Introduction:

An electrocardiogram (ECG/EGK) has been used for the investigation of the heart diseases for many years. However, on-line heartbeat type recognition on the basis of registered ECG waveforms has presented itself as a difficult measurement problem since heartbeats differ significantly even for the same type and patient.

This proposal addresses a real-time identification technique for the detection of ischemic episodes in long term electrocardiographic (ECG) signals using mathematical expansions involving the Discrete Dilated Hermite Transform. The discrete Hermite functions are generated as eigenvectors of a symmetric tridiagonal matrix that commutes with the centered Fourier matrix[1], [2]. The Hermite transform values are computed from a simple dot product between an individual ECG complex extracted from the MIT-BIH database and the corresponding discrete Hermite function. These values are found to contain information about the ECG shape, highlighting changes between ST-segment deviation and T-wave alterations which are the features of ischemic episodes shown in Figure 1. This information from the discrete Hermite transform, based on an orthonormal set of n-dimensional digital Hermite functions that serve as shape-identification functions, can be used to identify ischemic episodes from the ECG[3], [4]. The coefficients are fed as input to train a committee Artificial Neural Networks classifier to identify the ischemic features in the ECG complex. The trained network is tested with the long- term ECG. The performance is analyzed in terms of sensitivity and specificity.

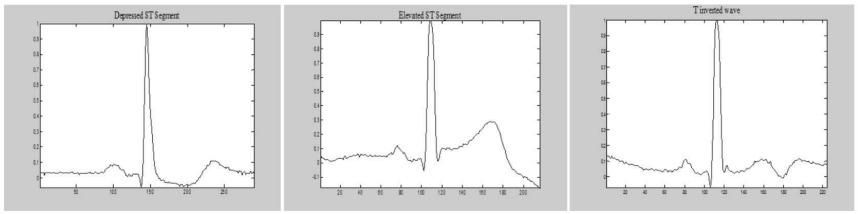

Figure 1 Depressed and elevated ST segments and T inverted wave in an ECG signal

Research Design/Approach:

This proposal addresses the recognition of ischemic heartbeats. Ischemic heart disease or ischemia is a condition in which fatty deposits accumulate in the cells of the coronary arteries. This causes an inability of provide adequate oxygen to the heart muscle and results in damage to it. Ischemia often causes the ST segment depression with a sharp angle at the junction of the ST segment and the T wave. Another commonly observed indication of ischemia is the T wave inversion. Typically inverted (negative) T waves are relatively narrow and symmetrical in Figure 1.

This proposal is a continuation of the work that I published in the journal of Cardiology in 2024[5]. The overall goal of the proposed research is to develop the ischemic detection method using the discrete Hermite Transform (DHmT) based on Artificial Neural Networks (MATLAB). The following specific tasks will be conducted:

Task 1- Extracting European Society of Cardiology (ESC) ST-T database from MIT-BIH databased that includes normal and abnormal (ST segment changes or T wave changes).

Task 2- Perform the discrete Hermite Transform (DHmT) for the extracted ECG signals in order to get the discrete Hermite Transform (DHmT) values.

Task 3-Heartbeat classification (T wave and ST segment changes) using Artificial Neural Networks (MATLAB) based on the discrete Hermite Transform (DHmT) values.

The method is evaluated by calculating the sensitivity and positive predictive value. These values give the accuracy of the method. A diagnostic test can classify the diseased and the non-diseased cases.

Broader Impact: When detecting heart problems based on ECGs, the doctor has to take time to check the heart beats one by one with his eyes. In order to save time to find heart problems from ECGs, the proposed research with the discrete Hermite Transform (DHmT) can be used for the automated identification of heart beats in real-time. If we could install the proposed research application into the ECGs recorder, the ECGs recorder would detect automatically abnormal beats such as ischemia without the need for a doctor to be present. This would save crucial time for identifying heart problems and administering treatment to the patient much earlier. The proposed project would advance the research distinction of the university as there are few academic papers written on this topic and it provides a real-world solution to an existing problem.

Goal statement: The success of the proposed research depends on knowledge of the shape of the electrocardiogram for Ischemic heart beats and of the properties of the discrete Hermite Transform. An additional project goal is to present the knowledge gained from the proposed research at a conference such as the Joint Mathematics Meetings (jmm) in 2026.

Timeframe: This project will begin on June 1st and will be continued till July 31, 2025. I will continue the project in 2025-2026 academic year.

Budget: two-month stipend $2,500 × 2

Bibliography:

[1] D. H. Mugler and S. Clary, "Discrete Hermite functions and the fractional Fourier transform," in *In Proc. Int. Conf. Sampl. Theo. and Appl.*, Orlando Fl, 2001, pp. 303–308.

[2] D. H. Mugler and S. Clary, "Discrete Hermite functions," in *In Proceedings of the International Conference on Scientific Computing and Mathematical Modeling*, Milwaukee WI, 2000, pp. 318–321.

[3] M. Arichi, "Fast computation and applications to ischemic detection from electrocardiograms of the dilated, discrete Hermite Transform," in *2009 IEEE 35th Annual Northeast Bioengineering Conference*, IEEE, Apr. 2009, pp. 1–2. doi: 10.1109/NEBC.2009.4967805.

[4] D. H. Mugler, S. Clary, and Y. Wu, "Discrete Hermite expansion of digital signals: Applications to ECG signals," in *Proceedings of 2002 IEEE 10th Digital Signal Processing Workshop, DSP 2002 and 2nd Signal Processing Education Workshop, SPE 2002*, Institute of Electrical and Electronics Engineers Inc., 2002, pp. 262–267. doi: 10.1109/DSPWS.2002.1231115.

[5] M. Arichi, D. H. Mugler, and S. Fannin, "Direct mathematical method for real-time ischemic episodes detection from electrocardiograms using the discrete Hermite transform," *J Electrocardiology*, vol. 88, p. 153834, 2025, doi: https://doi.org/10.1016/j.jelectrocard.2024.153834.