ENEL420 - Genetic Algorithms in Digital Signal Processing

Department of Electrical and Computer Engineering
University of Canterbury

Luke Trenberth (ID: 47277086)
Hassan Alhujhoj (ID: 35352633)

October 16, 2020

Abstract

I would like to say some bullshit here that summaries my report in an interesting way.

Contents

1 Introduction

Genetic Algorithms (GA) are inspired by the mechanism of natural selection where the strongest and fittest individuals would likely be the winners in a competing environment. Genetic Algorithm is used as a direct analogy of such natural evolution where it presumes that a potential solution of a problem is an individual and can be represented by a set of parameters. These sets of parameters are regarded as the genes of a chromosome and can be structured by a string of values in binary form. A fitness value is used to reflect the degree of goodness of the chromosome for the problem which would be highly related with its objective value [1].

History has shown that the fitter chromosome tends to yield good quality offspring which means a better solution to the problem. Practically, a population pool of chromosomes must be randomly set initially. The size of this population varies from one problem to the other. Each cycle of genetic operation is termed as an evolving process where a subsequent generation is created from the chromosomes in the current population. This evolving process can only be succeeded if a group of those chromosomes, which are generally called "parents" or a collection term "mating pool" are selected. The genes of the parents are then mixed to produce offspring in the next generation. From this manipulation of genes process, the "better" chromosome will create a larger number of offspring, and thus has a higher chance of survival in the subsequent generation, emulating the survival-of-the-fittest mechanism in nature [1].

To make sure the desired termination criterion is reached, the cycle of evolution is repeated. The offspring of the previous generation are reinserted into the model, further yielding higher quality offsprings [1].

There are two fundamental operators that facilitate the evolution cycle: Crossover and Mutation. Both operators are required for such a process even though the selection routine. To further illustrate the crossover procedure, the one-point crossover mechanism is shown in Figure 1. Genes are exchanged between parents to form offspring. Mutations are randomly generated after crossover with a small probability of occurrence.

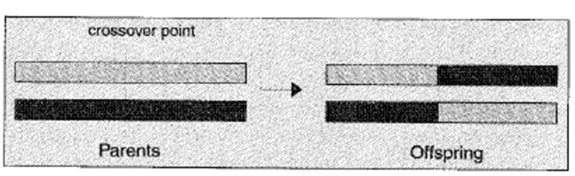

Figure 1: Interference frequencies present in the ECG signal.

2 Background

2.1 Digital Signal Processing of ECG Signals

In assignment one, a noisy ECG signal with 1024Hz sampling frequency was provided to be filtered. The assignment required the implementation of a notch filter with either an FIR or IIR filter. An FIR or IIR notch filter was suited to filter this ECG signal since there were a clear two interference frequencies present within the frequency spectrum of the ECG signal. These interference frequencies were identified to be $f_1 = 31.456Hz$ and $f_2 = 74.36Hz$ as shown in Figure 2. It should be noted that the first peak in Figure 2 is the DC component due to the use FFT to get the frequency response of the time domain ECG signal.

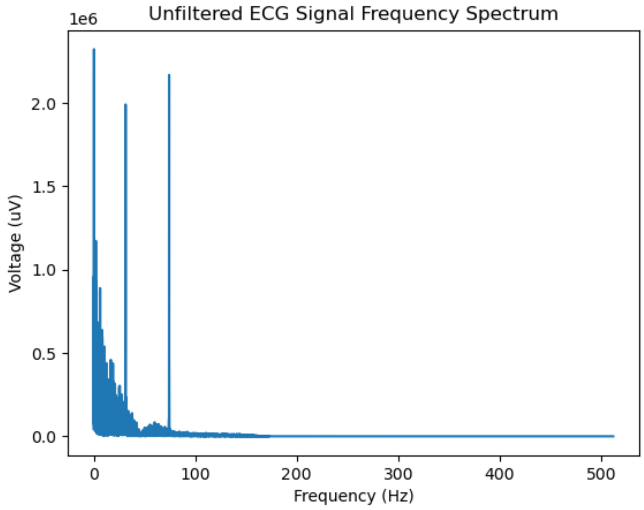

Figure 2: Interference frequencies present in the ECG signal.

One method to filter these two frequencies was to reject them with either a window or Parks-McClellan filters.

2.2 Genetic Algorithms

2.2.1 Crossover

Crossover is a GA operator which is a recombination operator that combines subparts of two parents chromosomes to produce offsprings that contain some parts of both parents' genetic material. Crossover is considered by many GA practitioners to be the determining factor that distinguishes the GA from all other optimisation algorithms [2].

2.2.2 Mutation

Mutation is another operator that introduces variations into the chromosomes. This variation can be local or global. Mutation can occur some occasionally but can randomly alters the value of a string position. A randomly generated bit can replace any bit of the chromosome bitstring mutating the original bit sequence of the parents [2].

2.2.3 Selection

3 Method

To apply genetic algorithms to Digital Signal Processing, it was decided to use genetic algorithms to design a Finite Impulse Response filter. Input parameters of the transition width of bands, the bandwidth and the filter frequencies were used to create a filter. A fitness function was then chosen to analyse the fitness of each sample in the population. By selecting the parents with the highest fitness and conducting genetic crossover, variation and mutation. Through iteration of this process, the population fitness increased, giving the optimal results, identifying the optimal parameters to identify the most optimal filter, and the best result was returned for the user.

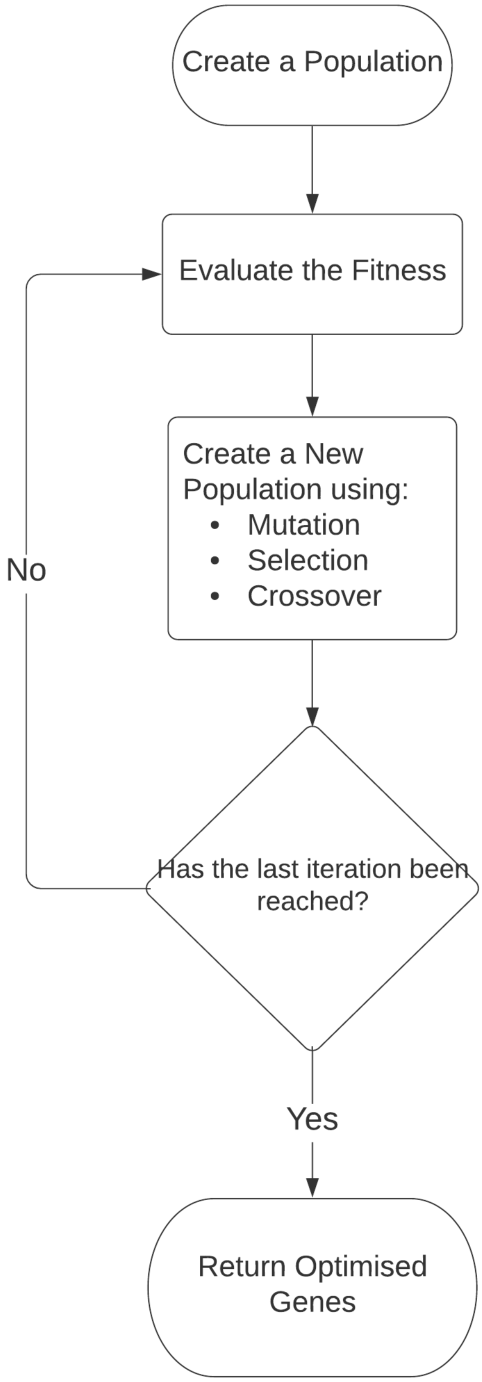

Figure 3: Flowchart diagram of GA of ECG signal.

3.1 Digital Signal Processing Data

Due to easily accessible data samples, the ECG signals from Assignment 1 have been analysed. This data contained two interference frequencies between $f = 30 - 100Hz$. The interference frequencies must be identified and removed for more useful data.

A python class was created to analyse the signal. This class was able to convert the time domain signal to the frequency domain, giving a plot of the signal. This class was able to conduct filtering techniques such as Window Filtering, Frequency Sampling and Parks-McLellan Filtering. Plots of filtered and unfiltered data was generated. This allowed the data to be analysed with a level of abstraction.

3.2 Fitness Function

For Genetic Algorithms, it was important to identify which samples were more optimal than others. A fitness function must be identified to identify more useful results. For digital signal processing, the Signal to Noise Ratio (SNR) is considered a useful metric for choosing the most optimal filtering coefficients. For each individual, a Parks-McLellan filter was generated, and then applied to the original data. The filtered signal power was then calculated by considering the variance in the signal. The difference between the filtered power and the original signal power was then considered the noise power, and the signal to noise power was calculated.

Signals with higher SNR's were considered more optimal filtering. Due to this, the signal to noise ratio of the signal was determined to be an appropriate measure of the sample's fitness.

3.3 Selecting Paranets for next GA Generations

Plz write something here.

3.4 GA Operators

Plz write something here.

3.4.1 Crossover

3.4.2 Mutation

3.4.3 Parents

Plz write something here.

3.5 Filtering of ECG Signal Using FIR Filters

3.5.1 Window Filter

Plz write something here.

3.5.2 Parks-McClellan Filter

Plz write something here.

4 Results

Describeæthe results you've got. Don't give your opinion in here that goes in the Discussion. Unless combine the Results and Discussion sections

$$V = IR \tag{1}$$

4.1 Creating a Population from DSP Singal Data

Plz write something here.

4.2 Fitness Function

Plz write something here.

4.3 Selecting Paranets for next GA Generations

Plz write something here.

4.4 GA Operators

Plz write something here.

4.4.1 Crossover

Plz write something here.

4.4.2 Mutation

Plz write something here.

4.4.3 Parents

Plz write something here.

4.5 Filtering of ECG Signal Using FIR Filters

4.5.1 Window Filter

Plz write something here.

4.5.2 Parks-McClellan Filter

Plz write something here.

Figure 4: Shows that you can relax at this beautiful beach

5 Discussion

Discussion.

6 Conclusion

Reinstate the stuff you've talked about in the report. Don't introduce new materials in here.

7 References

[1] K. F. Man and K. S. Tang, "Genetic algorithms for control and signal processing," in *Proceedings of the IECON'97 23rd International Conference on Industrial Electronics, Control, and Instrumentation (Cat. No.97CH36066)*, vol. 4, 1997, pp. 1541–1555 vol.4.

[2] W. K. Tang, K. Man, S. Kwong, and Q. He, "Genetic algorithms and their applications," *Signal Processing Magazine, IEEE*, vol. 13, pp. 22 – 37, 12 1996.

8 Appendices

8.1 Appendix A