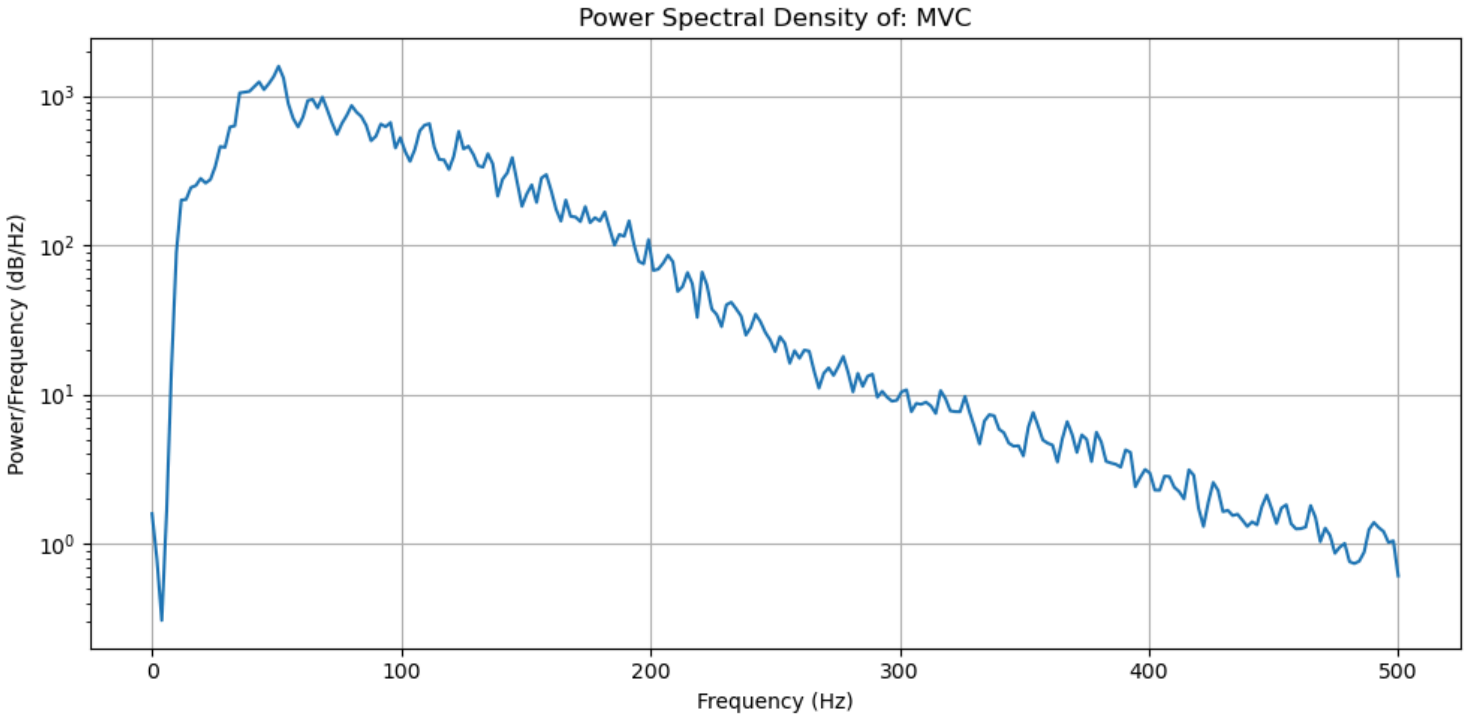
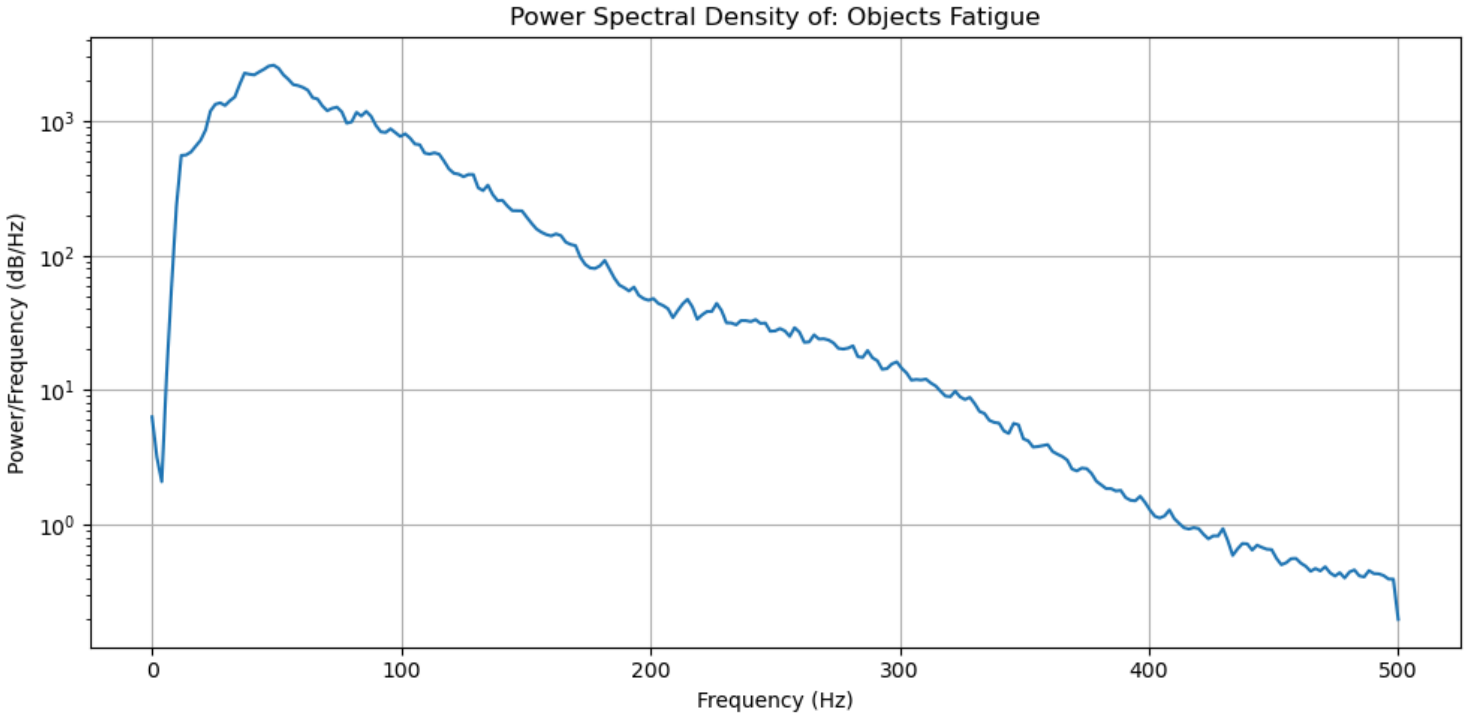
Line Noise


Power Spectral Density of: Different Objects
Power/Frequency (dB/Hz)
10^2
10^1
10^0
10^{-1}
0
100
200
300
400
500
Frequency (Hz)

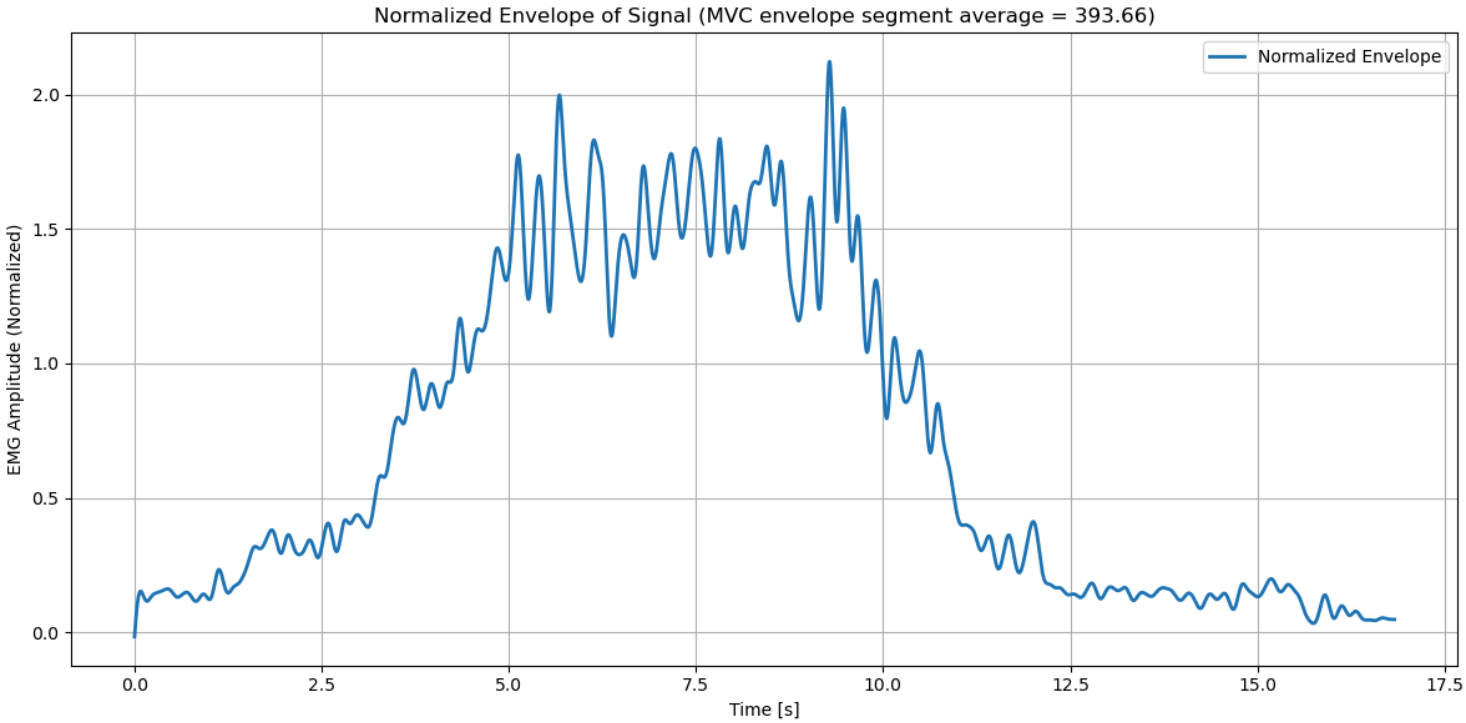

Power Spectral Density of: MVC Fatigue
Power/Frequency (dB/Hz)
10^4
10^3
10^2
10^1
10^0
0
100
200
300
400
500
Frequency (Hz)





Looking at the estimated PSDs, it seems like AC line noise of 60 Hz and its harmonics is not particularly prominent across each dataset. Perhaps there is already hardware/firmware filtering taking place in the IX-BIO amplifier. However, if AC line noise was causing an issue with feature extraction of the subsequent steps, an appropriate way to filter out the AC line noise of 60 Hz would be to use an IIR notch filter. Compared to an FIR filter, an IIR filter would be able to achieve a much narrower stopband than an FIR filter while requiring less filter coefficients. This will allow for more selective filtering at a lower computational cost, which is crucial in real time applications and for maintaining signal information (the dominant energy of EMG signals are from 50-150 Hz [1]). Although IIR filters have a non-linear phase response, within the context of EMG signal processing, original phase information is not an important feature for downstream signal processing steps. Looking at the remainder of the assignment, it is conclusive that a non-linear phase response is not a factor that needs to be prioritized during filter selection.

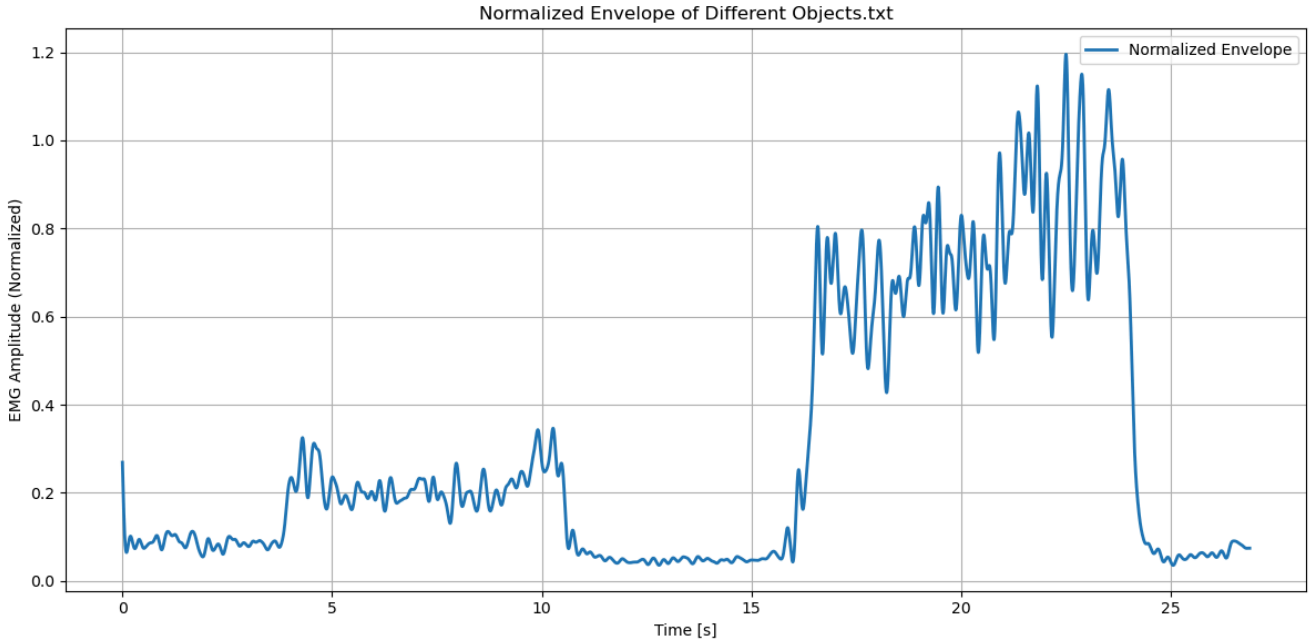
Maximum Voluntary Contraction



Low pass filter parameters:

- Type: Butterworth
- Order: 4
- Cutoff: 5 Hz

EMG for two levels of force

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Interval 1 (3.8–10.8s):
  Mean Frequency: 73.05 Hz
  Median Frequency: 54.69 Hz

Interval 2 (16–24.5s):
  Mean Frequency: 77.87 Hz
  Median Frequency: 63.48 Hz
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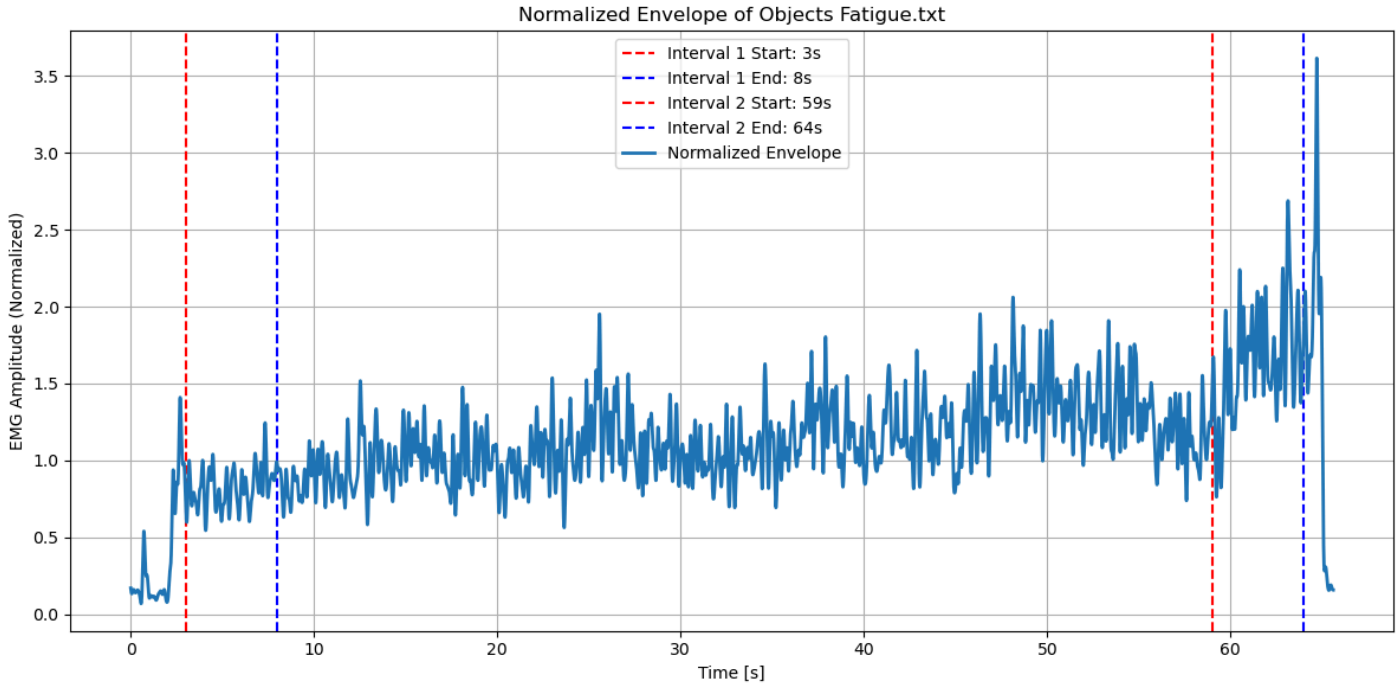
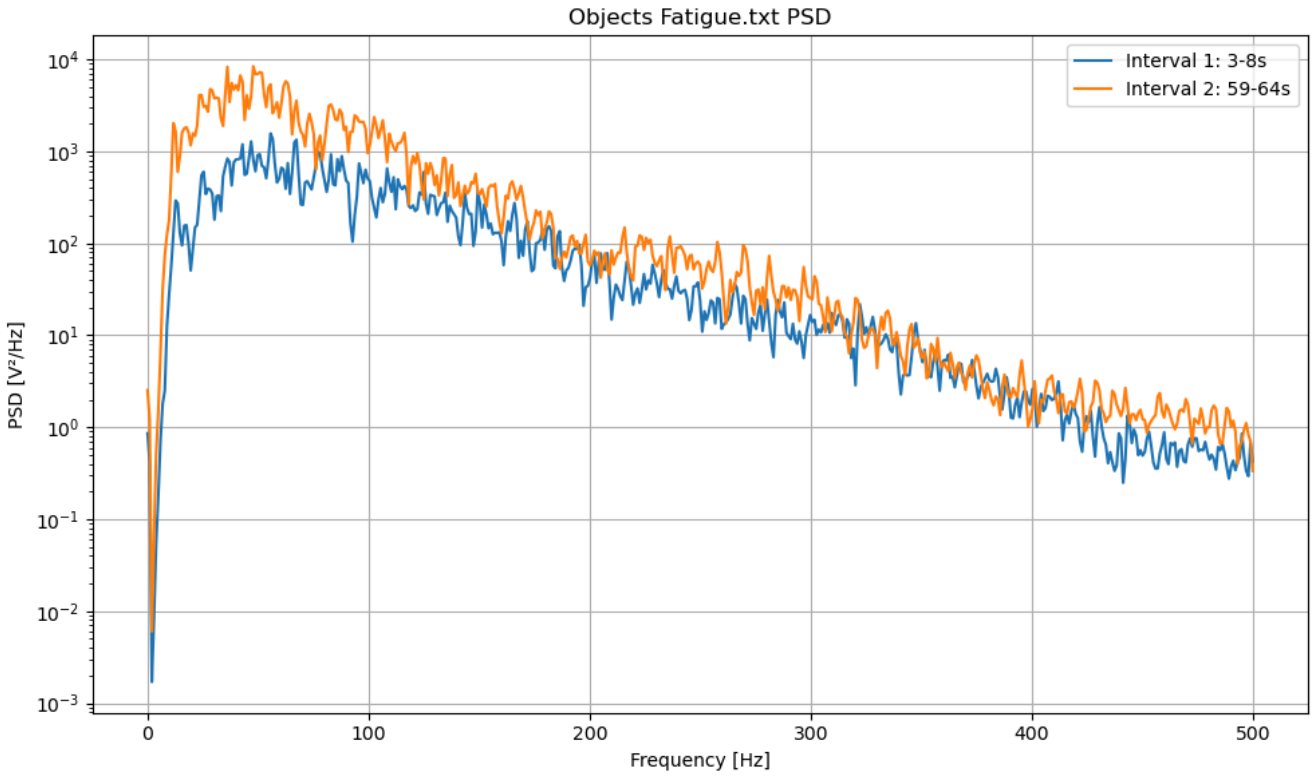
Sustained (sub-MVC) force



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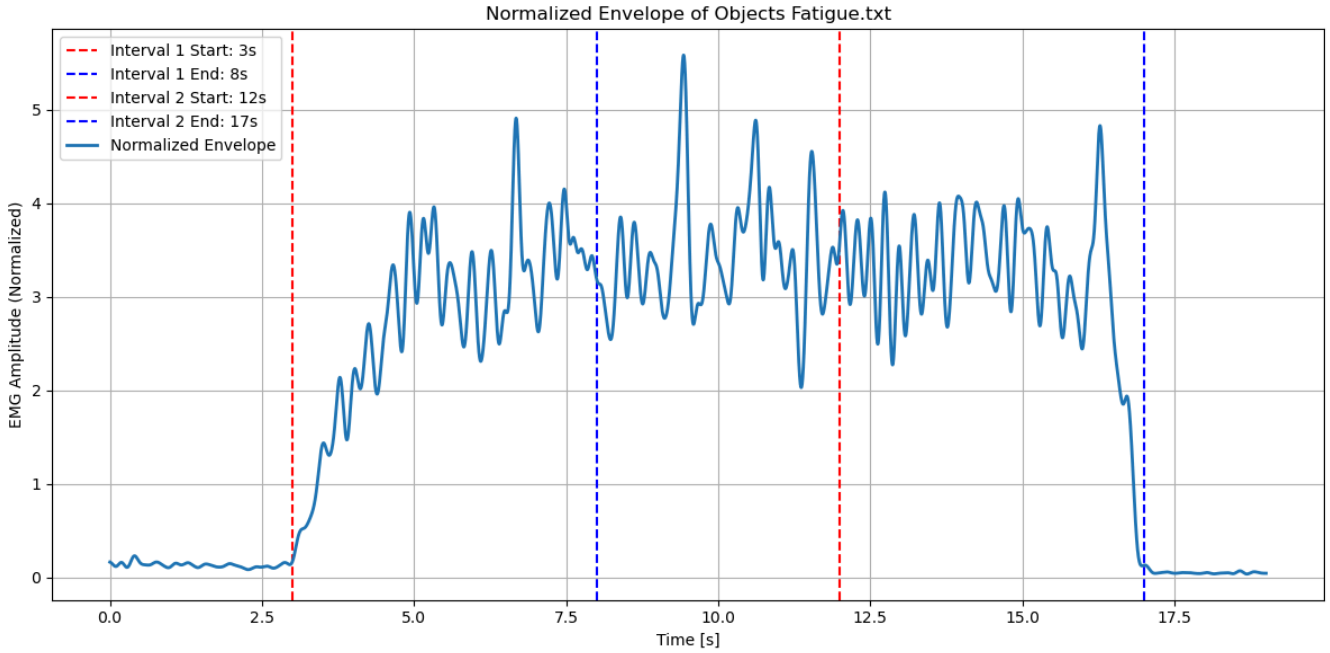
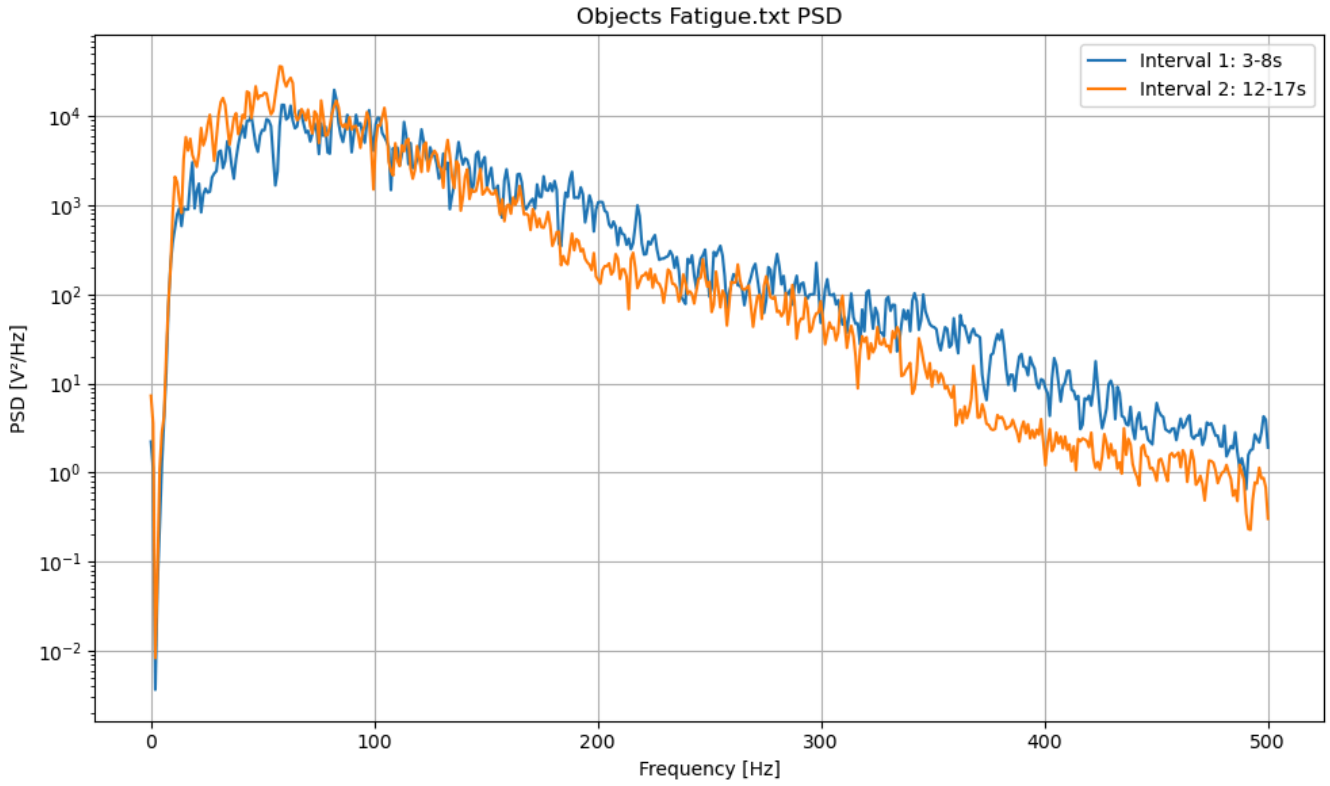
Interval 1 (3–8s):
  Mean Frequency: 90.09 Hz
  Median Frequency: 77.15 Hz

Interval 2 (59–64s):
  Mean Frequency: 68.34 Hz
  Median Frequency: 55.66 Hz
```

Sustained MVC force



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Interval 1 (3–8s):
  Mean Frequency: 94.58 Hz
  Median Frequency: 83.98 Hz

Interval 2 (12–17s):
  Mean Frequency: 72.42 Hz
  Median Frequency: 62.50 Hz
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Questions

1. EMG signals are normalized based on MVC because raw EMG amplitudes vary significantly between individuals due to factors such as skin impedance, electrode placement, muscle size, subcutaneous fat, signal amplification. Normalization will help to standardize these differences across subjects and sessions so comparisons can be made. I did in fact observe normalized responses that were greater than 1 (for all the other datasets). When conducting or using MVC for normalization, potential issues that need to be considered include incomplete activation during MVC, which causes underestimation of the MVC and overestimation when normalizing for other datasets. Fatigue during MVC is a similar issue which leads to underestimation of MVC. Other issues that need to be considered when using MVC for normalization is electrode placement (orientation and location) across sessions and subjects, cross-talk from nearby muscles, and muscle-injury.
2. For the sustained force, it was clear that median and mean frequency decrease over time. This is likely because fatigue causes conduction velocity to decrease (due to accumulation of metabolic byproducts) [2]. This is also likely due to the increased rate of fatigue of fast twitch muscle fibers resulting in a larger fraction of muscle fiber activation from slow twitch fibers. These factors would shift EMG power to lower frequencies.
3. For the sustained MVC, a similar observation can be made, which is a decrease of median and mean frequency over time. However, the median frequency for the sustained MVC was higher than the sub-MVC for both intervals. This difference is likely because sub-MVC results in a larger proportion of slow twitch fibers being recruited compared to full MVC since fast twitch fibers are better at providing short bursts of energy while slow twitch fibers are better at providing sustained effort.

References

[1] L. Shaw and S. Bhaga, “(PDF) online EMG Signal Analysis for diagnosis of neuromuscular diseases by using PCA and PNN.,” https://www.researchgate.net/, https://www.researchgate.net/publication/232905752_Online_EMG_Signal_Analysis_for_diagnosis_of_Neuromuscular_diseases_by_using_PCA_and_PNN (accessed Apr. 6, 2025).

[2] A. Eberstein and B. Beattie, “Simultaneous measurement of muscle conduction velocity and EMG power spectrum changes during fatigue,” *Muscle & Nerve*, vol. 8, no. 9, pp. 768–773, Nov. 1985. doi:10.1002/mus.880080905