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Impact of Population Size and Mutation Rate on Multi Clustered Parallel Genetic Algorithm

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Abstract: **Multi Clustered Parallel Genetic Algorithm using Gray value is found to be more efficient compared to Standard Genetic Algorithm. In proposed algorithm, multiple clusters are formed based on the fitness value and the reproduction operator is applied to low order clusters, so that these clusters can make active participation in GA. This paper shows the results of the algorithm based on various mutation rates applied with fixed and various population sizes. The results shows that the algorithm works well in the large population size groups.**

***Keywords*: Genetic algorithm, Gray Encoding, Multi Clustered Parallel Genetic Algorithm.**

I. INTRODUCTION

In Standard Genetic Algorithm, generally single population is used, all individuals in a single cluster. While selecting the parents for GA using selection mechanisms like Roulette Wheel Selection, Tournament Selection or Rank selection algorithms, only the high fit individuals are selected and less importance to the low valued individuals for further reproduction. To give importance to the low order individuals we proposed an algorithm, Multi Clustered Parallel Genetic Algorithm.

Multi Clustered Parallel Genetic Algorithm is a special form of GA, in which the initial population is clustered into N clusters based on fitness value. In each cluster the genetic operators are applied to produce new individuals. If the fitness value of the offspring varies in the cluster it can migrate to other cluster.

In most of the GA's, the chromosomes are represented based on the binary representation. Binary representation is the easiest way of representing the chromosome. When we have the binary value, all the genetic operators to be deployed to get the best individual in each generation. Here we represent the chromosome using gray value. Gray value encoding is done adding the adjacent gene value of a binary chromosome. Since the adjacent gene value are added it is enough to mutate a gene value in the chromosome to produce new traits.

In most of the multi population genetic algorithms the mutation is done for the best fit individual, obtained from the selection mechanism. The low fit individuals are mutated. Here we concentrated on the low fit individuals to take part in the GA for further generations.

Since we have clustered the entire population based on the fitness value. We concentrate the cluster which has low fitness value in order to make the best outcome from the cluster to fit in high order clusters. To make experimental we had implemented the algorithm with various mutation rates applied only to low order clusters and the results are analyzed.

II. PROBLEM STATEMENT

The performance of the algorithm is analyzed with the 0/1 Knapsack problem (Martello[1990]). The problem is formulated as follows:

Given a set on N items with a capacity C. Each of N item will have a profit P_j and a weight W_j . The problem is to select a group of items such that the total weight does not exceed the maximum capacity C and the profit should be maximum.

Where xj is the variable which has either 0 or 1 value. If it is 1 the item takes part in the knapsack and 0 otherwise.

Given a vector $(x1,x2,\ldots\ldots xn)\ \varepsilon\ \{0,1\}^{n.}$ with the capacity constraints

$$= \sum_{j=1}^{n} wij.xj \le ci\,, \ \ (1 < i < k)$$

Are satisfied for which $f(x)$ should be maximum.

$$f(x) = \sum^{n} pij.xj$$

Where wij is the weight of item j to the knapsack i.

Pij is the profit of item j to the knapsack i.

III. METHODOLOGY

The proposed Gray coded multi clustered parallel genetic algorithm (GMCPGA) produces better profit in the knapsack compared with the binary coded algorithm. The individuals are selected at random from the initial population. Usually the initial population will be in the binary form. The fitness values for the individuals are calculated. Based on the fitness value the similar individuals are grouped into a cluster. Similarly N numbers of clusters are formed with each Cluster having the same fitness value. The selection mechanism from any one of the selection mechanism is used to select parent in each cluster.

The selected individual is then gray coded. The mutation operator is applied to the converted parent to produce the new offspring. New offspring is converted as offspring with binary value to calculate the new fitness value and is used in the next generation. This procedure continues till the termination condition is satisfied. The best individual is obtained based on the fitness value.

The overall structure of the proposed methodology is shown in the pseudo code 1. Gray code Multi Clustered Parallel Genetic Algorithm.

Step 1 : Generate the initial population at random.
Step 2 : Calculate the Fitness Value for Each individual.
Step 3 : Sort the individuals based on the fitness value
Step 4 : Divide the individuals into n clusters based on the fitness value.
Step 5 : For each cluster perform the following

- Using Selection Mechanism, Select the individuals from each cluster.
- Convert the individual to Gray code.
- Mutate the Parent
- Convert the offspring to Binary Value.
- Calculate the fitness Value.

Step 6 : Group the clusters together
Step 7 : Allow the migration of individuals based on fitness.
Step 8 : Until Termination condition is reached repeat from step 5.
Step 9 : Select the best Individual.

Pseudocode 1 : Gray coded Multi Clustered Parallel Genetic Algorithm

IV. IMPLEMENTATION

The initial setup to analyze the performance of the genetic algorithm is done by changing the mutation rate from 0.05 to 0.5 and the other parameters remain constant.

Number of Chromosomes : 100
Elitism % : 10 %
Selection Mechanism : Tournament Selection
Number of Clusters : 4 Clusters

With this setup the experiment is carried out many times with the change in the mutation rate. Figure 1 shows the performance of the proposed algorithm with different mutation rates.

Generally mutation is applied to chromosome to have the sudden change in the value. Our concentration is focused mainly on the low fit individuals. Since the population is clustered by fitness value, the individuals with low fitness value are clustered at last. Hence the various mutation rates are applied to low order clusters and the results are shown in fig 1.

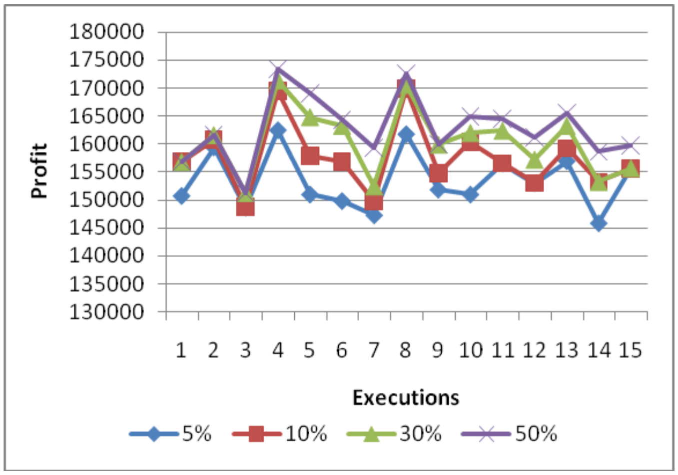

Fig 1. Impact of Various Mutation Rate.

The above figure shows the results of profits with variation in mutation rate (5%, 10%, 30% and 50%). The profit is increased when the mutation rate goes high.
When the mutation rate is high, the low fit chromosome has the chance to take part in the further generations.

Impact of Population Size:
The population size is also a crucial factor to analyze the performance of the genetic algorithm. Hence, the performance of the algorithm is analyzed with various population sizes with fixed mutation rate. Here the mutation rate is fixed as 5% and the population size varies as 100, 200 and 300 respectively with number of group remains constant.

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Fig 2. Impact of Population Size

Figure 2. shows that when the population is large with fixed group size the profit increases. It is also observed when the population size is high , the accuracy will be high. But when the population is high, time taken for execution is also high ie it takes more number of generations for execution.

The number of generations taken to execute the GA is measured as convergence velocity. For the above experimental setup the obtained covergence is shown in the figure 3.

From the figure 3 it is observed that if the population size is increased, time taken for execution also increases. It happens because, for larger population, the group size increases for fixed number of groups.

V. CONCLUSION

The result of the proposed methodology shows the improved performance over standard genetic algorithm. By applying the gray value it makes the algorithm much simpler and faster to execute. From the results it is identified that the algorithm is well suited for large population sized groups than small sized groups. Increased mutation rate produces the better result in terms of profit and by execution. Hence it is concluded that the algorithm works well with gray value with increased mutation rate in fixed number of groups of large population size. The future direction is to reduce the selection pressure of the algorithm, so that the efficiency can be improved further.

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