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Route Planning for Multiple AGV System Using Genetic Algorithm in Manufacturing Warehouse

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Conflicts of Interest
There are no conflicts to declare.

ABSTRACT

Many scholars have proved that path planning in a multiple automated guided vehicle (AGV) system is an NP-Hard issue. Traditionally, numerous mathematical strategies have been used to complete this difficult task. Based on a genetic algorithm, this research provides an efficient path planning solution for many AGV systems. The constraint in the optimization task is that, each AGV starts and returns to his starting place, minimizing single path distance of each Agv.Travelling to a unique set of pick-up stations, each pick-up station is visited by exactly one AGV for goods picking up. The Cost Function is to search for the shortest path the least distance needed for each AGV to travel from the start location to individual points and back to the original starting place. The experimental results show that the total path distance of all AGVs and longest Single AGV path distance are shortened by using the modified genetic algorithm.

Keywords: ROUTE PLANNING; GENETIC ALGORITHM; AGV; OPTIMIZATION; MANUFACTURING WAREHOUSE.

1. Introduction

Automated guided vehicle (AGV) systems are frequently used for transporting material within a manufacturing, warehousing, Distribution system. AGV is a portable robot that follows markers or wires in the floor, or uses vision, magnets or lasers for navigation. AGV are increasing the productivity while reducing labor costs. They are most often used in industrial applications to move materials around a manufacturing facility or manufacturing warehouses with many advantages. AGV has been widely used as the core equipment of modern logistics system. Nowadays the dispatching problem of the multiple AGV system is one of the most studies on worthy issues. Genetic Algorithms (GA) are adaptive heuristic search algorithm on the basis of evolutionary ideas of natural selection and genetics. As such they represent an intelligent exploitation of a random search used to solve optimization problems. Although randomized genetic algorithm (GA) is by no means random instead they exploit historical information to direct the search into the region of better performance in the search space. Problems of this procedure in relation with the design of the manufacture warehouse. Different path planning algorithms are suited for different warehouse layout. The proposed scheme applies to one particular type of layout improve the whole efficiency in practical situations of the factory. The basic techniques of the genetic algorithm (GA) are designed to simulate processes in natural systems Necessary for evolution.

In this paper, the genetic algorithm (GA) was utilized to finding the optimal path for multiple AGV in the manufacturing warehouse and minimizing single path distance of each AGV are exerted, gaining the optimal shortest total path distance. As shown in the experimental result. The improved genetic algorithm (GA) exceeds the original.

In paper the section 2, the relevant work is listed and discussed. The proposed algorithm was described in Section 3. Section 4 presents the experimental data and analysis, while section 5 concluded the whole work.

2. Related work

The path planning is an important research area of artificial intelligence and robotics which has been proven to be NP Hard problem. Dijkstra algorithm [1] searches for global space without considering in the target information.it causes that the solving time is long difficult to meet the need of fast path planning. Another path planning method named a star algorithm frequently used when the global environmental information already knows [2].

Many researches utilize (GA) to find optimal path [3, 4]. For instance Nallusamy dealt with generating of an optimal route for multiple vehicle routing problems by first clustering the given cities depending upon the number of vehicles and each cluster is allowed to a vehicle [5].Then the genetic algorithm (GA) were applied to the cluster and iterated to obtain the most optimal value of the distance after convergence. The find result shows that genetic algorithm gave better performance on optimal path planning. Each algorithm has its own advantages and disadvantages so it’s very important to choose the suitable algorithm for different situation.

Latombe [6] mentioned in the paper the traditional methods are mainly graphical and analytical methodologies. Graphical methods include road map method. Grid method Analytical method including Genetic algorithm (GA).Ant Colony. Optimization (ACO), Taboo search intelligent algorithm and its hybrid from are also used to solve the path planning problem.

The multi-AGV path planning is most important in ensuring an efficient flow of materials during production process. Path planning involves three issues in dispatching, scheduling and routing of tasks at the same time. The multi AGV path planning problem [7–8] is similar to the traveling salesman problem (TSP) [9-10] in the aspect of finding the shortest tour/time which has extremely large search spaces and is very difficult to solve.

Smolic-Rocak ET all used time windows in a vector form to solve the shortest path problem for multi-AGV systems [11]. Multiple automated guided vehicles (multi-AGVs), characterized by multi objectives, are playing increasingly important role in the area of distribution logistics due to their high efficiency for material handling among workstations. The applications of AGV systems face several important issues AGVs number determining [12, 13] path planning [14] and constraint exerting [15] etc.

3. Problem description and modeling

The mathematical formulation of the presented problem uses the following notation.

n - the number of stations in manufacturing warehouse to be visited and the number of nodes in the route network;

i,j,k - indices of station that can take integer values from 1 to n;

t - The time period or step in the route between the stations;

x_{ijk} - 1 if the edge of the network from i to j has been used in the step t and 0 otherwise;

R_{ij} - Arc between two workstations i and j;

d_{ij} - the distance calculated from station i to j;

The linear programming formulation of this problem can be example as:

The objective function is to minimize the total distance of all off selected elements of the tour:

$$\sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{t=1}^{n} d_{ij}\, x_{ijt}$$

The constraints are as following,

$\sum_{i}\sum_{j} x_{ijt}$ = 1 for all t; for all values of t, AGV is running in one segment.

$\sum_{j}\sum_{t} x_{ijt}$ = 1 for all I; for all station, at certain time there is just one other station which is Being reached from it.

$\sum_{i}\sum_{t} x_{ijt}$ = 1 for all j; for all station, at certain time there is one station from which it is being Reached;

When a stations is reached at time t, it must be left at time t+1 in order to exclude disconnect sub-tour that would otherwise meet all of the above constrains. These sub-tour elimination constrains are formulated as;

$$\sum_{i} x_{ijt} = \sum_{k} x_{ik(t+1)} \;\; For\ all\ j\ and\ t$$

In addition to the above constraints the decision variables are constrains to be integer values in the range of 0-1;

$$0 \leq x_{ijt} \leq 1$$

As a computational intelligence method genetic algorithm aim to find the approximate solutions to combined optimization problem.it constrains the algorithm idea of survive of the fittest. That is to guess solution’s first, and then combing the fittest solutions to create a new generation of solutions that should be better than previous generation.

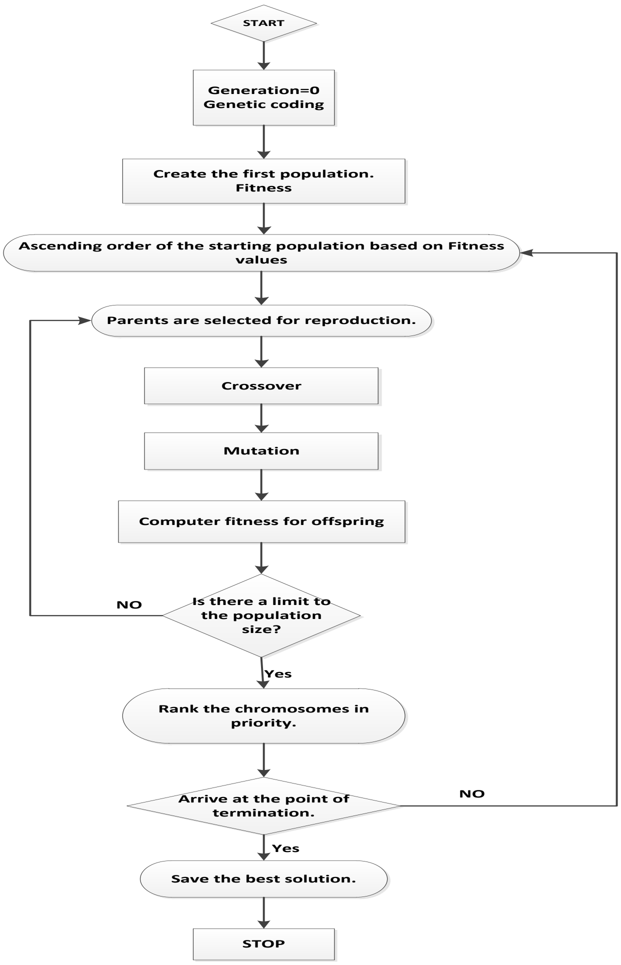


FIG.2 FLOWCHART OF GEGENTIC ALGORITHM

1. Genetic algorithm design

FIG.2 shows flowchart of the genetic algorithm. The key problem of applying the genetic algorithm to the multi-AGV path planning is to adopt the effective coding and decoding methods. (G.A) repeatedly select, crossover, and mutate the population to produce a new generation population that is more adaptable to the environment than its parents, until satisfying the desired requirements

I. Selection rules that choose which individuals called to as parents will produce to the following generation's population.

II. Crossover rules combine the children of two parents to create the next generation.

III. Mutation rules apply random changes to individual parents to form children.

Detail of the genetic algorithm including

The steps of the genetic algorithm includes: Encoding, Population Selection, Crossover operation, Mutation operation and Decoding.

1. Encoding:

A suitable encoding is found for the Solution to our problem so that each possible solution has unique encoding and encoding is some from string.

2. Population selection:

The initial population is then selected, usually at random though alternative techniques using heuristics have also been proposed. The fitness of each individual in the population is then computed that is, how well the individual fits the problem and whether it is near the optimum compared to the other individuals in the population.

3. Crossover operation:

The fitness is used to find the individual's probability of crossover. Crossover is where the two individuals are recombined to create new individuals which are copied into the new generation.

4. Mutation operation:

Some individuals are chosen randomly to be mutated and then a mutation point is randomly chosen. The character in the corresponding position of the string is changed.

5. Decoding:

A new generation has been formed and the process is repeated until some stopping criteria have been reached. At this point the individual who is closest to the optimum is decoded and the process is repeated until we get an individual with high fitness value.

Overview of facility layout

A manufacturing system with multiple AGV performs material delivering. There are M AGV traversing through N workstation (N > M).For the workstation distribution the following assumption are considered for describing the details.

- M AGVs traverse through N workstations (N > M).
- Only one AGV passes through each workstation (except the starting point).
- Each AGV starts from the same starting point (workstation) and comes back to the starting point.
- Each AGV travels one route separately with the predefined path and the fixed speed.
- Two constraints are exerted:

  The total path distance of all AGVs should be minimized;

  Each single AGV path distance should be minimized.

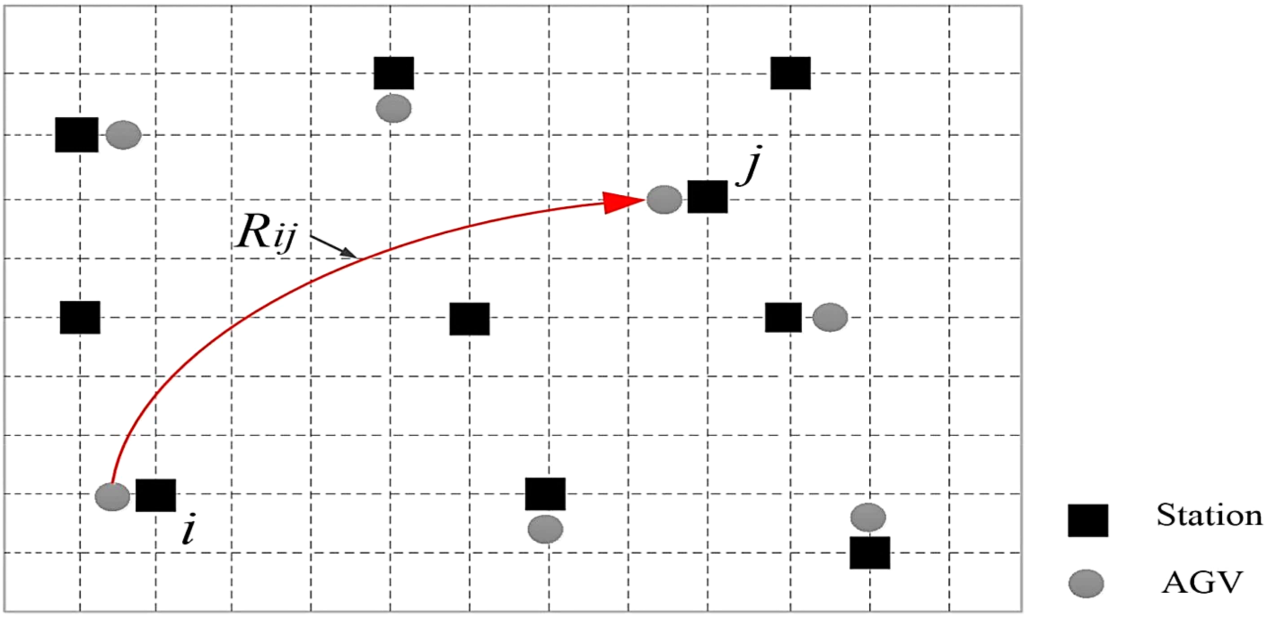


FIG.1 THE WORK DIAGRAM OF THE AGV SYSTEM IN MANUFACTURING WAREHOUSE

2. Modified Genetic Algorithm

The proposed algorithm modified the traditional genetic algorithm by using one chromosome.in this method the station are represented by of the integers from 1 to a, and the permutation is divided in to b sub-tour by the insertion of b negative integers (from 1 to b), thus the total length of the single chromosome is a+b.

A modified crossover operation is proposed based on the order crossover opration.in this crossover operation a randomly chosen crossover point divides the parent string in left and right sub-strings. The order crossover randomly selects several points in a parent's tour while the modified crossover selects all the right of position.

In the mutation steps, two points are randomly chosen in the string, and sub-string us reversed between these two cut points.

The algorithm employs a local search technique to obtain a better solution as compared to previous iteration. The search tries to improve route by replacing its two non-adjacent edges by two other edges. It's should be need that there several routes for connecting nodes and producing the tour again but the tour should satisfy all the constrains. Under the premise of satisfying all constrains. If the new tour produces a better value for the problem than the previous solution then only the unique tour will be accepted. The process is repeated until the termination condition is met.

4. Experiment

The proposed Algorithm is implementing and test in MATLAB.to reveal the performance of the algorithm. We test a case of certain number of AGV travelling in the manufacturing warehouse to pick-up parts and goods and come back to the starting point. The final task is to find the optimal path for each AGV using the proposed algorithm under the condition of each AGV is allowed to travel a minimum of 5 pick-up stations.

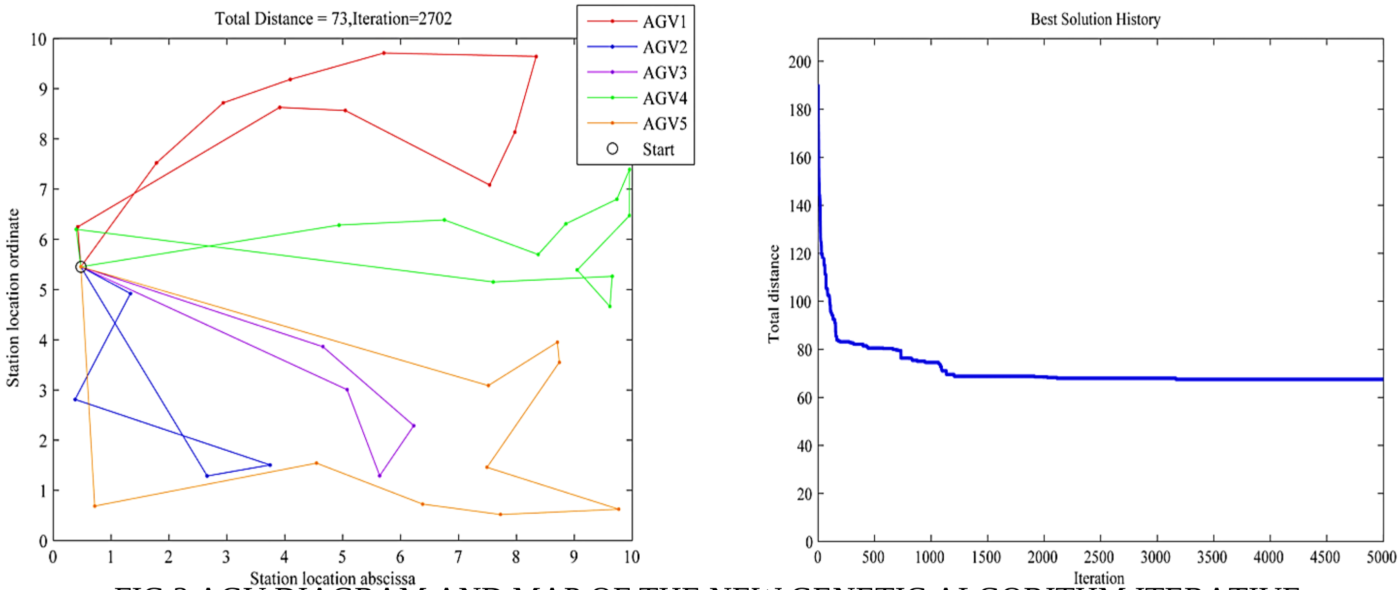
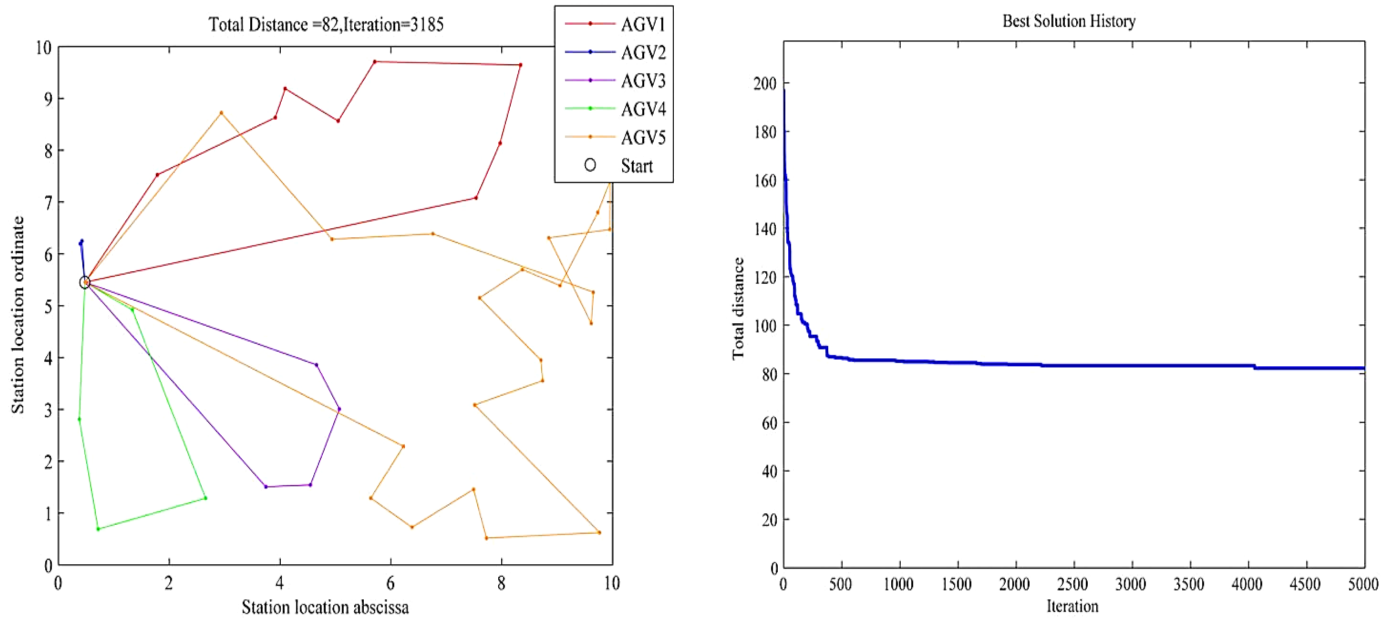


FIG.3 AGV DIAGRAM AND MAP OF THE NEW GENETIC ALGORITHM ITERATIVE

a. AGV path diagram

b. Genetic algorithm iterative map



a. AGV path diagram

b. Genetic algorithm iterative map

FIG.4 AGV DIAGRAM AND MAP OF THE TRADITIONAL GENETIC ALGORITHM ITERATIVE

5. Simulation

• Simulation on multiple AGV path diagram and iterative maps of the improved. Traditional genetic algorithms verify that the modified genetic algorithm has the shorter total path distance of AGV than that of the traditional genetic algorithm.

• We set up the production scene with 5 AGV and 50workstation.

• Set the population size is 200 for applying the proposed new genetic algorithm to perform path optimization.

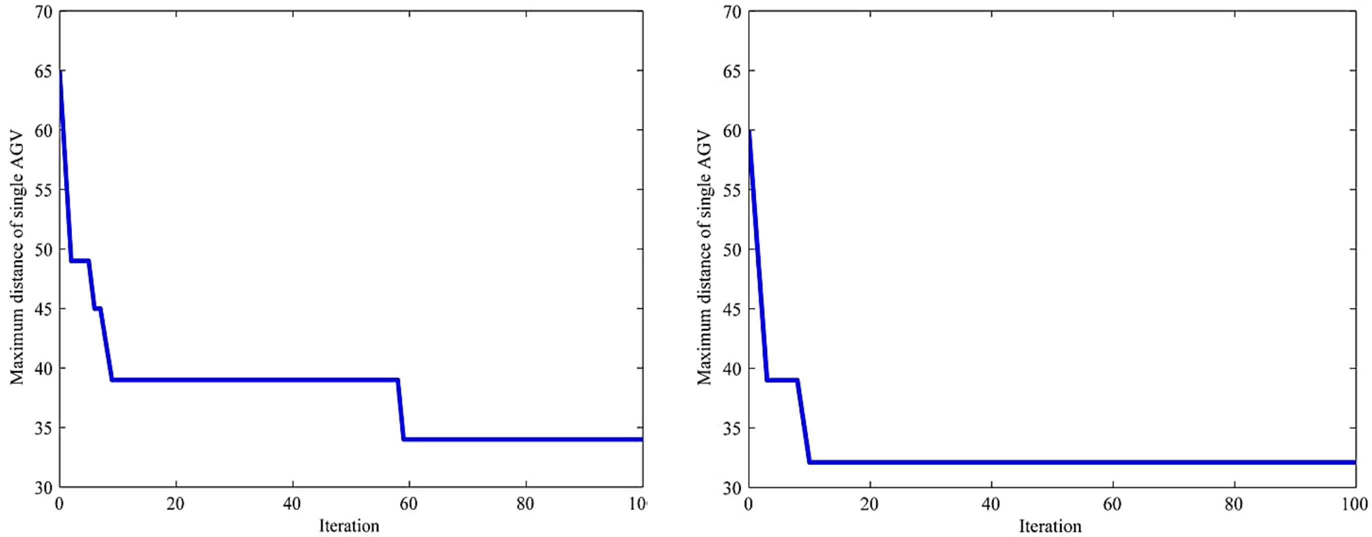
• The simulation result for two genetic algorithms is draw in FIG. 3 and FIG. 4

• FIG.3 shows that, At 2702 Iterations, the Total path distance is 73 for the New Genetic Algorithm.

• FIG.4 shows that, At 3185 Iteration, the Total path distance is 82 for the Traditional Genetic Algorithm.

• FIG.5 shows that, At 65 iteration the maximum distance of single AGV 34 for the Traditional Genetic Algorithm.

• FIG.5 shows that At 60 iteration maximum distance of single AGV is 32 for the Modified Genetic Algorithm.



a. Traditional genetic algorithm

b. New genetic algorithm

FIG.5 MAXIMUM DISTANCE OF SINGLE AGV

AGV NUMBERS	ALGORITHMS			
	Traditional genetic algorithm		modified genetic algorithm	
	Iteration	Total distance	Iteration	Total distance
5	3185	82	2702	73
1	65	34	60	32

FIG. 6 EXPERIMENTAL RESULTS OF DIFFERENT ALGORITHMS

6. Conclusions

This study is focused on the optimal path finding algorithm of multiple AGV Transfer goods in the manufacturing warehouse using genetic algorithm. By exerting the constrains of both minimizing the total path distance of all AGV's and minimizing Each AGV path distance, we gain an optimal shortest total path distance in AGV goods delivering task. The simulation results show that all AGV path distance and the longest Single AGV distance are shortened by using modified genetic algorithm. Further research can be done by considering the scheduling and collision problem between AGV to promote the total performance in manufacturing warehouse.

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