Analysis the effect of chromosome and generation count on genetic algorithm in construction projects: a case study

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Abstract. Resource leveling is utilized to minimize the resource deviation with a uniform distribution of available resources. Herewith the study is to measure the impact attained due to the variation of input parameters such as the number of chromosomes and generations on resource utilization histograms. A good selection of the internal parameters of a genetic algorithm provides rapid and accurate results. We studied the effects of change in a key parameter, namely the number of chromosomes and number of generations, on the optimization speed and reliability. We found that changing one parameter can be compensated for changing another. For this purpose, different combinations of chromosome count and generation count were used to optimize via a genetic algorithm-based model. The network for evaluation of the framed model was structured based on site observation. The change in the input parameters gives greater impact to the resource histogram. To analyse the impact, various combination of input parameters is implied. The quality of the result is measure with an objective function. By using a meta-GA, we found the possible change in attaining optimum results using different chromosome count and generation count.

1. Introduction
Optimization is the process of drawing the best final solution from the group which eliminates inappropriate and poor-quality ones. The best solution serves the purpose but there is no correlation with the remaining individuals from the group of solutions procured. Optimization is applicable where infinite solutions are serving the purpose. The application of optimization in the construction industry for resource management is focused. According to the different applications, feature selection based on the requirement and developing a model for evaluation are done. In the recent two decades, various optimization techniques are framed among which metaheuristics is the more time reducing and rapid performing so chosen for the study. In the construction industry, this optimization is used to improve resource management. Resource management deals with resource leveling [1,2] and resource scheduling. The main focus of this study is on resource leveling. Resource leveling is reducing resource deviation in the planned resource profile [3]. The deviation is reduced by striking a balance between the demand and the availability of the resources. Resource usage causes variation in the financial aspect of the project [4]. So accurate resource usage is vital in project management. There are various methods under metaheuristic such as the Genetic algorithm, Particle swarm [5, 6], simulated annealing [2, 7], Ant column [8], etc, the bigger advantageous aspect is more knowledge of these optimizations is not needed. They have merits like no need for domain knowledge or assumptions regarding the search space,
reaching multiple solutions in a single run. A most prominent feature is searchability in higher dimensional data. Evaluation can be done using single or multiple objective function. These metaheuristic methods being applied in software and evaluated with a multiple datum is named as search-based software test data generation. Various ways to implement Genetic algorithm are available. Among those, MATLAB is chosen because of its versatility using which Genetic algorithm is applied.

2. Methodology
A peer literature study was performed considering GA to evaluate resource leveling. The sample network used in the evaluation is obtained from the site observation is provided in Table 1. A network of nine activities is framed. A single resource is focused and resource usage is determined using an objective function. Input parameters of Genetic algorithm are the number of chromosomes (M), number of generations (N), probability of crossover (P_c), probability of mutation (P_m), chromosome length. The impact of the optimization process can be evaluated by providing different combinations of input parameters. Totally 20 trials are performed by varying number of generations and number of chromosomes. The number of generations and the number of chromosomes provides an improvement in results and also depends upon various other elements like the number of factors considered in the problem. Critical Path Method (CPM) is used to identify the start and end date and also float values. These float values are used to perform the resource leveling, helps to determine the possible resource movement in the schedule. Chromosome takes the start date of the non-critical activities as the genes.

3. Genetic algorithm
Genetic algorithm (GA) is a metaheuristic optimization technique which is evolved from the Darwin theory of natural evolution. The concept of GA originates from biology. The formation of new individuals from the good parents over a long duration undergoing various variations to attain the good required quality. This concept can be used in different purposes to attain optimum results. Genetic algorithm is a global search tool used for optimization purposes. It is good at dealing with multidimensional data. Genetic algorithm is potential tool to determine the appropriate solutions for complex problems as they are highly capable of solving unconstrained and constrained optimization issues. In the construction industry, resource management is one of the major elements to be focused in the preconstruction phase. The amount of resource consumption for the planned activity list is a more tedious process that is still a problem in the current reality. The application of GA for overcoming this resource consumption evaluation is done. The process of GA provides solutions in the form of chromosomes. The collection of the solution is stated as the population of chromosomes. These chromosomes are formed from different trials where trials denoted as generations. Initially, two individuals are provided for solving the problem, which undergoes crossover and mutation forming two children solutions. During each generation, the quality of the solution chromosome is evaluated with a fitness function using equation 1. Crossover is the formation of solutions from the original parent ones. The rate at which crossover to be performed is provided by the term probability of crossover (P_c). Adaptability is attained by performing a mutation in which new changes introduced in the solution. Similar to the probability of crossover controlling mutation process by the probability of mutation (P_m). The chances of selecting inappropriate solutions are overcome using the elitism parameter. Fitter chromosome continues the sequence and further taken to next
Attaining network details with duration, precedence and resource.

Deriving float values based on CPM

Framing Objective function

Performing genetic algorithm

Categorizing non-critical activities

Providing input parameters such as M, N, Pm, Pc

Obtaining minimum resource consumption

Varying input parameters such as M, N, Pm, Pc

Obtaining levelled schedule and uniform resource profile

Figure 1. Methodology.

generations. The fitter chromosome shows the higher quality and better survival probability. After performing a certain number of generations, the obtained result would be optimal or near-optimal solutions to the problem. The considered fitness function [9] is the following

\[
Z = \min \sum_{i=1}^{T} |R_{dev}| 
\]  

Note:

min = minimize;
i = day under consideration;
T = the duration of the project;
\(R_{dev_i}\) = deviation between required on day i and i+1

The chromosomes of the Genetic algorithm are formed based on the start date of the non critical activity [10]. The value of each chromosome is represented in binary form. The available free float
provides additional new possibilities of a start date for non critical activities [12], which changes the criticality of the activities and provides better resource usage.

| ACTIVITIES | PRECEDANCE | DURATION (days) | RESOURCE (men) | FLOAT (days) |
|------------|------------|-----------------|----------------|--------------|
| A          | -          | 2               | 2              | -            |
| B          | A          | 3               | 3              | -            |
| C          | B          | 4               | 7              | -            |
| D          | B          | 4               | 5              | 5            |
| E          | B          | 2               | 4              | 4            |
| F          | C          | 2               | 2              | -            |
| G          | F          | 3               | 2              | -            |
| H          | E          | 3               | 2              | 4            |
| I          | D, G, H    | 1               | 1              | -            |

4. Results and Discussion
The sample network was evaluated using twenty trials with a combination of four different numbers of generations such as 25, 50, 75, 100 generations and each with five different numbers of chromosomes such as 10, 20, 30, 40, 50 chromosomes. Figure 2 states the fitness value for each combination of the number of generations and the number of chromosomes. Fitness values for each generation with a different number of chromosomes are scattered and from Figure 2, it is inferred that by an increasing the number of chromosomes improves the speed of attaining a solution. The accuracy of the optimum result increased by 28 percentage and reaching result with fitness value as 706. By increasing the number of generations, the chances of premature convergence can be reduced and provide accrue diversity.

![Comparison of chromosome count with different generations](image)

**Figure 2.** Impact of variation in number of chromosome and number of generations.
5. Conclusion
The impact of accurate input parameters for performing Genetic algorithm helps to procure rapid results with better accuracy. Basically, by considering different objective function and the impact created is studied [12, 13], which is further developed by taking other input parameters. The elimination of inappropriate results can be attained fully. And this approach is one of the ways to attain an accurate combination of input parameters of genetic algorithm. There are various elements such as the probability of crossover, probability of mutation, elitism rate. The speed of attaining results and without premature convergence are benefits reached with perfect input parameters of Genetic algorithm. The search tool for optimization and multidimensional data can be evaluated using Genetic algorithm.

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