Detecting the presence of baseline wanders and powerline interferences in the ECG signal

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***Abstract*—This paper presents a Digital Signal Processing method to detect common noise types, namely the presence of baseline wanders and power-line interferences for Electro-Cardio-Gram(ECG) signals with the sampling frequency of 360 Hz for a duration of 10 seconds.Here I am using Matlab for the detection part using Fast Fourier Transforms(FFT) analysis and the GUI is constructed by Python using tkinter. These noises are often a hindrance because they have nothing to do with the electrical signals of the hearts themselves, which helps doctors diagnose patients better. This hybrid approach helps us get the best of both worlds MATLAB for the processing and Python for its convenient GUI useful for diagnostic and research purposes.**

***Index Terms*—ECG, FFT, baseline wander, power-line interference, MATLAB, Python GUI**

I. Introduction

Electrocardiograms (ECG) are very frequently corrupted by noise artifacts, which becomes a trade-off for accurate diagnosis. Two of the most dominant noise sources are baseline wander which occurs in the frequency range of 0-0.5 Hz and powerline interference in the frequency range of 50 - 60 Hz. This detection provides critical insight into clinical decision making. This project aims to detect these noises using FFT to understand its frequency analysis implemented in Matlab, with the results visualized using the Python Tkinter interface.

II. Methodology

A. Signal Acquisition

For ECG signals, the ideal and most recommended source is PhysioNet's MIT-BIH arrhythmia database which has a sampling frequency of 360 Hz which would be ideal for the project, but since the website never loaded due to network firewalls , the signals were sourced from Kaggle's the MIT-BIH arrhythmia database (Simple CSVs) which were CSV files with a sampling frequency of 360Hz for 30 minutes.

B. FFT based Noise detection

Since the project is the detection of 10 seconds of the signal, the FFT was performed on the first 3600 samples (since the sampling rate is 360 Hz) using an inbuilt function named FFT in MATLAB. The FFT gives us an idea on the frequency components of the signal, making it idealistic for detecting noise that depends on the frequency characteristics here. Now, since we get complex values that are harder to analyze, these values are converted to their respective normalized magnitudes. Then for the frequency range it ranges from 0 to 179.9 with a step value of 0.1. Now for our analysis, we only take the first half as they are symmetrical for real signals, which is our case here.Now for noise detection two types of noise were detected :-

- Baseline wander(0-0.5 Hz) Baseline wander refers to low-frequency fluctuations in an electrocardiogram (ECG) signal that are not of cardiac origin. It is typically below 0.5 Hz and can distort the ECG waveform, especially during stress tests or when there is movement of the body. Here, since this noise is a slow moving component and not a peak-like structure, comparing the mean of the values in this range to a certain threshold (taken 0.01) here is the best approach.

- Power line interference (50 - 60 Hz) Powerline interference refers to a common noise source in physiological signals such as ECG, caused by sinusoidal interference at 50 or 60 Hz frequencies. It hampers signal analysis by creating low-amplitude waveforms, making it difficult to identify specific regions like P-waves and T-waves.Powerline interfernces often appear as sharp spikes in that particular frequency region; hence comparing the max to 2.5 of the mean of the values in this range is perfect.

C. Python GUI for visualization

For an user friendly experience a GUI was created by Python's tkinter to support interaction with the ECG noise detection workflow.The GUI acts as a frontend through which the user inputs an ECG signals data in te form of a csv file which is handed over to the MATLAB backend for the processing mentioned above . Upon comlpetion the GUI reads the results using pandas and the results i.e. wether baseline wander or/and power-line interference is present or not will be displayed.Along side this the ECG's frequency spectrum will also be displayed in the form on an interactive graph which the user can play around to under stand the spectrum of the input signal better.

III. Results and detections

Fig. 1 shows the frequency dependence of an ECG signal with both powerline interference and baseline wander.

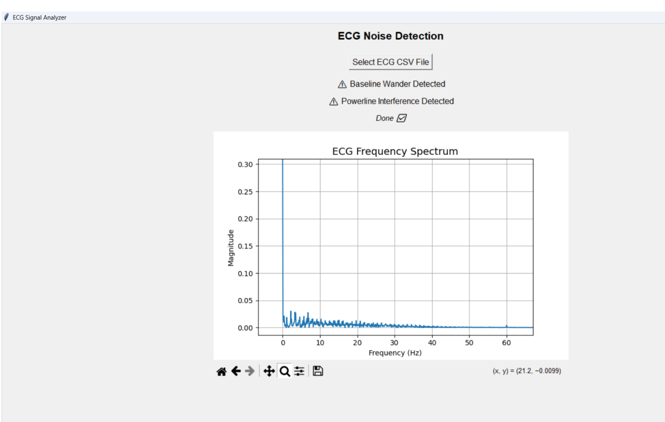

Fig. 1. FFT of 10-second ECG signal showing baseline wander and 50-60 Hz interference.

Fig. 2 shows the frequency dependence of a baseline wander of the ECG signal.

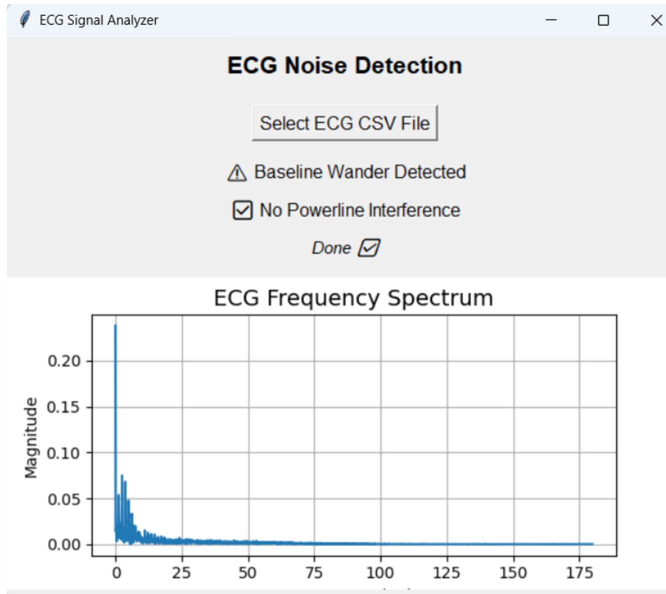

Fig. 2. FFT of 10-second ECG signal showing only baseline wander.

Fig. 3 shows the frequency dependence of an ECG signal both for powerline interference and for.

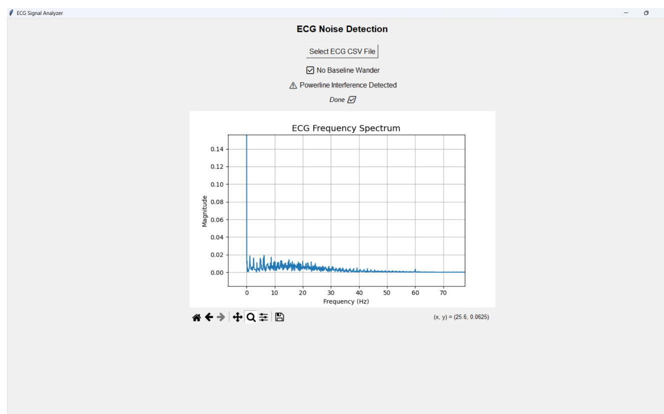

Fig. 3. FFT of 10-second ECG signal 50-60 Hz interference.

TABLE I
Noise Detection Results

Segment	Baseline Wander	Powerline Interference
1	Detected	Detected
2	Not Detected	Detected
3	Detected	Not Detected

IV. Conclusion

In this work, an FFT-based method was developed to detect common ECG signal artifacts—baseline wander and powerline interference—using MATLAB for spectral analysis and a Python Tkinter GUI for result visualization. The system efficiently identifies low-frequency drifts and high-frequency interference based on simple yet effective thresholding strategies in the frequency domain.

The integration of signal processing and GUI development ensures both analytical precision and user accessibility, making this tool suitable for both academic and clinical preprocessing workflows. Results across multiple ECG segments validated the method's ability to identify noise signatures visually and algorithmically.

Moving forward, the system can be expanded to include dynamic thresholding, multi-lead support, and real-time detection capabilities, positioning it as a foundation for more comprehensive ECG monitoring platforms.

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