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# Optimization of Construction Resource Levelling by Comparing Primavera and MAT Lab

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**Abstract:** Resource leveling is crucial for effective use of construction resources particularly to minimize the project costs. Optimal allocation of resources can be achieved by resource leveling. Critical path method (CPM) and Program Evaluation and Review Technique (PERT) are commonly used in scheduling of construction projects. However it is not capable of minimizing undesirable fluctuations in resource utilization profile. This will lead to a change in construction time which will automatically increase the cost of construction. This paper describes a Genetic algorithm approach to resource leveling and allocation in construction industry. In this study resource leveling problem is developed using genetic algorithm (GA) in MATLAB software.

***Keywords:*** *Resource leveling, MATLAB, Genetic Algorithm*

## 1. Introduction

Since late 1950's Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) are commonly used in scheduling of construction projects. The main purpose of scheduling is to minimize the total duration of the project. In last several years costs of construction resources have progressively rises. So project management has become very important. Several resource leveling models are designed to minimize resource fluctuations by using the floats available to keep duration of the project unchanged. This paper brings out a model of optimization using Genetic Algorithm (GA) for resource allocation and leveling. In this model, objective function optimizes both resource allocation and leveling simultaneously using Genetic algorithm in MATLAB software. Genetic Algorithm has several advantages as it consider the objectives of resource allocation and leveling all together. Genetic algorithm has more suppleness to solve scheduling problems because of no fixed heuristic rule.

## 2. Related Work

WajidHussain, in his paper says that resource allocation and leveling is one of the top challenges in construction project management, due to complex nature of the construction projects. CPM and PERT is not capable of minimizing undesirable fluctuations in resource utilization profile. The procedure which is used in this paper finds an optimum set of tasks and priorities that generate better-leveled resources profiles using Genetic Algorithm in MATLAB software.

N Satheesh Kumar, in his paper says that resource management ensures that a project should be completed on time, at cost, and its quality is as previously defined; nevertheless, the scarcity of resources is a usual reason for project delays. Traditional analytical and heuristic approaches are inefficient and inflexible when solving construction resource leveling problems. In the proposed method the activity to be selected first for shifting is based on the largest value of resource rate. The process is repeated for all the remaining activities for possible shifting of resources by searching the fittest solution by the Genetic Algorithm. The GA procedure searches for optimum results in set of tasks and priorities that produce shorter project duration and better using MS Excel Evolver software.

## 3. Methodology

There are different methods for optimizing resources. All methods have their own advantage and disadvantage. The various methods are Genetic Algorithm (GA), Swarm Intelligence, Neural Network, Artificial Immune systems, Fuzzy systems, Ant Colony optimization, And Expert systems etc.

Out of these methods, for this paper the optimization technique considered is Genetic Algorithm. This method is considered because to optimize a unimodal function, there is many other techniques which can work efficiently and faster than 'Genetic Algorithm' but for complex multimodal problems with a frequent change in nature the Genetic Algorithm are the best choice for optimization. This technique may be slow but robust in nature and confirmly produce the possible best solution for optimization.

When the best optimum solution is obtained the program gets stopped. This solution is the final output. Otherwise next generation is developed by doing the same procedure of crossover and mutation.

The best optimum solution is considered. The obtained solution is compared with the model developed in any existing software.

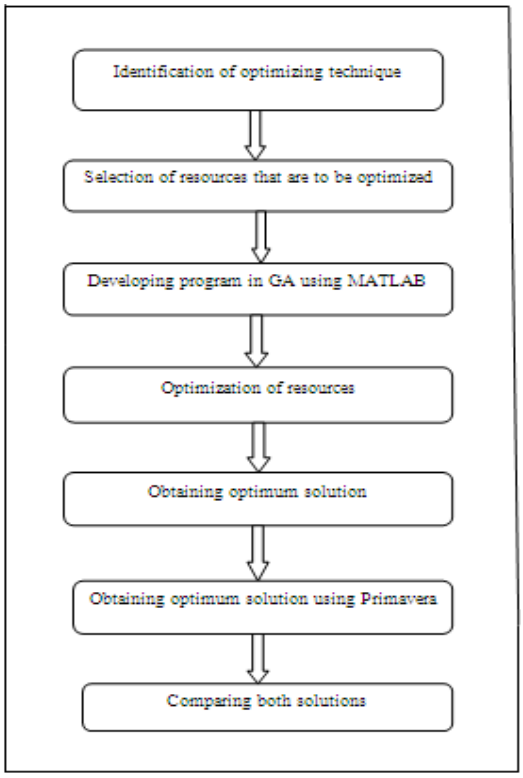


***Figure 1.****Proposed Methodology*

## 4. Genetic Algorithm

Genetic algorithms (GAs) were invented by John Holland in the 1960s and were developed by Holland and his students and colleagues at the University of Michigan. In contrast with evolution strategies and evolutionary programming, a genetic algorithm (GA) is a search technique used in computing to find true or approximate solutions to optimization problems. It is a global search heuristics. It is an evolutionary algorithm that use techniques inspired from evolutionary biology such as mutation, selection and crossover. Genetic algorithm uses genetics as its model of problem solving.

### 4.1 Chromosomes

In genetic algorithms, a chromosome (also sometimes called a genotype) is a set of parameters which define a proposed solution to the problem that the genetic algorithm is trying to solve. The set of all solutions is known as the population. The chromosome is often represented as a binary string, although a wide variety of other data structures are also used.

### 4.2 Fitness Function

A fitness function value quantifies the optimality of a solution. The value is used to rank a particular solution against all the other solutions. A fitness value is assigned to each solution depending on how close it is actually to the optimal solution of the problem.

### 4.3 Individuals

An individual is any point to which the function can be applied. The value of the fitness of an individual is its score; an individual is a single solution. A chromosome is a set of parameters which define a proposed solution to the problem that the genetic algorithm is trying to solve. The chromosome is often represented as a simple string.

### 4.4 Encoding

It is the process of representing a solution in the form of a string that conveys the necessary information.

### 4.5 Selection

The process that determines which solutions are to be preserved and allowed to reproduce and which ones deserves to die out. The primary objective of the selection operator is to emphasize the good solutions and eliminate the bad solutions in a population while keeping the population size constant.

### 4.6 Cross Over

The most popular crossover selects any two solutions strings randomly from the mating pool and some portion of the strings is exchanged between the strings. The selection point is selected randomly. A probability of crossover is also introduced in order to give freedom to an individual solution string to determine whether the solution would go for crossover or not.

### 4.7 Mutation

Mutation is the occasional introduction of new features into the solution strings of the population pool to maintain diversity in the population.

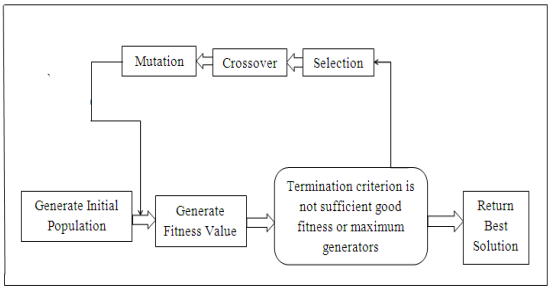


***Figure 2.****Basic Flow Chart of GA*

## 5. Resource Levelling

Resource leveling is a technique in project management that overlooks resource allocation and resolves possible conflict arising from over-allocation. When project managers undertake a project, they need to plan their resources accordingly .This will benefit the organization without having to face conflicts and not being able to deliver on time. Resource leveling is considered one of the key elements to resource management in the organization.

An organization starts to face problems if resources are not allocated properly i.e., some resource may be over allocated whilst others will be under-allocated. Both will bring about a financial risk to the organization.

### 5.1 Resource Levelling By Genetic Algorithm

Limited-resource allocation algorithms deal with a difficult problem that mathematicians refer to as a ‘‘large combinatorial problem.’’ The objective is to find the schedule duration that is shortest, as well as consistent with specified resource limits. There exist optimization methods as well as heuristic methods for solving the resource allocation problem. In construction projects resources are always limited and limitation on resources can considerably affect the performance and completion of activities on the scheduled time and can cause the project to be extended beyond the scheduled duration. Various activities of the project are to be scheduled in such a manner that there is best possible utilization of available resources. The main objective of any organization is not to waste the resources. There are some optimization methods and heuristics methods for solving the resource allocation and levelling problems.

The minimum resource moment algorithm was improved using both $M_x$ and $M_y$ resource moments. Resource fluctuations is represented by $M_x$ and the resource utilization is represented by $M_y$. When combined value of these moments is minimum that means resources are efficiently utilized. The random activity priorities and the combined moments approach from the basis of the optimization process.

### 6. Case Study

It is a real time project named “Cultural Centre” at Wayanad with the following resources is considered. The details of resources are mentioned below.

### 6.1 Objective Function

The objective is to minimize the cost of construction of the project by efficient utilization of resources.

### 6.2 Resources

The following table shows the range of resource limits. The requirement of resources per day is also shown in the table. This is the input of MATLab.

***Table 1.****Details of Resource*

| Sl.No | RESOURCE | MAX LIMIT | MIN LIMIT |
|---|---|---|---|
| R1 | EXCAVATOR | 2 | 1 |
| R2 | LOADER | 2 | 1 |
| R3 | MATE | 2 | 1 |
| R4 | COOLIE | 5 | 1 |
| R5 | MASON | 3 | 1 |
| R6 | BELDAR | 5 | 1 |
| R7 | BHISHTI | 3 | 1 |
| R8 | MIXER | 2 | 1 |
| R9 | VIBRATOR | 2 | 1 |
| R10 | FITTER | 3 | 2 |
| R11 | BLACKSMITH | 4 | 2 |
| R12 | STONE MASON | 3 | 1 |
| R13 | PAINTER | 5 | 1 |
| R14 | CARPENTER | 3 | 2 |
| R15 | GLAZIER | 3 | 2 |
| R16 | BANDHANI | 3 | 1 |

### 7. Results and Discussions

### 7.1 Primavera

Implementation of this problem in Primavera gives total project duration as 79 days. Resource profile was obtained as below.

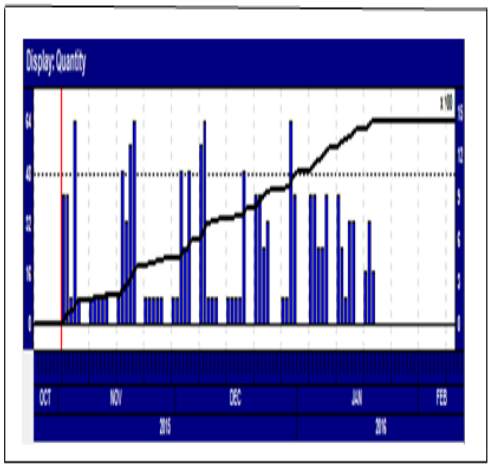


***Figure3*** *Primavera Solution*

After carrying out leveling operation, the total duration of the project is 80 days.

### 7.2 MATLab

The optimum cost was obtained by executing the problem using Genetic Algorithm. The optimum duration obtained is 99 days.

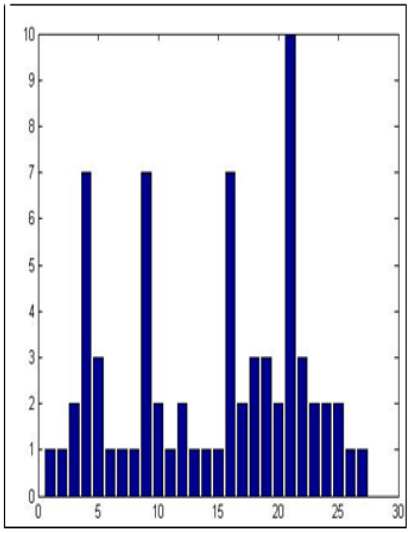


***Figure 4*** *MATLAB Solution*

### 7.3Comparison between Two Solutions

The objective is to achieve the best optimum duration so that the cost of construction is less.

The project needs 27 activities. The costs of each activity by both solutions are as shown below. The duration obtained by Primavera in practically not possible for execution. Hence optimized duration is 99 days.

***Table 2*** *Comparison of Cost*

| ACTIVITY | COST BY PRIMAVERA | COST BY MATLAB |
|---|---|---|
| A | 14020 | 14016.176 |
| B | 14020 | 14014.256 |
| C | 6500 | 5866.25 |
| D | 2310 | 1046.661 |
| E | 6570 | 6560.55 |
| F | 1520 | 1510.688 |
| G | 1130 | 1125.299 |
| H | 3250 | 2788.825 |
| I | 2310 | 2305.852 |
| J | 4100 | 4008.621 |
| K | 1080 | 1041.444 |
| L | 4100 | 4098.321 |
| M | 1520 | 1496.125 |
| N | 1130 | 1128.687 |
| O | 3250 | 2693.6 |
| P | 2310 | 2236.542 |
| Q | 4100 | 3910.58 |
| R | 5460 | 5455.458 |
| S | 4230 | 4210.585 |
| T | 6500 | 6276.4 |
| U | 18000 | 11131.2 |
| V | 5310 | 5309.258 |
| W | 2260 | 2241.245 |
| X | 3000 | 2964.787 |
| Y | 2920 | 2915.354 |
| Z | 1640 | 1624.321 |
| A1 | 730 | 611.302 |
| **TOTAL COST** | ***123270*** | **112588.387** |

From the above table, it can be observed that the total cost of project obtained from MATLAB is lower than that obtained from Primavera even though the duration is increased.

## 8. Conclusion

A model is developed using Genetic Algorithm for obtaining a better resource profile. From this model it is observed that the total construction cost is reduced even though the duration increases. A real time project solved using this optimization software shows that best converging result can be obtained. It is hoped that the implementation of this model justifies the efforts in saving the project cost.

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