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A NOVEL METHOD FOR DETERMINING CHARACTERISTICS OF A PSEUDO PERIODIC SIGNAL

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ABSTRACT

Computing Periodic Signal's Characteristics accurately, can now be treated as a classical problem. Many of the traditional signal analysis algorithms may comprises of noise-filtering the raw signal, differentiating, squaring, running a moving window integral, normalizing and much more, all in order to determine the signal's characteristics. In this work we have tried to apply principles of Genetic Algorithm (GA) in conjunction with a novel method similar to wavelet transform to compute signal characteristics, the method is named as Variable Wave Approximation (VWA). The proposed method (VMA) along with GA can be used for various signal processing and pattern recognition applications.

In this method a template waveform, which looks similar to the test signal, is selected. A family of similar template waveforms can be auto-generated (VMA) and compared (GA) with the signal under consideration. GA will compare the "Variable Wave Template" with the unknown signal and return the parameters of the "Approximately" similar waveform. In this way the characteristics of the unknown waveform can be determined.

The VWA method generates a "Variable Wave" of a given template. The template may be a square wave or saw tooth template. If square wave is taken as the template then GA will now use VWA to generate a whole range of square waves and find the difference between the Variable wave and the template. The GA will modify the parameters which generate the Variable, such that, the difference between the variable wave and the unknown signal is optimized, tending towards zero. The GA will finally return the parameters required to generate a wave which is optimally similar to the unknown signal. If square wave is taken as template then the parameters returned by GA describes about frequency, amplitude, phase, on-duration and off-duration

Keywords: Genetics Algorithms, Variable Wave Approximation, Signal Characteristics.

I. INTRODUCTION

The proposed algorithm can be used to find the unknown characteristics of a pseudo periodic waveform. The characteristics such as the amplitude, frequency, zero-crossing, on-duration (T_on), off-duration (T_off), and phase can be determined. Variable Wave Approximation method generates a family of template waveforms one of which will be similar to the signal under test. GA [1] will return the parameters of the optimally "Approximate" waveform. In this way the characteristics of the unknown waveform can be determined.

II. PROPOSED ALGORITHM

The various steps of the proposed algorithm are as follows :

Step 1: A template wave is selected from a wave bank. The template wave must be close in shape, to the pseudo periodic waveform under test. The template wave is manually selected. The template wave may different parameters such as amplitude, frequency, zero-crossing, on-duration (T_on), off-duration (T_off), phase etc. The wave bank contains a lot of template waves of most common (basic) periodic signals such as

Square wave, Triangular wave, Sinusoidal wave etc. This process is similar to selecting a wavelet [4] from a wavelet bank for a wavelet transformation.

Step 2: The template waveform which was selected from the wave-bank has certain parameters. If these parameters are varied in various permutations, a family of waveforms can be generated. There may be infinite number of ways to permute various parameters of the template waveform, the ranges of numeric values are not restricted. A subroutine is devised which returns the data samples of a template waveform using the given parameters from the wave bank. The subroutine is named as Variable Wave Generator. When the wave parameters are fed to this subroutine it generates data samples. Let us consider an example, in which pseudo random wave looks similar to a square wave [2]. The characteristics of the pseudo random waveform are to be determined. Hence the template wave is taken as a square wave. To generate a square wave the following parameters are required:

where, *T_on* *The period of time when the wave remains high,*

T_off *The period of time when the wave remains low*

Amplitude *The amplitude of the template wave.*

L-shift *The amount of phase-shift required to match both the waves.*

Step 3: Suppose all of the four parameters described above are varied then a whole family of square wave may be generated [2][3]. Out of the infinitely possible waves which may be generated, there will be at-least one waveform which will match closely to the pseudo periodic waveform. This is true because the template wave was similar in shape (to the pseudo periodic waveform). If one waveform which closely matches the pseudo periodic waveform is found, the characteristics could be determined. But there are virtually infinite number of possibilities, how to find the single wave out of the whole family of template waveforms. Here comes the Genetic Algorithm (GA) into picture. GA is used to optimize the input parameters generating the waveform such that the numeric difference between the data-samples tends to zero.
The outputs of the GA, are the waveform parameters which forms a wave, which is the closest match to the unknown pseudo periodic waveform.

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III. EXPERIMENTATION

In order to experiment with the proposed theory, experiments were done by coding in MATLAB's GA toolbox [5]. The configuration of GA to suit the problem specific requirements are discussed below.

Step 1: SELECTING THE INITAIAL POPULATION: For the 4-unknown individuals a random population is generated. The four individuals T_on, T_off, amplitude and l_shift (phase-shift towards left side of the reference number line) act as genome. A random population of 20 genes is generated for each genome. MATLAB’s 'CreationFcn' is used to specify a function that creates the initial population. The population size depends on the nature of the waveform and data-samples available as it affects the execution time.
If the waveform is known to have the unknown parameters in a certain range, than they may be considered for deciding an initial population. This will ultimately reduce the execution time. If the initial population range is to be defined the parameter 'PopInitRange' may be initialized.

Step 2: FITNESS FUNCTION: Fitness function, prescribes the optimality of a solution so that that the particular chromosome-set (genome) may be ranked against all the other chromosomes. The unknown parameters of the waveform are considered as chromosomes. Optimal chromosomes breed and mix their datasets to produce a new generation that will hopefully be better. That is, the new chromosomes will be closer to the result describing the unknown better.

Genome is a full set of chromosomes. Thus a vector (or an array) of chromosomes can be called as a genome. In our case, we have defined fitness function which
a)Inputs the parameters to generate a template waveform,
b)Finds the data samples using above
c)Calculates the difference between the above and the unknown pseudo periodic waveform
d)Returns the difference
GA applies the genomes to the fitness function and calculates the score for each. The fitness function (minimization) is:

$$d = f\ (\ T\_on, T\_off, amplitude, l\_shift\ )$$
$$d = \sum |\ vsw - ppwf\ |$$

where:
vsw: is a vector containing samples of the “Variable Square Wave” generated, using a set of genomes from the current population.
ppwf: is a vector containing samples of the “Pseudo Periodic Waveform”
d:is the difference of, absolute values of, individual samples of the two vectors.

The GA’s goal is to optimize the value of d to a minimum value tending to zero.

Step 3: SELECTION: During each successive generation, a proportion of the existing population is selected to breed a new generation. In this step a second generation of population is generated through crossover and mutation

Step 4: TERMINATION: This generational process is repeated until a termination condition has been reached. Terminating condition may be any one of the following:

a)Solution is found: A set of waveform parameters is found, which generates a template wave, which is closed to the unknown pseudo periodic waveform.
b)Fixed number of generations reached
c)Allocated computation time expires
d)Has reached a stage such that successive iterations no longer produce better results center.

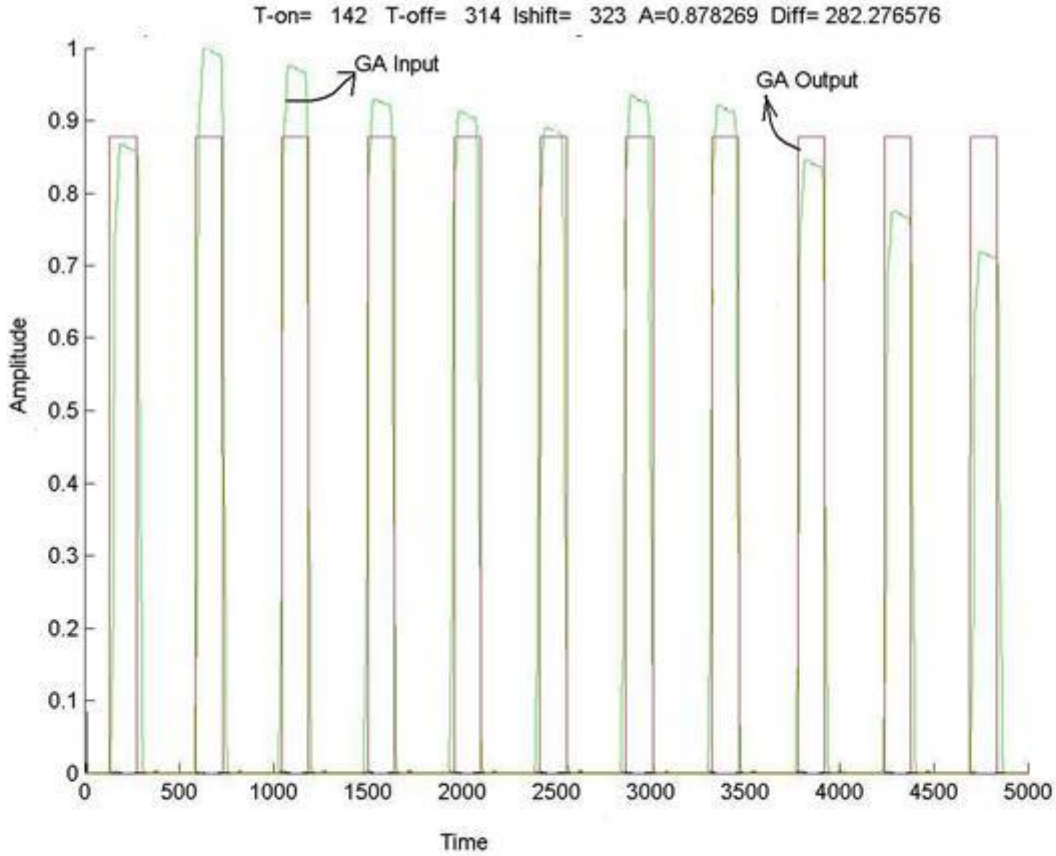

Fig. 1 Results obtained by the algorithm.

IV. Performance Enhancement

The last three conditions for termination of GA as discussed above represent the failure of the GA and in that case the result is not achieved. The GA is executed at the most five times in order to prevent the program going into infinite loop. The GA is re-run by re-initializing the population randomly. The initial random values play an important role sometimes.

V. Conclusion

The proposed algorithm was coded in MATLAB programming language.

INPUT: Data samples of a waveform which looked similar to a square wave were taken. The input wave is shown as "GA Input" in Fig 1. Template wave was taken as a square wave.

OUTPUT: The unknown parameters of the square wave were found. As shown in the Fig 1.

After visual (and mathematical) analysis of the input and output signal it was found that the algorithm gave very close results. This method has got special applications detection of beats in biomedical signals.

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