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Application of Crossover Factor on FPSGA in Optimization Problem

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Abstract. Genetic Algorithms is a genetic behavior inspired search procedures classified in the area of evolutionary algorithm. Genetic algorithm is very much depending on the two operators namely; crossover and mutation. In a population, not only the qualities of the genes determine the quality of next generations but it is also depending on the effectiveness of the operators which is crossover and mutation. In this paper, a factor which is a controller affected on the number of uni-chromosome crossover is introduced to the crossover operator. The performance of the crossover factor on the Finite Persisting Sphere Genetic Algorithm, FPSGA has been analyzed. This proposed method was tested in experiment of numerical analysis and it was proved that the method proposed can improve the performance of the crossover factor in reaching the global solution.

Keywords: genetic algorithms, FPSGA, crossover operator

1. Introduction

There are a lot of studies being done in order to improve the performance of Genetic Algorithm (GA) in optimization problem since the algorithm is very useful in a lot of application such as digital circuit design, antenna design, power electronic circuits optimization and many more [1]-[3]. The two operators in GA studies which is the crossover and mutation play a big impact on the performance of the algorithm. Because of that many researchers involve in developing a non classical operators to enhance the capability of the operators to solve the optimization problems and applications. Simoes et. al substitute the traditional crossover operator by a new idea of transpositions that promotes the movement intra or inter chromosomes to improve the role of the operator in producing good genes[4]. H. Nazif et. al proposed a GA using Optimize Crossover Genetic Algorithm (OCGA) where this operator produce O-Child and E-Child in order to solve vehicle routing problem[5].

In this paper, a new concept is introduced which is crossover factor where it is applied on the Finite Persisting Sphere Genetic Algorithm (FPSGA) to improve the performance of the developed method [6]. FPSGA use a new development operator which is uni-chromosome crossover and it is run simultaneously with Finite Persisting Sphere process . The crossover factor that has been introduced in this paper is a factor that is applied in the process of FPSGA to determine the total internal generation of the uni-chromosome process. The factor is named as Total Internal Generation Factor, $f_{TIG.}$ In this paper, the performance of the factor will be discussed on the same mathematical problems that was solved in [6].

2. Methodology

As mentioned earlier, Total Internal Generation Factor, f_{TIG} is applied on the Finite Persisting Sphere Genetic Algorithm. From [6], the process of FPSGA can be summarized as in Fig.1:

```
1.0    Start
2.0    For i:=1 to L do
2.1    Generate initial population
2.2    Generate 1 random value, x
       (Number of internal  generation)
2.3    For j:= 1 to x do
              Execute uni-chromosome
                     crossover
              First evaluation
2.4    Mutation
2.5    Second evaluation
3.0    Take out the best answer
4.0    End
```

Figure 1. Pseudocode of FPSGA

In this paper, the same uni-chromosome crossover is applied. However a new factor, f_{TIG} is injected to the crossover operator in order to increase the probability of fast convergence which can help to improve the efficiency of the processing time in a system.

Here, the number of internal crossover is restricted to the factor applied instead of running it uncontrolled [6]. It means that the number of internal crossover can be controlled when applying the factor and reducing the processing time. This method is also applying the concept of Finite Persisting Sphere to maintain the diversity of the great population. The process of the proposed method is represents in the psuedocode in Fig.2.

```
1.0 Start
2.0 Generate initial population
3.0 Evaluation
4.0 For i:=1 to Total number of
generation
       4.1 Roulette Wheel Selection
       4.2 Execute Finite Persisting
           Sphere process
              4.2.1 Applying Total
                    Internal Generation
                    Factor, f TIG
              4.2.2 Generate number of
                    internal crossover,
                    X depending on the
                    value of f TIG
              4.2.3 for j:=1 to X
                     do
                     4.2.3.1 Execute uni-
                             chromosome
                             crossover
                     4.2.3.2 Evaluate
                             fitness
                             function
                     end
       4.3 Mutation
       4.4 Evaluate fitness function
5.0 Take out the best result
6.0 End
```

Figure 2. Pseudocode of FPSGA with f_{TIG}

In this paper the same mathematical problem in [6] is considered for the experimental purpose. The equation is used to find the maximum number can be produced from the range of x_1 and x_2 The equation for the optimization problem is as follows:

$$f(x_1,x_2) = 21.5 + x_1 \sin(4\pi x_1) + x_2 \sin(20\pi x_2) \quad (1)$$

where

$-3.0 \leq x_1 \leq 12.1$

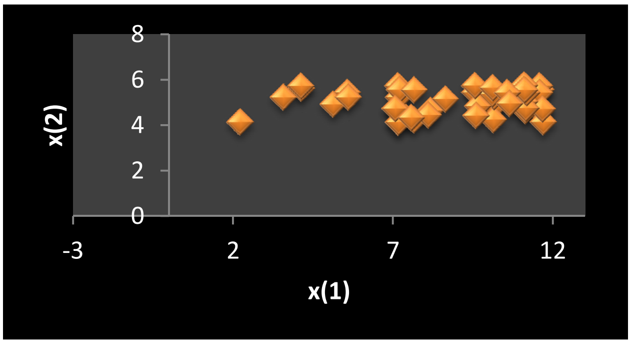
$4.1 \leq x_2 \leq 5.8$

The function within the range given above creates multi local optimums. From [6], the global optimum for the problem is 38.8417 where the value of x_1=11.625 and x_2=5.725. The GA parameters applied in the experiment are shown in Table 1.

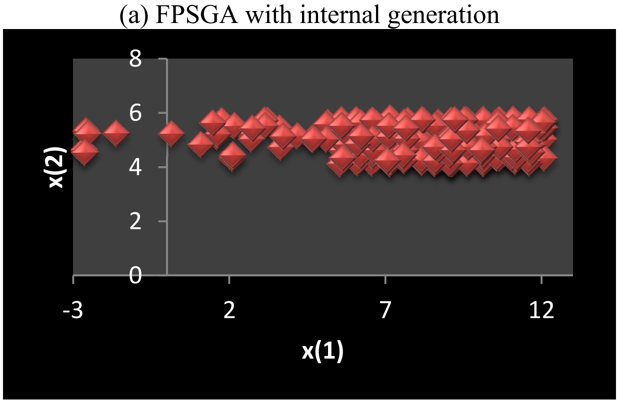
TABLE I. CHARACTERISTICS APPLIED IN THE EXPERIMENT BY APPLYING TOTAL INTERNAL GENERATION FACTOR , F $_{TIG}$.

Population Size	50
Length of Chromosome	33
Probability of Crossover	1.0
Probability of Mutation	0.8
Number of Generations	100

3. Experiment Results



(a) FPSGA with internal generation



(b) FPSGA with external and internal generation

Figure 3. Chromosome distribution in the solution pool

Fig. 3(a) and (b) show the chromosomes distribution in solving the optimization problem when the f $_{TIG}$ is applied. In Fig. 3, the internal generation means that the developed GA is run until it finish the process of 4.2 (refer to psuedocode in Fig. 2) without finishing the whole process of the developed GA . This is done in order to study the behavior of the uni-chromosome crossover and Finite Persisting loop. FPSGA with external and internal generation in the process is means that the whole process is run to determine the global solution of the problem.

The total internal generation factor, f_{TIG} is introduced in order to improve the capability of FPSGA for fast convergence. Individuals or chromosomes with great quality are very useful to ensure that the local optimum can be reached in a fast way.

Fig. 3a represents the chromosomes distribution of one population where only internal generation is run. It shows that 24 chromosomes from the total of 44 chromosomes are generated between 10 to 12.1 for x_1 and 4.1 to 5.8 for x_2 where the area of global optimum exists. It means that by applying the f_{TIG}, 57 percents from the total chromosomes comprise of great individuals survives in that internal generation. Fig. 3b represents the chromosomes distribution with the external and internal generation. Again it shows that the chromosomes are very crowded in the area of global optimum exist.

Fig.4 shows the effect of applying different f_{TIG} on the same problem where the other parameters applied are kept constant. It can be seen that different total internal generation factor will give different global solution. It is obviously shows that as the f_{TIG} increase, it will show increment on the global solution. When applying f_{TIG} from 10 to 165, the global optimum increases from 38.4636 to 38.8484.

From the graph, it can be concluded that the higher the factor, the higher the efficiency of the system.The best global optimum defined from this experiment is 38.8484 where x_1 is 11.6247 and x_2 is 5.72472.

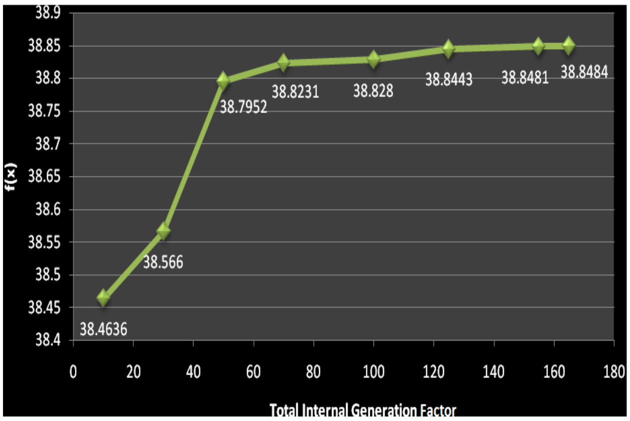
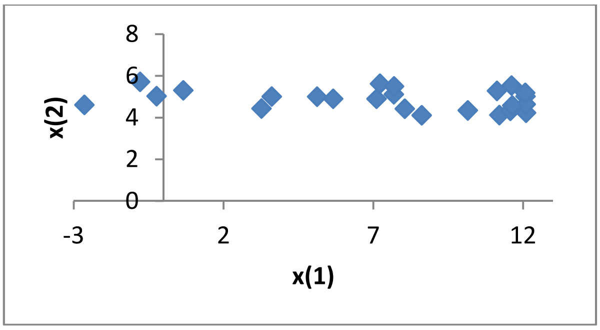


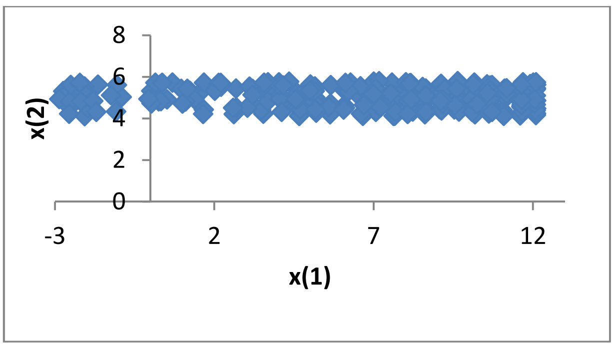
Figure 4. The effect of varying total internal generation factor on the global solution

4. Discussion

The following figures are the result from [6] for the same optimization problem with the same parameters applied.



(a) FPSGA with internal generation



(b) FPSGA with external and internal generation

Figure 5. Chromosomes distribution in the solution pool

From [6], the density of the great individuals are 42 percent from the total chromosomes. However the percentage of the great individuals is increased from 42 percent to 57 percent after the f_{TIG} was applied . It means that the chromosomes converge faster than the method in [6] and at the same time maintains the diversity of the chromosomes.

When comparing Fig. 3b to Fig. 5b, note that the density of the chromosomes are very packed in the area of global solution while it can be said that the density of the chromosomes are packed in two area which is from -3.0 to -1.0 for x_1 and 4.1 to 5.8 for x_2 and from 7.0 to 12.1 for x_1 and 4.0 to 6.0 for x_2. It shows that by applying total internal generation factor, the distribution of the chromosomes is more precise and only converge in the area of global solution where the value of x are between 10 to 12.1 for x_1 and 4.1 to 5.8 for x_2. Obviously the efficiency of the chromosomes distributions becomes more efficient than in [6].

To analyze the global optimum of both methods, basic FPSGA maximized at 38.8417 where the value of x1=11.625 and x2=5.725 while by applying the f_{TIG}, the global optimum optimized at 38.8484 where x_1 is 11.6247 and x_2 is 5.72472. This shows a significant increment on the final result of the system.

5. Conclusion

In this paper, an improvement on the basic FPSGA performance is successfully developed. The ability of the Total Internal Generation Factor, f_{TIG} to improve the efficiency of fast convergence is proved and at the same time maintain the great diversity to ensure that the answer is not trapped in the local optimum. The total internal generation factor is provided give a big impact to find the global solution of the problem.

For future development, more experiments needed in order to investigate the saturation level of the total internal generation factor to the global solution of a problem.

6. Acknowledgments

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