Project 34

Real-time Pacemakers for Gastrointestinal Diseases

Embedded Systems

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A. Background

- Gastroparesis disrupts the movement of food from the stomach to the intestine.
- This movement relies on electrical signals called slow waves, generated by special cells in the stomach wall called Interstitial Cells of Cajal (ICC).
- Damage or loss of ICC leads to gastroparesis
- 1.8% of the population can have gasteoperosis, and can be fatal [1]
- No approved Closed Loop Pacemaker available

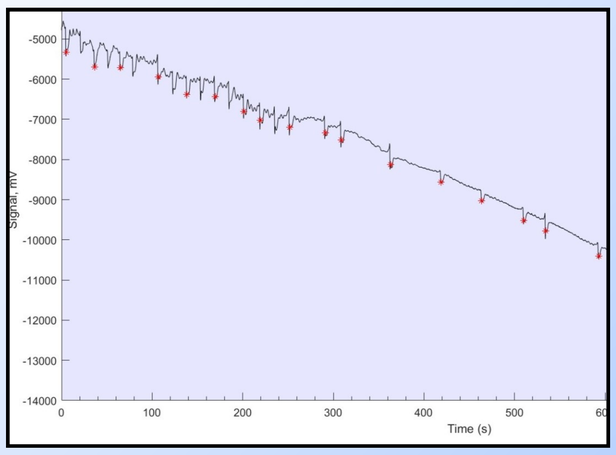
B. Objectives

- Implement a closed-loop gastric pacemaker designed to regulate slow waves into a real-time embedded system [2]
- Implement reliable filters for easier ICC activation detection in a noisy environment.
- Implement the proposed FEVT method for thresholding in C
- Do pacing the after examining thresholded signal

C. Methodology

- Utilize the C programming language for modeling
- Select the De1-Soc as the target architecture for implementation.
- Conduct observations to collect data related to the C model's pacing
- Worst Time Execution:- Used For Timing Constraints
- Using Accuracy and positive Predictive Values to benchmark binary classification models

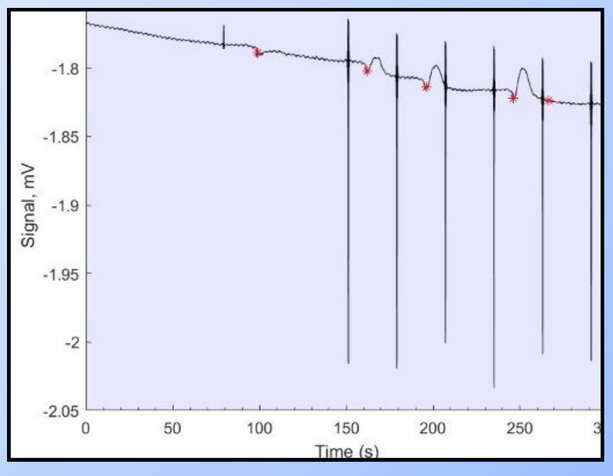
E. Results



True Positive: 27
True Negative: 26911
False Positive: 0
False Negative: 2

Accuracy: 99%
Sensitivity: 97%

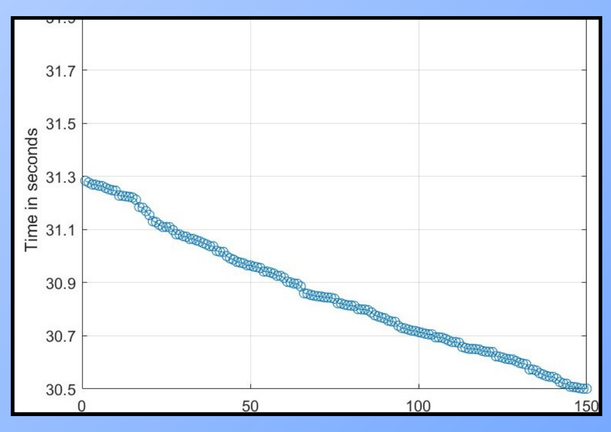
Signal Processing High Resolution Good Signal



True Positive: 4
True Negative: 9595
False Positive: 1
Fslse Negative: 0

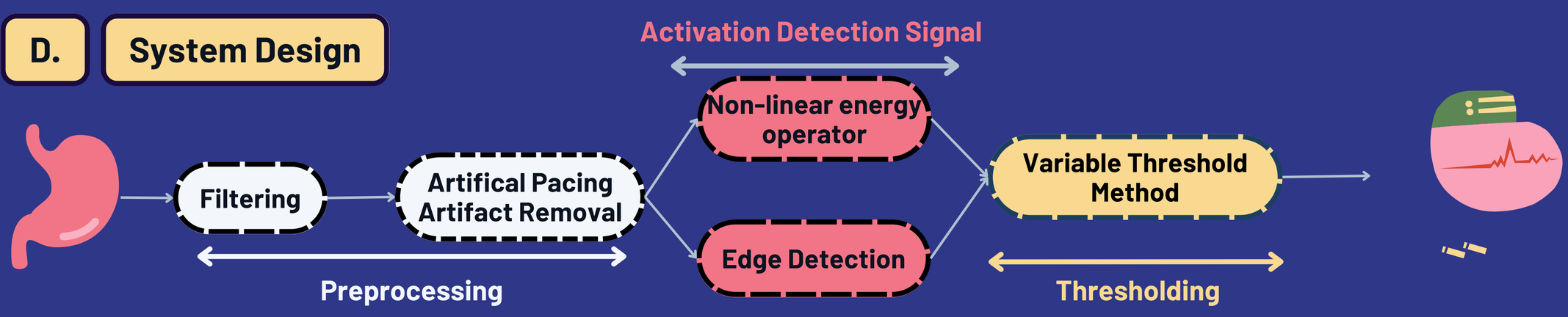
Accuracy: 99%
Sensitivity: 80%

Signal Processing Low Resolution Bad Signal



Worst case exeuction time (WCET) = 31.35s

D. System Design



E. Challenges

The gut needs to pace at a model rate of every 20 seconds (3 cycles/min). Within this timeframe, the model pacemaker needs to do the following:

11.) Capture the behaviour of the gut

2.) Determine whether pacing is required or not

3.) Pace the gut

G. Conclusions

The ICC waves can be detected in real-time using signal processing methods on the Embedded Platform

Pacing is done if ICC activation is not detected.

[1] M. Camilleri, V. Chadid, A. C. Ford, et. al, "Gasteoperosis", Nature reviews Disease primers, vol. 4, no. 1, pp 1-19, 2018.
[2] L. Wang, A. Malik, P. S. Roop, L. K. Cheng, N. Paskaranandavadivel, and W. Ai, "Design of a closed-loop gastric pacemaker for modulating dysrhythmic conduction patterns via extracellular potentials.", in 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), IEEE, 2020, pp 2504-2507