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Aleksandar Đorđević[1)]

1) Faculty of Mechanical Engineering, University of Kragujevac, Serbia
cqm @kg.ac.rs

USING GENETIC ALGORITHAM TO OPTIMISE MACHINE LAYOUT PROBLEM

Abstract: *In this paper, it is presented problem of machine layout optimization. The importance of resolving the problem is large for manufacturers, who whant to save production time and cost. Poor layout gives longer traveling distance from one machine to anather and biger cost in handling the material for production. Time saving and cost reduction are achived by redusing the travel distance of people, especialy material and informations. The papire deals with genethic alghoritm whose objective is to find the appropriate placment of the machines in workspace.*

Keywords: *genethic algoritham, machine layout, travel distance*

1. INTRODUCTION

One of the biggest problems in the design of workspace manufacturers of heavy industry is the layout of machines. Importance of layout machines is manifested through cost of the matreial handle, time and matreial flow. Material handling costs contribute an estimated 15 to 70 % of total operation expenses and can be reduced by approximately 10 to 30% if an efficient layout is emplyed [4]. In that way machine layout affects on manufacturers productivity and efficiency.

How the machines will be placed depends on the type of manufacturing industri. There are meny types of layouts. Extrema layouts are layout by product and layout by function. Layout by product is a layout with high volumes of prodacts, but with low variety of products, on the other hand layout by function is a layout with high variety of products and low volumes of products. Type of layout that stands between these types is celullar layout. For havy industry, whos layout is considerd in this papir it is used layout by product.

A product layout arranges activities in a line according to the sequence of operations for a particular product or service. This would be an assembly line, such as a ship's winch line. This kind of line is eficient, but it has its imperfections. So the finding of optimal path between machines would reduce these imperfections.

Machines layout path is combinatorial optimization problem that attempts to find an optimal path through layout from a finite set of paths. An optimal tour is one which distance is minimized.

A large variety of optimisation solutions for layout are found in literature. Such as heuristic methods like genetic algorithm and ant colony optimisation algorithm (ACO), optimisation could be done by using quadriatic assignemnt problem (QAP) formulation.

An ACO algorithm is an artificial intelligence technique based on the pheromone-laying behavior of ants; it can be used to find solutions to exceedingly complex problems that seek the optimal path through a graph. [2]

QAP formulation is a fundamental combinatorial optimization in the branch of optimization or operation research in mathematics, from the category of the facilities locations problem. In the case of machine layout, with n machines and n locationes, distance is specified between locations and the amount of materila that is going to be traneferd between machines. Problem is to assigne all machines to different locations with the goal of minimising the sum of the distances multiplied by the corresponding flows.

Heuristic methods are often used for combinatorial problems. Genetic algoritham as heuristic method that attempts to find an optimal solution based on a process of natural selection and evolution. The process involves generating random solutions and applying genetic operators in hopes that the solution will evolve to find the optimal solution. This process can be characterized by four stages:

- Initialization
- Selection
- Reproduction
- Termination

In this paper is described use of genetic algorithm for finding the shortest path between random placed machines in a havy industry workshop.

This paper is organized in the following way: in Section 2 the description of genetic algorithm is given, in Section 3 optimisation of a path for randomly chosen positions of machines and conclusions are presented in Section 4.

2. GENETIC ALGORITHM

Genetic algorithm is as already mentioned in the introduction heuristic optimization method. Heuristic methods are trying to find a solution through process of iteration. By iteration they are trying to find best solution for the given problem. All of this methods have their rules for choosing the parameters that are going to be evaluated and rules for the execution of these evaluations.[3]

Genetic algorithm uses rules of natural selection and genetics (mutation, reproduction) for evaluating the parameters. In fact, individuals in the nature that is best adapted to the conditions and surroundings in which it lives has the greatest likelihood of survival, and thereby transferring their genetic material to their offspring. For genetic algorithm one solution is one individual. Each individual in GA is represented by the same data structure (number, string, matrix, tree, etc). These individuals are called chromosomes. Each solution is assigns a certain measure of quality that is usually called goodness in the literature, goodness is determined objective function. By selection, most fitted individuals are chosen to be transferred into the next population and by mating of genetic materials new individuals are create. This cycle of selection, reproduction and mutation of genetic materials of individuals is repeated until the stopping condition of evolutionary procesa is not fulfilled. In genetic algorithms, key for selection is the objective function, which adequatelya represents the problem. Just like in nature, where environment and natural selection determines the survival of some individuals, in the same way the objective function makes selection on a population of solutions.

When starting the GA it starts with initila population of individulas. Usually this initial population is generated randomly from domain of posibal solutions; although it is possible to generate uniform initial population (it means that all the chromosomes are the same and at the beginning GA isn't very efficient). Also, it is posible to implant initial population derived from some other optimisation method. The following process is repeated until the maximum number of iterations is reached, or some condition is satisfied. This process consists of the activities of genetic operators like selection, crossover and mutation over a population of individuals. During the selection poor chromosomes are discarded, and better survive and are used for the next step, crossing – breeding. By breeding characteristics are transferrred from parents to children; and by mutation change of characterisitcs is done on gen of random chosen individual from a population. This kind of procedure is done from generation to generation, and with each succeeding generation the average goodness of population is greater and greater. Pesudo code of GA is given on the fig.1.

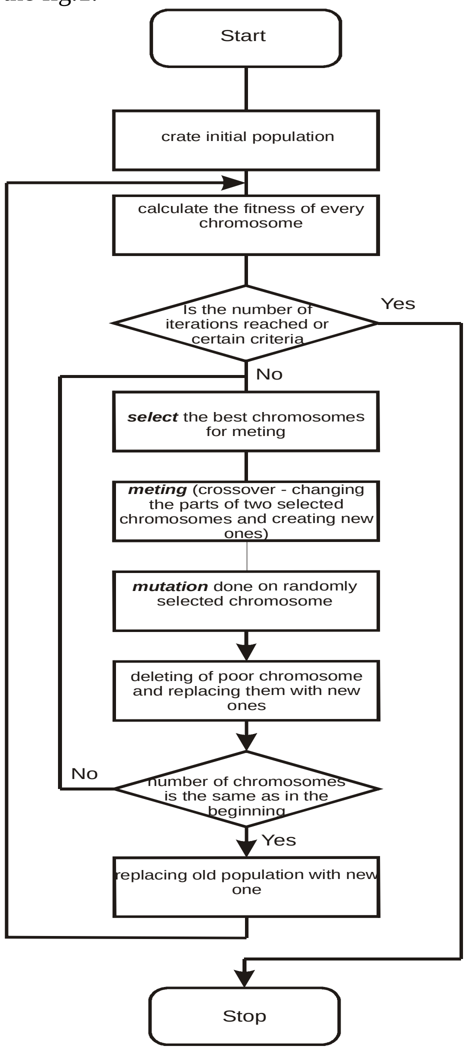

Figure 1 Pseudo code of GA

From the figure 1, it can be seen that after creating initial population GA goes in loop until certain criteria or assigned number of iterations is reached. To protect best solution from mutations, so it can not be lost during the iterations, often is used elitism. Elitist selection does not allow any changes on a best solution from the previous iteration.

In this paper, for solving the problem of finding the shortest path between the machines layouts it is been used GA based on problem of traveling salesman.

3. MACHINES LAYOUT SHORTEST PATH OPTIMIZATION

In this Section, the cretion of machines layout shortes path optimization is described.

3.1 Modeling optimization

In this paper, it is considered optimization of a path for randomly chosen positions for machines in a heavy industry workshop. As previously mentioned for heavy industry it is used product line. So, based on chosen positions for machines, first it will be optimised the shortest path, and then based on the operations that should be performed in production, machines would be placed.

Machine layout is modelled here as an undirected weighted graph, such that machine positions are the graph's vertices, paths are the graph's edges, and a path's distance is the edge's length. It is a minimization problem starting and finishing at a specified vertex after having visited each other vertex exactly once. Often, the model is a complete graph (each pair of vertices is connected by an edge). Also, workshop is presented with rectangular graph whose dimensions are 10x10.

Restriction for positions, where machines will be puted, is that thay form metric; they should satisfy the triangle inequality. This can be understood as the absence of "shortcuts", in the sense that the direct connection from A to B is never longer than the route via intermediate C:

$$d_{AB} \leq d_{AC} + d_{CB}$$

The edge lengths then form a metric on the set of vertices. When the machines are viewed as points in the plane, many natural distance functions are metrics, and so many natural instances of machines layout satisfy this constraint.

The cost function for the simplest form of the problem is just the distance between the positions for the given ordering (x_n, y_n), n = 1, …, N (where the N is number of positions) given by[4]:

$$\cos t = \sum_{n=0}^{N} \sqrt{(x_n - x_{n-1})^2 + (y_n - y_{n-1})^2}$$

Where (x_n, y_n) are the coordinates of the *n*th position for machine. In this papir, starting is at the origin, so (x_0, y_0) = (0, 0) = starting point and ending poin is at the output of workshop which has coordinates (x_n, y_n) = (10, 10). In this paper, it is considered abut positioning 15 machines in the workshop, so N = 15. Given the fixed starting and ending points, there are a total of 15!/2 = $6.5384 * 10^{11}$ possible combinations to check [1].

When looking at the algorithm, it can be seen, that the population size for this problem is the initial number of random paths that are created when the algorithm starts. A large population takes longer to find a result. A smaller population increases the chance that every path in the population will eventually look the same. This increases the chance that the best solution will not be found. For this problem it is chousen population of 100 chromosomes.

Through each generation, the number of paths is randomly chosen from the population for all neighboring positions for machine. The best 2 tours are the parents. The worst 2 paths get replaced by the children. High number will increase the likelyhood that the really good paths will be selected as parents, but it will also cause many paths to never be used as parents. A large numer of neighboring positions machines will cause the algorithm to run faster, but it might not find the best solution.

The mutation operator randomly chooses a path and changes gene in chromosome of that path. This produces a new path that participates in the creation of new populations, which is going to be evaluated in next iteration.

Through each iterations and performance of operations (selection, meiting and mutation), AG comes to optimal solution for positioning of the machines.

After starting the software, results were obtained and are shown in Figures 2 and 3, for randomly selected positions for placement of machines.

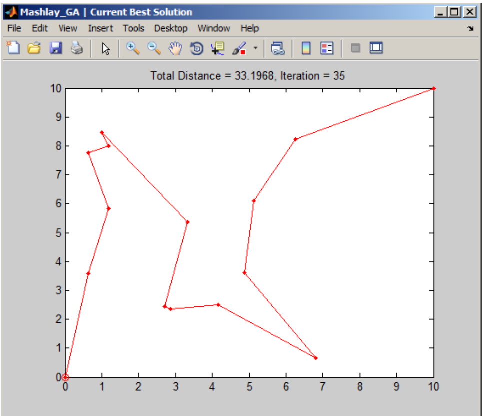

Figure 2. Optimized path for randomly chousen 15 posiciones in 35 iterations

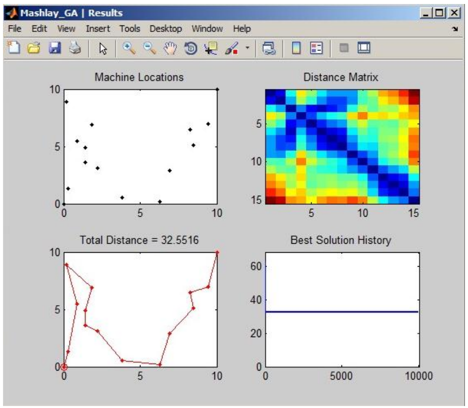

Figure 3. Optimal solutions at the end of program execution, with distance martix between the positions of the machines

Figures show the selection of the most optimal path for 13 machine positions, and the starting position for storage and final position (the output from the workshop). It is now possible, depending on production needs at positions 2 through 14 to set the appropriate machine.

4. CONCLUSION

In this paper, Genetic Alghothani for shortest path between positions for machines is presented.

Optimization with AG of the shortest path between the positions of the machine can be very significant, because it reduces the cost of production companies. Algorithm is not required for the workshop with smaller operations, but when the number of operations, or machines that are used more ag is of great benefit.

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