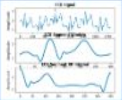
Silicon Valley Cybersecurity Institute

Filter	NF- Window Filter (SVM)
FIR	60.21%
Kalman	88.02%
Filfit	88.02%
Bandpass	88.02%
Savitzky-Golay	89.90%

Introduction

Introduction to Biometrics:
Measurements or Data related to human characteristics. (It's used in computer science as a form of identification or as a means to gain control of something. e.g. recognition) *Biometric identifiers:* used to identify difference of characteristics between different individuals. There are several ways devices can read signals from your body, in order to ensure it's you. (e.g. face ID, fingerprint). Some ways can be faked. A fake fingerprint or a faceID can be used as a means for a cyber attack. We will be discussing the heartbeat biometric characteristic which can't be easily faked as it isn't a characteristic visible on the outside, rather the inside.

ECG: To understand how the electricity that flows through the heart. ECG tracing is specifically used to track the rate and pattern of a person's heartbeat. There are 10 electrodes in a standard ECG (limb electrodes)

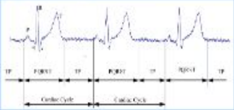


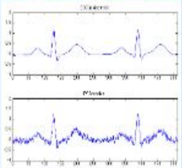
Our Project: For our project, we will be focusing on the User's ECG noise signal: used for heartbeat detection ECG records the electrical heart signal, which then analyzes various information about an individual's heartbeat (e.g. rate & patterns).

Methodology

Segmentation

The first step is to segment the ECG signal into different parts. Then, the extraction of the PQRST complex can be made. This complex is divided into intervals which can be calculated using features such as amplitude, slope, distance, and angular positions.





Denoising & Fluctuations

As an example, in the PQRST complex, the p-peak and the t-peak have fluctuations. The p-peak is filtered whereas the t-peak contains the raw data. This causes fluctuations in the data making it a challenge to comprise a normal ECG signal.

Extending Features & Implementation

It is important to know how to differentiate the signal between two individuals; this is done by comparing two segments from the same ECG. After comparison and verification, set a threshold to see if it passes the acceptable similarity level.

Analysis and Results

ECG Feature Extraction

Identity verification performed by various biometric systems include the extracted data from a specific individual for applications. The following characteristic points of an ECG signal: P, Q, R, S, T determines the characteristics of an ECG signal. A useful feature extraction method is proposed to extract the PQRST point values, for each record of the ECG.

A total of 50 different interval, amplitude, slope, distance, and angle values were used for implementation. 20 features were newly added to the feature set. These new features entailed a majority of the angles formed by the peaks of the ECG signal.

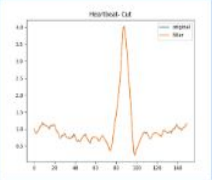
Extracted Fiducial Features

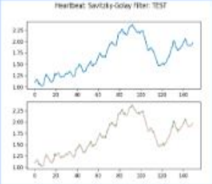
QR Interval	PR Amplitude	PR Slope	QT Distance	QPR Angle
RS Interval	PQ Amplitude	PQ Slope	PS Distance	PRQ Angle
PQ Interval	RT Amplitude	QS Slope	TRS Angle	QTS Angle
QS Interval	PS Amplitude	ST Slope	QRS Angle	PRT Angle
PS Interval	PT Amplitude	RT Slope	RST Angle	TPR Angle
PR Interval	QS Amplitude	PR Distance	RQT Angle	PTR Angle
ST Interval	TQ Amplitude	PQ Distance	QST Angle	PQT Angle
QT Interval	TS Amplitude	QS Distance	SRQ Angle	PST Angle
RT Interval	QR Amplitude	ST Distance	TPR Angle	QRT Angle
PT Interval	RS Amplitude	RT Distance	QTS Angle	STR Angle

The feature extension process helps with the fiducial point extraction. The PQRST complex consists of the P-wave, QRS complex, and T-wave. Corresponding to the waves, there are fiducial points which refer to the onset, offset, and peak points. The amplitude of peaks can easily be calculated because the local maximum and a local minimum are already given to us. In addition, the rate of amplitude change is large enough. Whereas, finding the angles formed between 3 peaks allows for an in-depth, stronger, and more accurate application. The detection of fiducial points is critical as it greatly affects subsequent ECG signal analysis, like the implementation of filters.

Savitzky-Golay

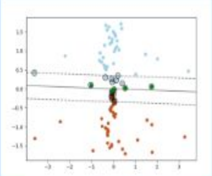
The new filter implemented is Savitzky-Golay. Like all other filters, Savitzky-Golay is used to smooth ECG signal, but this filter includes a window length and poly-order as parameters. The poly-order determines polynomial degree of the filter, while window length determines the amount of points considered for the polynomial function and can be changed to determine the best value for error and accuracy, allowing for more flexible implementations.

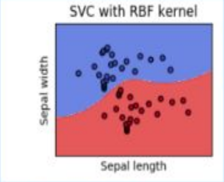




LIBSVM

Initially, to find the distance between the two datasets for the template and user segment, dynamic time warping and euclidean distance were implemented. Dynamic time warping measures the similarity for graphs with different lengths, and upon replacing these methods with machine-learning LIBSVM, accuracy was shown to be around 89.90% for the average of all data points.





Regression and classification graphs were plotted to show similarities between specific points that happened to overlap or appear closer, signifying that the data within template and user segment happens to overlap.

Applying different filters with LIBSVM yielded different average results as shown in the chart above. The highest accuracy was with Savitzky-Golay, while the accuracy of other filters appeared to be close as well, with the exception of the FIR filter.

Summary/Conclusions

Savitzky-Golay is a flexible filter that can be applied to graphs like ECG. In regards to using machine learning on ECG, the outcomes were rather positive with a very high average accuracy, showing that it can be used alongside dynamic time warping to produce feasible results and present machine learning as a reliable tool in this aspect. In conclusion, the general outcomes of this project were positive.

Key References

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