ADAPTIVE ECG SIGNAL EXTRACTION USING SVD AND MULTIRESOLUTION WAVELET ANALYSIS

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ABSTRACT

A wavelet and singular value selection-based ECG signal extraction technique is suggested with the goal of reducing the noise in the received ECG signal. The ECG signal component corresponding to each singular value is obtained by first performing the singular value decomposition on the ECG signal. Cross-correlation coefficients with other components are then computed using the signal component that corresponds to the maximum singular value. The number of singular values for ECG signal reconstruction is calculated by adding the cumulative contribution rate of singular values. The final identified signal components are de-noised using the wavelet threshold de-noising technique. Lastly, reconstructing the signal components yields the de-noising ECG signal. When compared to the wavelet threshold approach, the experimental findings demonstrate that the method has a good noise reduction effect and can effectively suppress noise and extract signal.

Keywords: ECG signal, signal extraction, singular value decomposition, wavelet

I INTRODUCTION

Electrocardiogram (ECG) signals are widely used for diagnosing and monitoring heart diseases. However, several kinds of noise frequently alter ECG data obtained in real-world settings, which can distort crucial signal characteristics and lower diagnostic accuracy. Thus, to enhance the quality of the ECG signal, efficient techniques for signal extraction and noise suppression are required. Although wavelet threshold methods and other conventional denoising techniques are frequently employed, they may result in the loss of important signal information or inadequate noise reduction in complex noise situations. This research suggests a hybrid ECG denoising technique based on wavelet thresholding and singular value decomposition (SVD) to overcome these problems. The suggested approach outperforms conventional wavelet-based techniques by efficiently suppressing noise while maintaining crucial ECG signal properties through the selection of significant singular values and the use of wavelet denoising.

II LITERATURE SURVEY

[1] In 2022, a study title named Fetal Electrocardiogram Signal Extraction Based on Fast Independent Component Analysis and Singular Value Decomposition by Jingyu Hao, Yuyao Yang. The authors proposed hybrid FastICA–SVD approach for extracting fetal ECG signals from noisy abdominal recordings, followed by wavelet-based detection of fetal QRS and ST segments. Useful in Prenatal diagnostic system.

[2] In 2020, a study title Evaluation of an external fetal electrocardiogram monitoring system: a randomized controlled trial by Cara Heuser, Martha Monson. The authors proposed a study evaluates and compares the clarity and reliability of fetal heart rate signals obtained during labor using wireless abdominal fetal electrocardiography versus conventional external Doppler monitoring. Useful in labor, Detection of fetal distress.

[3] In 2018, a study title named ECG Signal De-Noising and Feature Extraction using Discrete Wavelet Transform by Raaed Faleh Hassan, Sally Abdulmunem Shaker. The authors proposed a work focuses on ECG signal denoising and feature extraction using the Discrete Wavelet Transform (DWT) to accurately detect cardiac. Useful in Telemedicine platforms.

[4] In 2016, a study title named Hybrid method based on singular vale decomposition and embedded zero tree wavelet technique for ECG signal compression by Ranjeet Kumar. The authors proposed a method uses SVD and EZW wavelet to compress ECG signals by reducing redundancy and preserving important features. It achieves high compression ratio with low signal distortion.

[5] In 2001, a study title named ECG data compression using truncated singular value decomposition by Jyh-Jong Wei, Chuang-Jan Chang.The author proposed a method that uses truncated Singular Value Decomposition (SVD) to compress ECG signals by retaining only the most significant singular values that represent essential cardiac features.

III PROPOSED SYSTEM

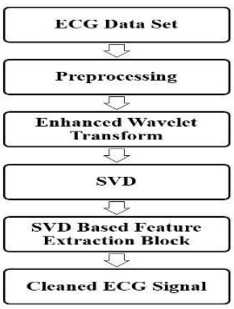
The suggested system proposes an effective ECG signal denoising and extraction method by combining Singular Value Decomposition (SVD) with wavelet threshold denoising. The major purpose of this system is to minimize noise while keeping the fundamental morphological properties of the ECG signal.

The noisy ECG signal is then broken down into several signal components that correspond to various singular values using Singular Value Decomposition. A unique energy contribution of the signal is represented by each component. Since it contains the most important ECG data, the component linked to the maximum single value is chosen as the reference component.

The similarity between the reference component and other decomposed components is then assessed using cross-correlation coefficients. The ideal number of singular values needed for precise ECG signal reconstruction is also found using the cumulative contribution rate of singular values. While noise-dominated components are eliminated, dominant signal components are preserved because to this adaptive selection.

Wavelet threshold denoising is used to further eliminate any remaining noise in the chosen components after the effective signal components have been chosen. This technique optimises noise reduction without generating major distortion to ECG characteristics. Ultimately, the processed signal components are combined to reconstitute the denoised ECG signal, producing a clean and dependable ECG signal.

Compared to traditional wavelet-only denoising techniques, the suggested system offers greater signal preservation and noise reduction performance, making it appropriate for realistic ECG signal processing applications.



Fig,1 Block Diagram of Proposed System

Algorithm Steps

1. ECG dataset block contains the raw ECG recordings collected from databases or acquisition systems. The signals may include various types of noise and artifacts.
2. Preprocessing removes baseline wander, power-line interference, and high-frequency noise using filtering and normalization techniques to make the ECG signal suitable for further analysis.
3. EWT decomposes the preprocessed ECG signal into multiple time–frequency sub-bands. It helps in isolating important ECG components (P, QRS, T waves) while suppressing noise.
4. SVD decomposes the wavelet coefficients into singular values and corresponding components, separating dominant ECG information from noise-dominated components.
5. Significant singular values and components are selected to reconstruct or extract meaningful ECG features, discarding components associated with noise.
6. The final output is a denoised and enhanced ECG signal with preserved morphological features, suitable for diagnosis or further processing.

IV RESULTS

The result shows that the hybrid SVD–wavelet ECG signal extraction method effectively removes noise from the original ECG signal. DWT reduces high-frequency noise, while SVD further extracts the dominant ECG components. The final output clearly preserves QRS complexes with improved baseline stability, making the ECG signal cleaner and suitable for reliable analysis.

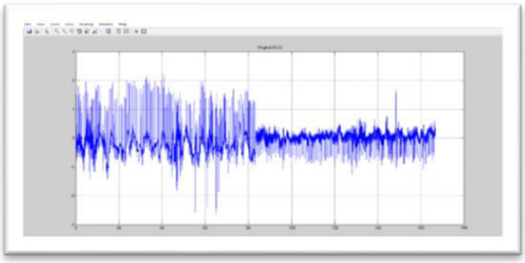


Fig.2 Original ECG signal

The presence of noise and abrupt spikes indicates interference from power line noise, muscle activity, and acquisition artifacts.

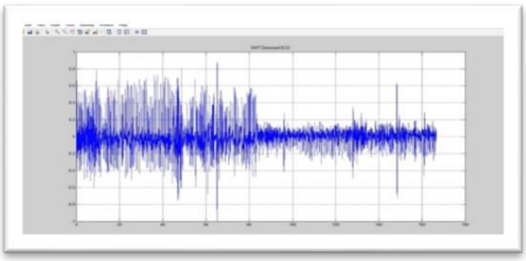


Fig.3 DWT Denoised ECG Signal

This plot represents the ECG signal after Discrete Wavelet Transform (DWT) denoising, where noise is partially reduced while preserving the signal structure.

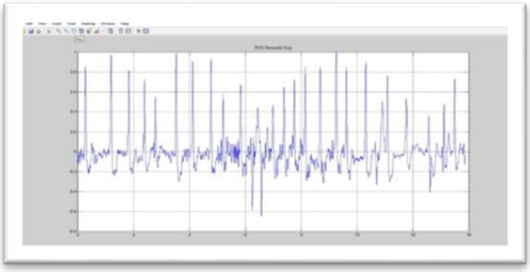


Fig.4 SVD Denoised ECG Signal

The plot shows the SVD-denoised ECG, which exhibits clearer P–QRS–T complexes and improved signal smoothness, indicating more effective noise suppression and better preservation of cardiac features.

V CONCLUSION

A method for extracting ECG signals that combines wavelet threshold and singular value decomposition is suggested. The findings of the experimental investigation demonstrate that the suggested approach effectively eliminates noise and extracts the ECG signal. When compared to the wavelet threshold approach, the results demonstrate that the ECG signal is well reserved, the effective singular value chosen is suitable, and the noise can be successfully eliminated.

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