Spreading Code Optimization using Genetic Algorithm

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Abstract.

In the method of optimization we can determine the best one among all the possible solutions. Optimization in spread spectrum displays a very important role in these days. Hence in wireless communication, optimization of spreading code is very essential because in the modern system of communication utilization of CDMA (code division multiple access) method with one unique code to each user is very essential. Hence researchers should give attention for optimized spreading code generation. This study shows a Genetic Algorithm based spreading code which is generated using logistic map code. Properties of the generated bit is discussed in this paper with the help of mono bit test, run length test, and computational complexity also compared with other existing spreading code (like spreading code generated from logistic map and optimized spreading code using exponential scale factor-based DE). The proposed spreading code shows better results than the existing state-of-the-art spreading code. Therefore, the proposed spreading code can be easily applicable to wireless communication schemes.

Keywords. Optimization, Genetic Algorithm, Spreading Code, Logistic map;

1. INTRODUCTION

Primary factor of CDMA (code division multiple access) is spread spectrum [1]. Utilization of more bandwidth compared to primary message is the main idea behind spread spectrum [2], [3] . In spread spectrum, same signal power is maintained and is masked by noise, which makes the signal very challenging to separate from noise therefore more difficult to intercept and jam. To spread the spectrum, direct sequence (DS) [4] and frequency hopping (FH) [5] are two very important techniques. To make larger bandwidth rapid phase transition of data is the main idea behind DS method and in FH method, in random narrow bands signal jumps take place within a larger bandwidth. Gold, PN (pseudo noise), Walsh, Kasami are some basic codes which are generally applied in spread spectrum techniques. Not only that spreading code generated from logistic map are also used in today's word [6],[7]. But the result can be improved by applying optimization technique. In the process of Optimization we can determine the best one among all the possible solutions. Optimization in spread spectrum displays a very important role in these days, hence in wireless communication, optimization of spreading code is very essential because in the modern system of communication utilization of CDMA (code division multiple access) method with one unique code to each user is very essential. Hence researchers should give attention for optimized spreading code generation. There are various metaheuristic approaches like ant colony optimization (ACO) algorithm, particle swarm optimization (PSO) algorithm, differential evolution (DE) algorithm etc [8], [9], [10]. Rather than these algorithm, genetic algorithm (GA) displays a very important role in the field of metaheuristic. This study shows a Genetic Algorithm based spreading code which is generated using logistic map. Genetic algorithm is used here because it has several advantages than other optimization techniques, they have superior parallel capabilities, it improves over time, derivative information are not required not only that problems related to continuous functions, multi objective problems, discrete functions can also be optimized using genetic algorithm. Code generated from logistic map is considered here because logistic map based spreading code has several advantages over PN/Gold code [6]. Logistic map is a second order polynomial mapping, it provides a view of how a complex chaotic nature can get from a non-linear dynamic equation. Sensitivity to initial condition is the main property of this logistic map code [7]. Hence, spreading code is

generated from logistic map and then genetic algorithm is applied to optimize the spreading code. Properties of the generated bit is discussed in this paper with the help of mono bit test, run length test and computational complexity also compared with other existing spreading code (like spreading code generated from logistic map and optimized spreading code using exponential scale factor-based DE). The proposed spreading code shows better results than the existing spreading code. Therefore, the proposed spreading code can be easily applicable to wireless communication system.

2. LITERATURE REVIEW

Some important research papers are discussed in this section. A gist of which are given bellow. For computer model estimation genetic algorithm is utilized which is taken from the field of genetics in biology. In this review paper, author explained how different problems are solved using Genetic algorithm [10].

Recent advances considering genetic algorithm is carried out in this paper by the authors. In review paper different GA based implementation along with pros and cons are elaborated. Also, operation of genetic algorithm along with their utilization are also displayed in this paper [11]. In this paper, author discussed comparison between wavelet-based DE and exponential scale factor-based DE and also their application in direct sequence spread spectrum techniques. In this paper spreading codes are optimized with the help of wavelet-based DE and then applied to direct sequence spread spectrum scheme [7].

3. PROPOSED METHOD

3.1 Basic operation of GA

The basic operation of Genetic Algorithm is elaborated with the flow diagram given in Fig. 1.

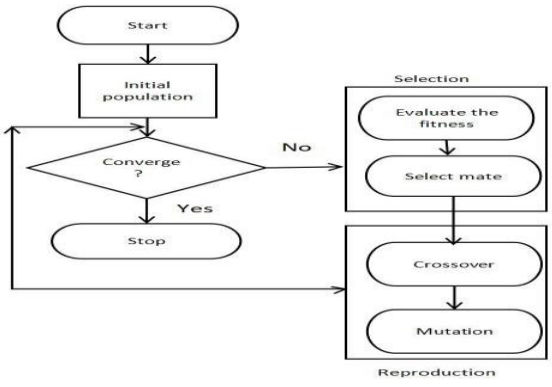

Fig 1: Flow diagram of Genetic algorithm

Steps for genetic algorithm are:
1) Binary string encoding
2) Generation of random population
3) Fitness calculation
4) Fitness based pairs of parent string selection
5) Generation of new string with mutation and crossover until a new population has been produced.
Repeat steps 2 to 5 until the solution is not satisfactory.

3.2 Logistic map-based binary spreading code:

Binary spreading code is generated from logistic map using two methods: These are

- **Method** 1: Threshold method

- **Method 2**: Floating point value to bit conversion

Both the methods are elaborated by the flow diagram in Fig. 2 and Fig. 3.

Suppose the floating-point value for the chaotic code is x. The threshold method to convert *x* to binary code is as given in the following equation.

$$( ) = 1; \geq 0.5$$
$$= 0; < 0.5 \quad (1)$$

And logistic map equation is given by

$$_{+1} = * (1 -) \quad (2)$$

Here, r is the rate at which population is increased or decreased and range is between 0 to **4.** And is the ratio of present population to the possible population (maximum) at year n. It lies between 0 to 1. And in the second method i.e in integer to bit conversion technique, floating points are converted to integer and then to binary. Frame based sequence is utilized here to convert integer to binary. Properties of both the techniques are elaborated in the following.

3.3 Properties of proposed spreading code (Method 1 & 2)

Various tests are executed to set up the properties.

Mono bit test: To check the number of ones & zeros for the whole sequence is the main aim of the test. The role of the test is to figure out the number of 0's & 1's in a sequence is almost equivalent or not to check the randomness of the sequence. That means half number 0's and half number 1's should be present in the sequence.

Run length test: Number of runs present in the sequence is the main focus of this test. A run is an unbroken sequence of same bits. If L is the run length, then L consists of exactly L same bits and after and before this L opposite bits are present. This test calculates the oscillation speed, i.e. the oscillation between both the bits (0's & 1's) is too slow or too fast.

Computational complexity: Computational complexity of threshold method is less compared to integer to binary method. Computational complexity is calculated by doing auto correlation between then sequences.

3.4 Spreading code optimization with scale factor-based DE and GA

The spreading code optimization flow diagram is as given in the Fig. 2 & 3.

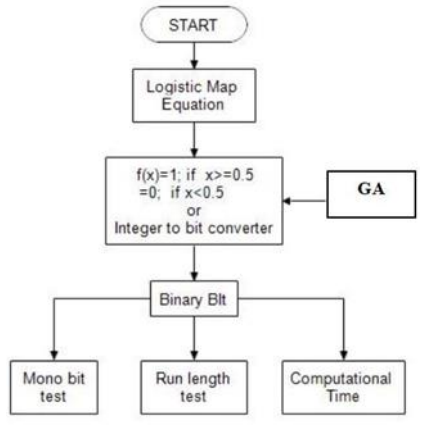

Fig. 2 Flow diagram of GA based Optimized binary sequence generation

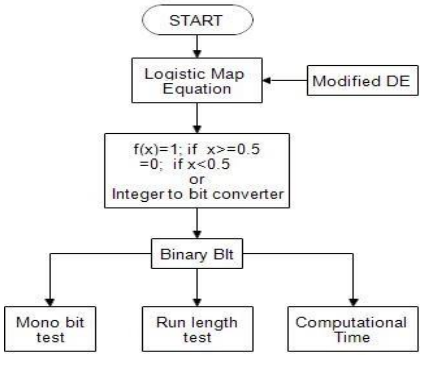

Fig. 3 Flow diagram of modified DE (exponential scale factor) based optimized binary sequence generation

The entire simulation is carried out in MATLAB. From logistic map equation binary bits are generated by taking the value of r = 3.56, and x_n is between the range 0 to 1. Parameters that are used in this paper are given in Table 1. Properties (run-length test, computational time, mono bit test) of optimized generated bits using GA are compared with the non-optimized one along with the optimized spreading code which are optimized by exponential scale factor based DE as shown in the Table 2.

Table 1: Parameters of proposed method

Parameter name	**Value of parameter**
r	3.56
x_n	0.1
Population size	64/128/256
Crossover rate	1
Mutation rate	1
Maximum number of iterations	32000

Table 2: Comparative study of Properties of the generated bit sequence

Test	Properties of non-optimized generated bit		Properties of optimized generated bit Using exponential scale factor based DE		Properties of optimized generated bit Using GA	
	Method-1	Method-2	Method-1	Method-2	Method-1	Method-2
Mono bit test	No. of Zeros=66 No. of Ones=34 Out of 100 bits	No. of Zeros=41 No. of Ones=59 Out of 100 bits	No. of Zeros=63 No. of Ones=37 Out of 100 bits	No. of Zeros=43 No. of Ones=57 Out of 100 bits	No. of Zeros= 60 No. of Ones= 40 Out of 100 bits	No. of Zeros= 42 No. of Ones= 58 Out of 100 bits
Run length test	Run is 5 out of 20 bits	Run is 5 out of 20 bits	Run is 5 out of 20 bits	Run is 6 out of 20 bits	Run is 7 out of 20 bits	Run is 6 out of 20 bits
Computational complexity	CT is 1.02 seconds	CT is 1.94 seconds	CT is 1.41 seconds	CT is 2.13 seconds	CT is 0.99 seconds	CT is 1.88 seconds

4. CONCLUSION

Spreading of the signal spectrum is very essential in wireless communication system. In this modern era, because of the high demand of CDMA communication, optimization of spreading code is necessary. Hence, in this paper spreading code generated from logistic map is optimized using genetic algorithm. Out of all the metaheuristic algorithms, GA is chosen because it has several advantages than other optimization techniques, they are superior parallel capabilities, it improves over time, derivative information are not required not only that problems related to continuous functions, multi objective problems, discrete functions can also be optimized using genetic algorithm. From the properties of the proposed optimized spreading code, it is clear that computation complexity is less in the GA based spreading code, also from mono bit test and run length test it is clear that our proposed method shows better results than other sate of art algorithms. Hence, the proposed spreading code can be applicable to wireless communication technology. In future, the GA based spreading code can be utilized in OFDM and massive MIMO system.

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Biographies

Dr. Katyayani Kashyap has received the bachelor's degree in Electronics & Communication Engineering from Gauhati University (GIMT) in 2012, the master's degree in Electronics & Communication Engineering from Gauhati University in 2014, and the philosophy of doctorate degree in Electronics & Communication Engineering from Amity University in 2021, respectively. She is currently working as an Assistant Professor at the Department of Electronics & Communication Engineering, Chandigarh University. His research areas include soft computing in wireless communication. She has been serving as a reviewer for many highly-respected journals.