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Resource Allocation in a Repetitive Project Scheduling Using Genetic Algorithm

Biju Samuel* **and Jeeno Mathew**

Dept. Of Mechanical Engineering, St. Joseph's College of Engineering and Technology, Palai, Kerala, India.

*Corresponding author E-mail: samuelbiju1990@gmail.com

Abstract. Resource Allocation is procedure of doling out or allocating the accessible assets in a monetary way and productive way. Resource allocation is the scheduling of the accessible assets and accessible exercises or activities required while thinking about both the asset accessibility and the total project completion time. Asset provisioning and allocation takes care of that issue by permitting the specialist co-ops to deal with the assets for every individual demand of asset. A probabilistic selection procedure has been developed in order to ensure various selections of chromosomes

1. Introduction

Many of the labour-intensive facilities involve highly experienced workers and supervisors which are required to carry out the processes. Labour intensive production processes are those processes that require a highly efficient labour compared to capital investment. Such processes are more liable to be visually perceived in job shop production scenarios. The high cost of experienced labour in labour-driven processes is being a force driving the engenderment planner to amend productivity. This algorithm can help to evaluate changes to the existing crew allocation technique and can also test new crew allocation scenarios such as crew schedules. The high labour cost in the existing industries and the dynamic nature of the scheduling processes emboldened project planners in the industry to develop more keenly intellective and optimal labour allocation strategies. Genetic Algorithms (GAs) are inspired by Darwin's theory about evolution. The Genetic Algorithm is a global search procedure that search from one population of solutions to many another, concentrating on the area of best solution. It designed with a set of solutions (known as chromosomes) called initial population. The calculations are done by the creation of an initial population of chromosomes. Furthermore the characteristics of a population of solutions are modified over a large number of generations. It is then evaluated, until a satisfactory solution is achieved.

2. Literature Review

Kandiland El Rayes [1] applied a multi-objective genetic algorithm to optimize resource allocation in a large-scale construction project. El Rayes and Kandil [2] visualized the 3-D trade-offs which are duration of the project, expenses, and quality by computing the effects of various resource utilization on the performance of the project. They have considered methods of construction, formation of crew, and overtime of the crew as the variables for decision. Optimizations of planning of construction project are the general optimization problems which are mainly concentrated for research [3, 4]. Optimization problems have been studied since 1960s and are considered as a particularly difficult combinatorial problem. These problems in planning of construction project are the kinds of general optimization problems which are Non-deterministic Polynomial-time hard (NP-hard) which means it might take long periods of time to achieve the desired results[5,6]. There are various methods to solve

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the NP hard problem. (1)Mathematical programing methods: it is a method in which mathematical techniques that are used to solve optimization problems where the objective is to maximize or minimize an authentic function by selecting the values of authentic or integer variables systematically from the sets that are allowed. (2)Heuristic methods: these methods are based on the experiences of the project planner and the assumptions made by him/her.

3. Objective

To find a methodology to obtain a sequence to minimise duration in a repetitive project industry where multiple crew options are available.

4. Problem Description

Considering a project with 'n' number of sites and 'm' number of activities. Let the number of task be represented by 'i' and the number of sites be 'j'. There is a precedence relation between these activities. The Start time of an activity is denoted by 'Sij' and the Finish time of an activity is denoted by 'Fij'. More than 1 crew options are available for a particular activity but with a different production rate.

Assumptions

1. There is a precedence relation between these activities.
2. For each activity different crew options are available and each crew is limited to only one particular activity.
3. In each site, the quantity of work of each activity is different.
4. Production rate of one crew is same for that activity, which won't depend on the quantity of work.
5. Crew move from one location to another without any time breaks, all crews are available at a particular time

5. Mathematical Formulation

Let, Number of site	=	n
Different activities in each site	=	m
The number of tasks	=	i
The number of units or sites	=	j
Quantity of work	=	Qij
Production Rate	=	Pij
Duration of an activity i in site j	=	Dij
Starting time of activity i in site j	=	Sij
Finishing time of activity i in unit j	=	Fij
Project Duration	=	PD
Objective Function	=	Min [PD]
Subject to the Constraints	=	$Sij + Dij \leq S(i+1), j$

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$$F_{ij} \geq S_{ij}\ (\text{previous}) + D_{ij}$$
$$i \leq m,$$
$$j \leq n$$
$$i, j, k \geq 0$$

6. Scheduling Algorithm

The Algorithm helps us to find the total project duration

Step 1. Define the number of activities. Also define the number of sites for a repetitive project.

Step 2. Calculate the duration of each activity Dij using the formula Dij = $\frac{Qij}{Pij}$ where Qij is the quantity of work and Pij is the production rate of that particular crew

Step 3. Let the starting time of first activity be zero. $S_{11} = 0$

Step 4 Calculate the Finishing time of first activity. $F_{11} = S_{11} + Dij + Lag$

Step 5 Calculate the starting time of the second activity and so on till the last activity at the various site

$$Sij = \text{Max}\,[F_{i-1,\,j}, F_{i-2,\,j}, \ldots\ldots F_{i-k,\,j}]$$

OR

$$\text{Max}\,[F_{i,\,j-1}, F_{i,\,j-2}, \ldots\ldots F_{i,\,j-k}]$$

Step 6 Calculate the Finishing time Fij = Sij + Dij +Lag

Step 7 Find the finishing time of the last activity at last site Fij which in turn denoted the total project duration

The above said mathematical formulation is coded in Matlab. The inputs data is stored in a separated excel sheet which is later called into the program.

7. Genetic Algorithm

Now, let the activities 'i' is increased to 100 and the units or the site is also increased to 100. This process can be used to solve the above said problem but is time consuming as well as tedious to solve the problem in a limited time span. This will be prove to be a NP-hard problem. As a project scheduler, one has to take fast decision in order to finish the project as soon as possible. Therefore to solve this problem we can use heuristics or Meta heuristics procedures.

The requirement to find a satisfactory solutions of tedious problems in limited time is the reasons for using heuristic methods. Some of the other reasons for using metaheuristic methods are:-

1. There is no method available for solving the problem to optimality.
2. The exact method to solve any tedious problem can't be used on the hardware that is available.

3. The exact methods are less flexible than the heuristic methods, allowing, for example, addition of a particular constraint later is quite difficult.
4. The optimality of the problem can be guaranteed with the heuristic methods because it uses a global search method

The property of a good heuristic algorithm:

1. Less calculation is required to obtain a solution.
2. The optimality of the solution that we obtain should be high
3. The chance for getting a solution which is far from optimality should be low.

Genetic algorithms (GAs) have been continentally used as find and optimize implements in different areas. In Genetic Algorithm, the chromosomes denotes a possible solution to our problem and these chromosomes gets nearer to optimum with the help of crossover and mutation operators. The total number of chromosomes in a population is its population size. The initial population is created randomly. Each chromosome has a fitness function which is also the objective function to our problem. During the selection procedure, the chromosome with near optimum fitness function value will be selected to next population.

8. Results and Discussion

To validate the above said formulation, a problem is analysed. This reference problem was solved using Fuzzy linear programming by A. M. El-Kholy. (Dec-2012)

Quantity of Work

Table 1. Reference Data obtained for Quantity of Work from A. M. El-Kholy "Scheduling Repetitive Construction Projects"

ACTIVITIES	Unit 1	Unit 2	Unit 3	Unit 4
Excavation	1147	1434	994	1529
Foundation	1032	1077	943	898
Columns	104	86	129	100
Beams	85	92	104	80
Slabs	0	138	114	145

Production Rate

Table 2. Reference Data obtained for Production Rate from A. M. El-Kholy "Scheduling Repetitive Construction Projects"

ACTIVITIES	Crew 1	Crew 2	Crew 3	Crew4

Excavation	91.75	0	0	NA
Foundation	89.77	71.81	53.86	NA
Columns	5.73	6.88	8.03	NA
Beams	9.9	8.49	7.07	5.66
Slabs	8.73	7.76	0	NA

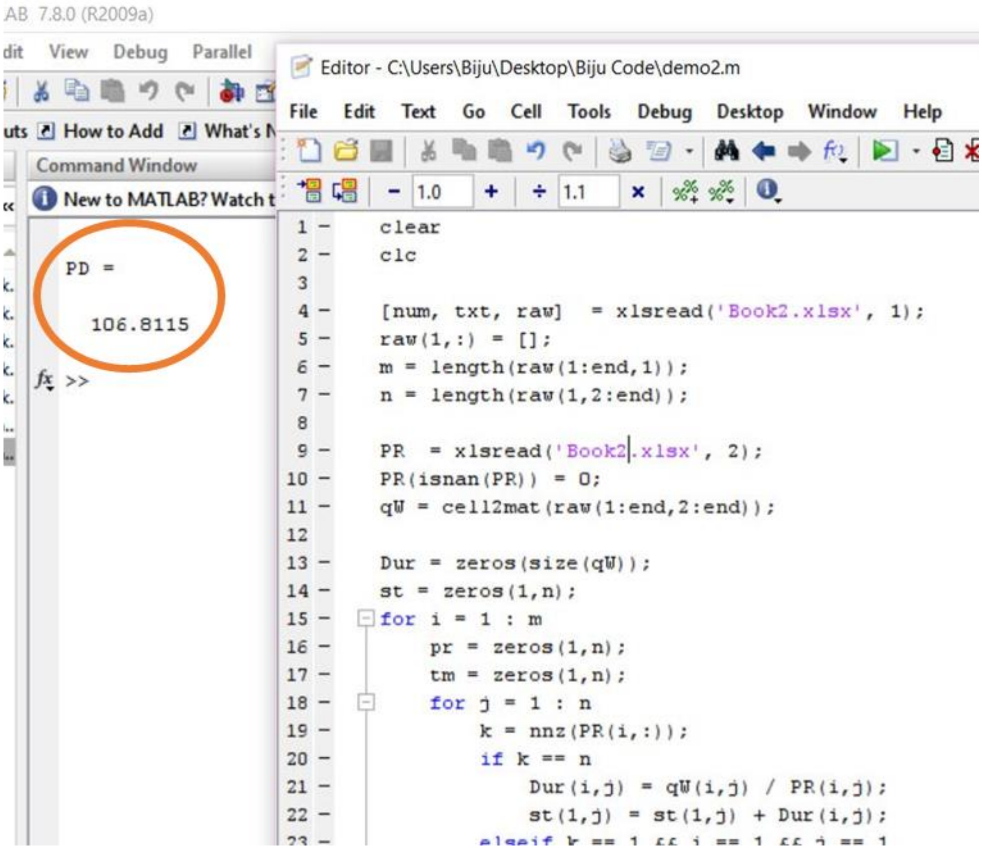

Figure 1: Solution obtained using Matlab

This problem was also solved using Genetic Algorithm. The total population size was obtained to be 72. The corresponding fitness functions were calculated thus forming a suitable population for the application of Genetic Algorithm to the problem. The selection method used here waas roulette wheel selection, the crossover rate was 95% and the mutation rate was kept to 0.01%. The value obtained by using GA was also found to be 107days. According to A. M. El-Kholy "Scheduling Repetitive Construction Projects" the project Duration obtained was 107 days and by using the above said mathematical formulation, a value of 106.8115 days is obtained.

9. Conclusions

This study shows a flexible model for solving the optimization problems for repetitive projects which are linear in nature. This method mainly focuses on the minimization of the overall project duration keeping the constraints factor regarding the precedence logic and crew availability. The paper focuses on both mathematical modelling and metaheuristic approach (GA) to solve a resource allocation problem. A study from a published literature was used to validate the formulation. Here crews were selected with different production rate for a particular activity. Therefore the overall project duration will increase if the production rate of the second crew is less than that of first crew.The Genetic Algorithm is a global search technique therefore it has difficulty in solving complex problems or the problems with higher genes. In the above problem, increasing the available crew of one particular activity from 3 to 4, the number of chromosomes in the population increased from 12 to 72.Therefore further studies can be conducted in this field to reduce the number of chromosomes. It was observed that the explained method can help a project planner to easily allocate the available crew within a constrained time limit.

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