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Signal Processing Techniques for ECG Analysis and R-Peak Detection

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Abstract

This report presents a detailed analysis of signal processing techniques employed for electrocardiogram (ECG) analysis and the detection of R-peaks. The objective of this project was to develop an efficient algorithm that can accurately detect R-peaks, which are significant landmarks in ECG signals. The project utilized MATLAB as the programming tool and implemented two key files: "ecgdemo.m" and "ecgdemowinmax.m". The former file demonstrates the processing stages involved in ECG analysis, while the latter file implements a window-based filtering technique for R-peak detection. This report provides an overview of the project, explains the functionality of the MATLAB files, and discusses the outcomes and implications of the implemented algorithm.

Introduction

The field of biomedical signal processing plays a crucial role in diagnosing and monitoring cardiovascular diseases. ECG signals, in particular, provide valuable insights into the electrical activity of the heart. Accurate detection of R-peaks, which correspond to the depolarization of the ventricles, is essential for various clinical applications. This project aimed to develop a reliable algorithm for automated R-peak detection, utilizing signal processing techniques.

Methodology

The project employed MATLAB as the programming platform due to its versatility in handling signal processing tasks. The main MATLAB files used in the project are "ecgdemo.m" and "ecgdemowinmax.m". The former file provided a demonstration of the processing stages involved in ECG analysis, including preprocessing, filtering, and peak detection. The latter file implemented the window-based filtering technique, known as the winmax algorithm, for identifying R-peaks.

ECG Analysis and R-Peak Detection

The "ecgdemo.m" file processed two ECG data samples to demonstrate different scenarios. The steps involved the removal of lower frequencies using FFT filtering, application of the winmax algorithm for filtering the ECG signals, scaling the filtered signals, and detecting peaks based on a threshold filter. The algorithm optimized the window size for the winmax filter based on the distance between peaks. Finally, heart rate was calculated using the detected peaks.

The Winmax Algorithm

The "ecgdemowinmax.m" file implemented the winmax algorithm, which involved sliding a window over the ECG signal and identifying the maximum value within each window. The algorithm iteratively processed the signal in multiple passes, considering different segments. At each window position, the algorithm determined if the maximum value was centered within the window. If so, the corresponding output value was set to the maximum value; otherwise, it was set to zero. This step helped preserve the significant R-peaks while eliminating other positions.

Results and Discussion

The implemented algorithm successfully detected R-peaks in the ECG signals, as demonstrated in the processed data samples. The filtering and peak detection stages provided a clear representation of the ECG waveform and highlighted the R-peaks accurately. The heart rate calculation based on the detected peaks yielded reliable results, demonstrating the effectiveness of the algorithm in clinical applications.

Conclusion

The project showcased the application of signal processing techniques in ECG analysis and R-peak detection. The MATLAB implementation using the "ecgdemo.m" and "ecgdemowinmax.m" files demonstrated the effectiveness of the winmax algorithm for accurate R-peak detection. The project's outcomes have implications in various healthcare settings, where automated ECG analysis can aid in diagnosing and monitoring cardiac conditions.

Future Scope

Further enhancements can be explored to improve the algorithm's robustness and adaptability to different ECG signal characteristics. This may involve incorporating advanced filtering techniques, considering additional features for peak detection, and optimizing the algorithm's performance for real-time applications. Moreover, the algorithm can be validated and evaluated on a larger dataset to assess its generalizability and performance in various clinical scenarios.

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Keywords

ECG analysis, R-peak detection, signal processing, winmax algorithm, MATLAB, cardiovascular diseases.