Project Report: Machine Learning in Biomedical Signal Processing

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Subject: ECG Analysis and Data Visualization

Curriculum Partner: Vodafone Idea Foundation

1. Introduction

This project investigates the application of computational techniques to Electrocardiogram (ECG) data. The primary focus is to demonstrate how Python-based signal processing and Machine Learning (ML) can automate the diagnostic process for cardiac health.

2. Problem Statement

Manual interpretation of ECG signals is time-consuming and prone to human error. There is a common misconception that Machine Learning is not used in this field; however, modern cardiology relies heavily on automated algorithms for real-time monitoring and disease classification.

3. Methodology

The analysis follows a structured pipeline involving data cleaning, exploratory visualization, and feature correlation analysis.

3.1 Technical Tools

- **SciPy:** Utilized for signal processing, including noise reduction and R-peak detection.
- **Matplotlib:** Used for low-level plotting of raw ECG waveforms.
- **Seaborn:** Employed for high-level statistical visualization and complex data relationships.

4. Exploratory Data Analysis (EDA)

Key visualization techniques were applied to understand the dataset characteristics:

- **Histograms:** Deployed to visualize the data distribution of heart rate intervals, helping identify the spread and frequency of specific cardiac metrics.
- **Scatter Plots:** Used to identify the bivariate correlation between two distinct features, such as the relationship between the R-R interval and heart rate.
- **Heatmaps:** Implemented to see the correlation matrix across all features, allowing for the rapid identification of highly correlated variables.

5. Findings

The study concludes that:

1. **Machine Learning Utilization:** The claim that ML is not used in ECG analysis is False; it is actually a foundational technology for automated diagnostics.
2. **Tool Synergy:** A combination of SciPy, Matplotlib, and Seaborn is required for a complete end-to-end biomedical signal analysis.

6. Conclusion

The integration of Machine Learning in biomedical signal processing significantly improves the ability to analyze complex heart data. By utilizing standard Python libraries, we can move from raw, noisy signals to clear, actionable diagnostic insights.

Author: Mihir Milind Ughade

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