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OPTIMAL SPATIAL ARRANGEMENT OF SHIPBUILDING BLOCKS IN THE PRE-ERECTION AREA OF SHIPYARD

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1 Introduction

The major problem arises at shipyard is because of scarcity of space for arranging the building blocks of ship under construction. A standardized erection sequence diagram is generally available to provide the prioritized erection sequence and it serves as the frame work. In order to make a timely erection of the blocks a post plan has to be developed so that the blocks lie in the nearest possible vicinity of the material handling devices while keeping the priority of erection and the blocks are arranged in the pre-erection area. This kind of readiness of blocks leads to a very complex problem of space. This arises due to the least available space leading to an urgent need for intelligent spatial schedule without compromising the rate of production. There exists two critical problems ahead namely, the spatial occupation layout of pre-erection area and the evacuating pattern in the spatial vicinity. The block shape is assumed be rectangular. The related input data's are the dates of erection (earliest as well as the latest), geometrical parameters of block available on pre-erection area, slack time and the like. World over industrial engineers and decision makers are brainstorming hard to find an ideal solution for their unique problems. Every scheduling and decisional problems end up in complicated iterative loop system.

2 Major Shipyard Problems

The shipbuilding industry is a large production unit with multilevel probability of bottleneck formation during regular work flow pattern. In order to exemplify the problem in engineering modules, a cross work has to be done for introducing mathematical formulation, so as to precipitate into a generalized optimization problem with well defined objective function and subjective constraints.

More commonly addressed methods of minimization are the identification of erection sequence, the manpower work flow management, load balancing over man and machine, the spatial scheduling, look ahead techniques by the system to anticipate the flow blockade, productivity analysis, resource utilization aspects, and the like. Any large manufacturing industry like shipbuilding muddles itself in very complex scheduling problem and optimal production systems to maintain the profit targets by effectively enunciating constraints reviewing its operational hurdles. This brings in a whole new dimension of thinking to come up with effective intelligent expert system providing vital support in decision-making process. The natural phenomenon and consideration with geometrical consideration is one of the serious issues of concern. Thus, we create a research background for conducting various experiments on evolutionary algorithms and programs.

These situations bring forth the urgent attention towards effective scheduling problems. An efficient spatial schedule rewards considerable improvement in profitability in terms of time, man and machine productivity all culminating to monetary aspects.

3 Spatial Scheduling

The spatial scheduling problem is complex as it must simultaneously consider spatial layout planning for allocating objects to the working space and the heuristic scheduling for complying with assigned erection dates with the standard availability of space and constraints. An integrated and concurrent approach is developed by both a spatial layout algorithm for allocating the objects to working space using genetic algorithm and bottom left algorithm for scheduling candidate objects to optimize the spatial utilization and to meet assigned erection dates. The proposed algorithm leads to an useful and efficient solution that confines to parametric boundaries.

In fact it addresses the requirement of optimal and best arrangement pattern of blocks so that it occupies minimum possible area in the pre-erection (PE) space. These problems are very serious issues in large industries like that of ship building industry. A feel of the problem can be had from Fig.1 and Fig.2. Along with spatial occupancy criteria, a consideration has to be made in such a way that the blocks are arranged in easily accessible position to man and other material handling devices operating in PE and at dock premises.

An efficient spatial schedule should match the stipulated dates of erection of blocks designated by erection sequence diagram, most effective usage of the available space also the maximum usage of space, other non spatial resources and elimination of idle time for progressing tasks or inventories and other stringent constraints.

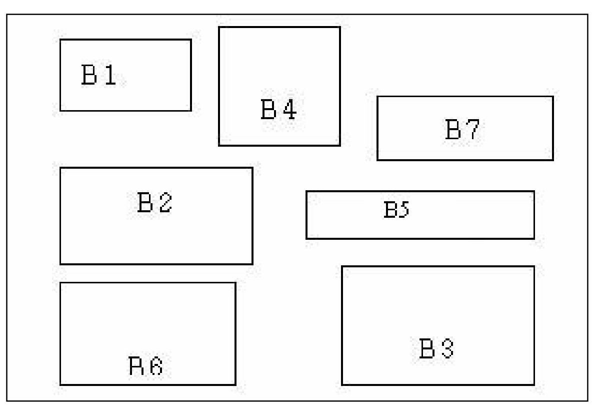

Fig. 1 Haphazard block layout in the Pre- Erection Area

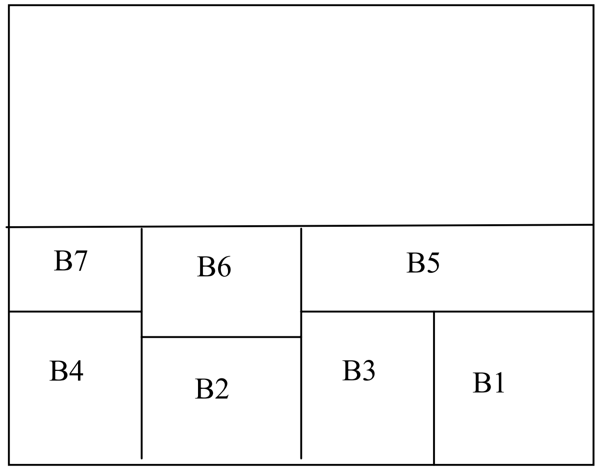

Fig. 2 Target Spatial Layout in the Pre- Erection Area

In this paper, genetic algorithm approach of optimization is adopted for solving the stated problem.

4 A Genetic Algorithm Approach

Genetic algorithms are general-purpose search algorithm based on the principles of evolution observed in nature. Genetic algorithms combine the genetic operators such as selection, crossover, and mutation operators with the goal of finding best possible solution for the problem. A genetic algorithm searches for the optimal solution until a specified termination criterion is met.

The solution to a problem is called a healthy chromosome and a chromosome is made up of a collection of genes which are simply the parameters to be optimized. A genetic algorithm creates an initial population (a collection of chromosomes), evaluates the population, and then evolves the population through multiple generations using the genetic operators in the search for an optimal solution.

Genetic algorithms can be applied to a wide variety of optimization problems such as scheduling, computer games, stock market trading, medical, adaptive control, transportation, the traveling salesmen problem, etc.

This approach generally embeds itself in such a way that a concept of machine learning is invoked and system makes its own decisional moves in order to terminate to an optimal solution.

5 Heuristic Backgrounds

The generally accepted heuristic of bottom left algorithm is adopted here (fig.3) when an assumption of rectangular global (Pre Erection area) and the local layout (block plan area) is made. Here each block is moved as far as possible to the bottom and as far as possible to the left. An ideal position is found when the rectangle coincides with the boundary layout at the lower and left side. In the fig, we can see placement of permutation order (2, 1, 3, 4). In order to avoid the gaps in the arrangement, we have to ensure that the blocks are well seated in the best possible way as our heuristic is based on the allocation of the lowest sufficient large region in the partial layout rather than on the series of bottom-left moves, as it will ensure the minimization of the scrap area (the left over area).

This concept is observed for the present problem and a variety of spatial search techniques namely, maximal remnant space utilization strategy, maximal free rectangular space strategy, initial positioning strategy, and edging strategy are in use. The rotations of blocks are restricted in this problem.

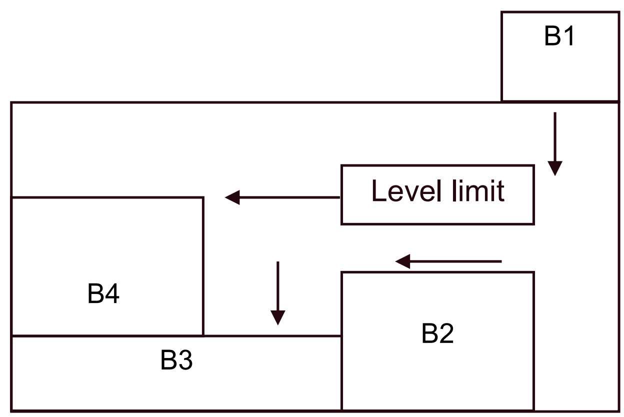

Fig. 3. Illustration of Bottom Left Algorithm

6 Spatial Layout Problem Using Genetic Algorithm

In the present problem, an optimal spatial arrangement has to be generated in Pre Erection Area for ship building blocks using optimal spatial occupancy as well as taking care of erection order or in other words ranking.

6.1 Encoding and Initial population

Encoding is done with various requisite parameters to Genetic algorithm designations. The data structure concept of object oriented programming is used for the implementation of this algorithm. In this algorithm, gene stands for block data, which includes geometric parameters like length and breadth, dates of erection and priority ranking or in short the attributes. A chromosome comprises of various gene to create individual strands. The number of genes in a chromosome is decided based on the total number of blocks available and thus an attempt is made to derive the chromosome length. The backbone of the entire algorithm lies on the random number program as it helps in instant decision making for selection of genes and chromosomes.

The blocks are considered with the accumulation of block data parameters where associated database are stacked using data structures into predefined memory space and builds up into arrays.

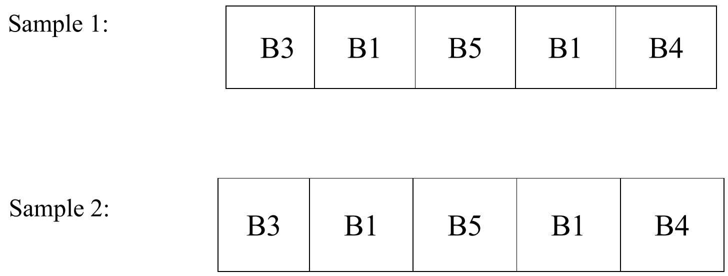

Fig. 4(a) Sample chromosomes

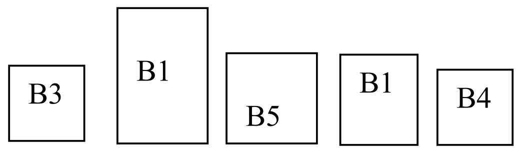

Fig. 4(b) Pattern arrangement of the sample chromosome

In this paper, a permutation encoding representation is used to solve the spatial problem. These are encoded into a defined string length. This string length depends on the number of blocks available in the problem. A typical chromosome is defined in Fig. 4(a) and Fig 4(b) is the pattern of arrangement of blocks deduced from permutation encoding. The total number of chromosomes generated will be N!, where 'N' is the pattern of arrangement of the blocks or in GA terms the number of chromosomes. All these numbers defines the strength of the initial population.

To begin with, the initialization of population is done based on a random fashion depending on the number of blocks. The genes in chromosomes are determined based on the potential optima say, in this case based on the geometrical data of pre erection area and the blocks. This iteration proceeds and offspring generation is continued till the termination conditions are satisfied.

A new population of genes is created by applying the following operations to chromosomes selected from the population with a stochastic probabilistic approach based on fitness criterion (with re-selection allowed).

6.2 Crossover

The selected chromosomes are copied to the new population. This copying facilitates the addition of the chromosomes into agile group to improve the system to develop maximum possible random combinations (Fig.5).

In this step new offspring are created by the system for the new population by recombining randomly chosen parts of two selected genes. Thus enormous samples are created.

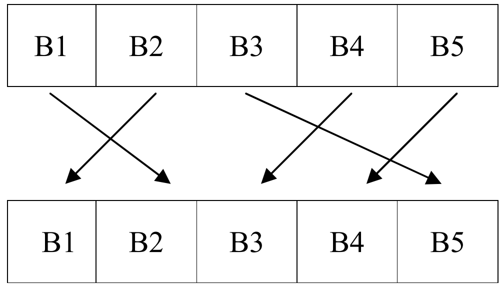

Fig. 5 A typical Crossover operations

The newborn offspring are obtained by the individual crossover operation as a result. In short, the adopted GA is described in the flow chart (Fig.6).

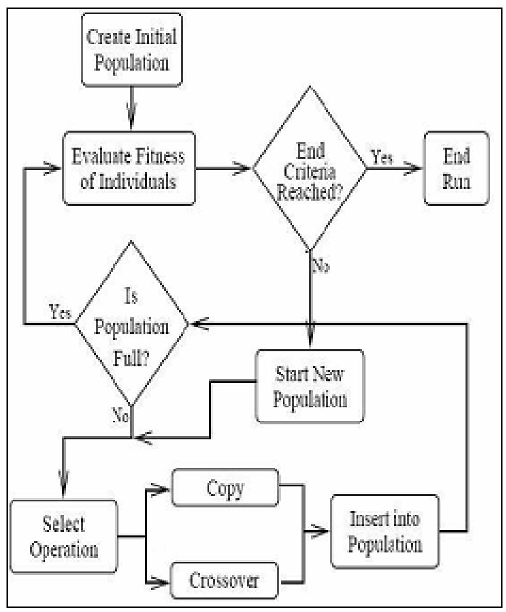

Fig. 6. Modified Genetic Algorithm Flow Chart for the Problem

6.3 Fitness

Since this is a case of constrained optimization problem. For many optimization problems, the feasible regions can be represented as a system of equalities or inequalities (linear or nonlinear). Here we use penalty function method as the penalty techniques transform the constrained problem into an unconstrained problem by penalizing infeasible solutions. Here the addition form is used to construct the evaluation function.

$eval(x) = f(x) + p(x)$

Being minimization of scrap area is the main objective of the problem, we require

$p(x) = 0$ if x is feasible
$p(x) > 0$ otherwise

Where eval(x) is the evaluation function, f(x) is objective function, p(x) is penalty term. The fitness parameter is set as 0.3 to converge the results into an optimal value. The fitter chromosomes have the lower value of eval(x).

6.4 Terminations Conditions

In this paper the termination condition for per GA run is defined as follows:

1. The termination conditions met when the system finds a duplicate sample in the allocated result space.
2. When the system finds no further healthier chromosomes in the allocated memory space.
3.

Thus, penalty approach is used to force the genetic search to approach the optimum from both feasible and infeasible region. This final selection is based on this kind of stochastic theory.

7.0 System assembly

The genetic algorithm works as a vital core source engine optimizing the spatial arrangement and producing the best possible results. In the real-time situation where the incoming block data changes day to day or it varies dynamically creating an in consistent input theme.

The (fig. 7) demonstrates the whole systems model. The diagram can be classified into four parts namely, the input block, the processor block, the output block, the retainer block.

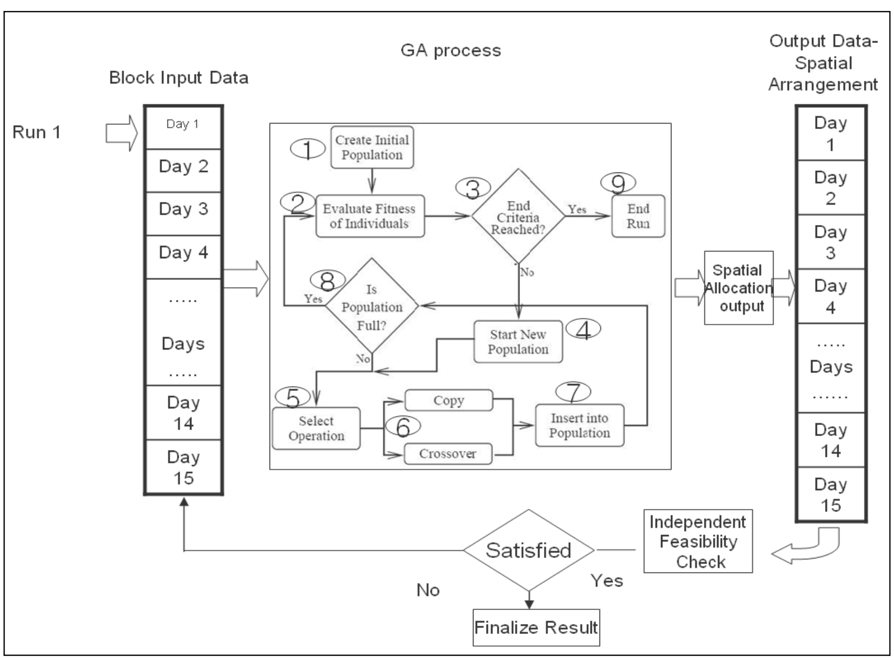

Fig. 7 The block arrangement pattern flow diagram

Firstly, the input block takes care of the whole input data as it varies dynamically based on time and date. This data is highly vulnerable depending on the blocks that have been pushed out of the respective production shops. The different input block to the pre-erection area means the redefining the new spatial arrangement pattern and finding the space for the new inlet block and the filling the space for the void that has been created by the removal of the block from the PE towards the erection point.

Secondly, the processor block works as explained in the previous section (Section 6.0).

Thirdly, the out block is based on the dynamic input value the out value also project out to be dynamic in nature and this serves a vital source of information back bone.

Fourthly, retainer block is the step for the result accumulation.

These steps are carried out days in advance to the real operation time and hence the bottle necks are anticipated and the time based corrective actions are implemented serving as the huge cost saving at the shipyard.

8.0 Result

The generated results are obtained as graphical waveform in the scatter diagram pattern.

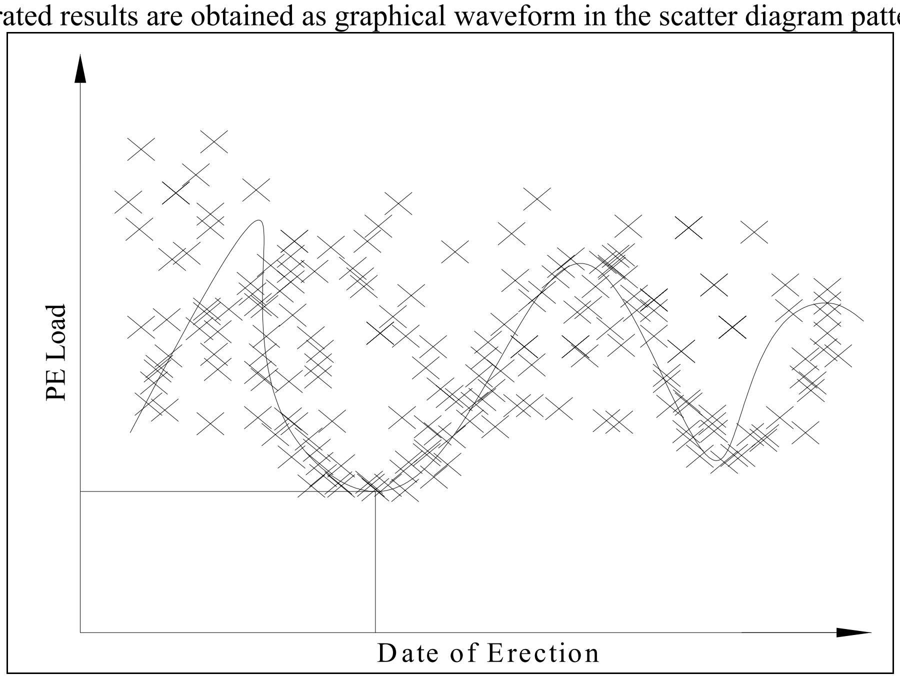

Fig. 8 The system based result evaluation

The results obtained are basic scatter diagram which is smoothened using the curve fitting methods and regression procedures. This is projected as in fig. 8, where on the X axis it represents

These results are decoded to achieve finding the optimal solution. This optimal wave gives the best possible spatial layout for the shipyard under study.

9 Conclusions

The developed spatial scheduler algorithm is capable of handling any desired number of blocks required for ship building. The algorithm is claimed to be robust with inter file handling systems, database modifications facilities for customizing and producing the network related solutions. Here enormous usage of data structures has been done to handle the huge working database and random operator's work space. This could produce self explained graphical color output of the spatial layout of pre-erection area, which helps in reconsidering and giving proper MIS to take required corrective actions. The main advantage of such efforts is that without any additional investment in man and machine, an eventually competent working strategy is evolved.

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