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- RESEARCH ARTICLE-

Double Robot Arm Movement Planning Using Genetic Algorithm

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Abstract

In this study, it is aimed to ensure that the robot arms on both sides of the conveyor belt reach the targets on the conveyor belt in equal or close numbers. In the system, a band that can carry 1025 materials per unit time is used. Each frame to be processed on the conveyor belt is considered a matrix of 25 rows and 41 columns. It is aimed that the robots make a division of labor for a common problem and that the number of materials they collect and the path they cover are equal or close. For this purpose, optimization of the system has been provided by using Genetic Algorithm technique. With the developed algorithm, the work sharing between the robots in terms of the number of materials received and the total distance traveled has been achieved as close to 100%.

Keywords:
Robot, Optimization, Genetic Algorithms.

Introduction

Today, robots have become an important part of the industry. It decreases manpower and margin of error and increases production efficiency. From the first robot of Al Cezeri, who lived between 1136-1206, today have been reached autonomous robots that can decide on their own (Al-Jazarí 2011).

We can see robots and their applications in many different areas. Robots make production efficient in many areas such as cutting, arc and spot welding, material handling, assembly, painting, packaging, placement.

There are many different types of robotic arms, but most can be characterized into one of six major categories by their mechanical structure. Cartesian (also known as Gantry), Cylindrical, Spherical (polar), SCARA, Articulated and Parallel robots. In the last 40 years, many different academic studies have been carried out on robot applications and algorithms.

In this study, an application has been developed for the control of the robot arm. The aim of this study is to optimize the task of two robotic arms using Genetic Algorithms (GAs). Uyanık. B., (2003). Kert M. (2006). In this respect, the studies on this subject in the literature are listed below.

In literature review, algorithms developed for optimization of mobile robot and robot arm movements have been studied.

Parker, J. K., Khoogar, A. R., Goldberg, D.E. (1989), in their study, they used GA to make the optimal trajectory planning of the robot arm's course. They also tried the application on PUMA566. They reported good results.

In another study, Sun, S., Morris, A., & Zalzala, A. (1996) present experimental results of multiple double-arm robots that cooperatively manipulate an object whose workload and size exceeds the capacity of a single robot. In this study, the force to be applied to the load is determined by using the information coming from the sensors.

Vidaković J, et al. Conducted a study on the use of two robotic arms in surgery in 2017, based on a multi-objective cost function.

Multi-Robotic Task Allocation (MRTA), a team of robots, addresses issues related to efficient job assignment. Arif M. and Haider S. (2017) also describe MRTA as a generalization of the Multiple Traveling Vendor Problem (MTSP) and use evolutionary algorithms (EA) for optimal task assignment. Ma, X., Zhang, Q., & Li, Y. (2007) stated that more than one robot was more successful in the discovery of the unknown environment and their task areas were determined by GA.

When the studies made on the robot with the genetic algorithm are examined in the literature, taking the material, finding the shortest path between two points (Güllü, 2017), traveling without hitting obstacles (Aksungur and Kavlak, 2009), the position of the machines in a manufacturing cell made by robot, it is seen that there are many studies in order to make the production processes efficiently by optimization (Usta, 2005).

There are no studies in the literature about how to obtain target materials in terms of number and distance.

Materials and Methods

Genetic algorithm was used as a method in this optimization project which was developed to coordinate multiple robots for a target. GAs is an optimization algorithm that works on possible solutions with the basic idea of having a high probability of survival for solving problems. Optimization is to find the most suitable solution alternative in the solution space, which may be under some restrictions. Therefore, genetic algorithm is a very suitable algorithm for this work.

In this study, it is aimed that two robots will pick up 20 randomly selected materials on a belt capable of carrying a total of 1025 materials, with 25 on the row (Y) axis and 41 on the column (X) axis.

When multiple robots work for the same job, the distances covered by robots may be different and imbalances may occur, such as when one collects more material than the other. Therefore, the rules listed below apply to the balanced workload distribution of the robots.

1- Robots must collect targets close to them.
2- The number of materials they collect should be equal or close to each other.

3- The amount of distance that the robots travel to collect materials must be equal or close to each other.
These rules were used to calculate the suitability value in the algorithm developed using GAs. Figure 1 shows the flowchart of the GAs.

Preparation
A band combination with a capacity of 1025 materials consisting of 25 rows and 41 columns was created and 20 target materials were randomly selected in the combination. (Figure 2)

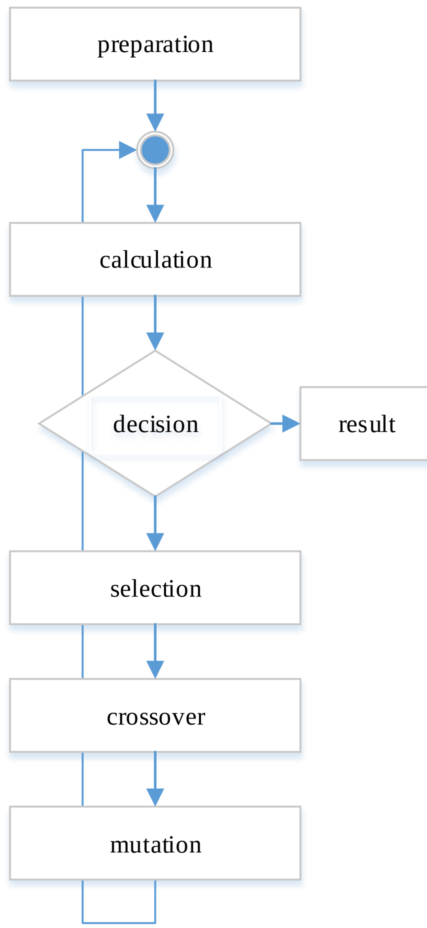

Figure 1. Flow Diagram of Genetic Algorithm

									R1									
01	01	02	03	*	*	*	19	20	21	22	23	24	*	*	*	39	40	41
02																		
03		1HM							9HM								20HM	
*				3HM										15HM				
*						5HM						11HM			18HM			
*														16HM				
*			2HM					7HM					13HM					
*					4HM					10HM		12HM					19HM	
*							6HM											
25									8HM						17HM			
26													14HM					
									R2									

Figure 2. 20 target materials created

Establishing the initial population

When creating a genetic algorithm, it is necessary to identify the possible solution with a chromosome. In this study, there are information about which material is picked from the robot and how many materials are taken from the robot. Targets placed randomly on the belt are picked up in random order with 2 robots positioned on both sides of the belt and at the exact midpoint. This data is also processed into the chromosome. This process is repeated for a specified number of times to form the first population. In this experiment, the number of chromosomes in the population was chosen as 20.
The total distance and the points covered by the robots are given in Tablo-1.

Tablo 1: 5 different chromosomes from the first population

1	1	1	2	2	3	2	4	1	5	1	6	2	7	1	8	1	9	1	10	1	11	1	12	1	13	1	14	1	15	2	16	2	17	2	18	1	19	1	20	14	6	609,76	315,90	22,203
2	1	1	2	2	3	2	4	1	5	2	6	2	7	2	8	1	9	2	10	1	11	2	12	2	13	2	14	1	15	1	16	1	17	1	18	1	19	2	20	9	11	422,34	513,78	67,255
1	1	1	2	1	3	1	4	1	5	2	6	1	7	2	8	1	9	2	10	1	11	1	12	2	13	2	14	1	15	2	16	1	17	1	18	2	19	1	20	13	7	604,61	387,25	34,488
2	1	1	2	2	3	1	4	1	5	2	6	1	7	1	8	2	9	2	10	2	11	2	12	1	13	2	14	2	15	2	16	2	17	1	18	1	19	1	20	9	11	403,17	532,38	61,959
2	1	2	2	2	3	2	4	1	5	2	6	2	7	1	8	1	9	2	10	1	11	2	12	2	13	1	14	2	15	1	16	1	17	2	18	1	19	1	20	9	11	393,12	476,94	67,440

Table-1 shows 5 sample chromosomes in the first population, including the best-rated chromosome.

Calculation of fitness value

The fitness value is calculated as follows. Which robot takes the material and the way it takes to get it is calculated.

Equation 1 for the robot 1,

Equation 2 is used for the robot 2.

Indicates the coordinate of the X axis b_1 and the coordinate of the Y axis b_2.

$$r_1u=\sqrt{(b_1(o)-1)^2+(|\ 31-b_2(o)\ |\ )^2} \quad (1)$$

$$r_2u=\sqrt{(32-b_1(o))^2+(|\ 31-b_2(o)\ |\ )^2} \quad (2)$$

With these calculations, the number of materials the robots take (rb1a, rb2a) and the total distance (uz1, uz2) are found.
The ratio of the total number of materials taken by robots to each other (t2)

$$rb_1a<rb_2a \quad \text{if} \quad t_2=rb_1a/rb_2a \quad (3)$$
$$rb_1a>rb_2a \quad \text{if} \quad t_2=rb_2a/rb_1a \quad (4)$$

and ratio of total distances (t21)

$$uz_1<uz_2 \quad \text{if} \quad t_21=uz_1/uz_2 \quad (5)$$
$$uz_1>uz_2 \quad \text{if} \quad t_21=uz_2/uz_1 \quad (6)$$

the product multiplied by 100;

$$Maxson = (t_2 * t_21) *100 \quad (7)$$

Maxson gives the fitness score.

$$Error=(100-maxson)=100-99.9=0.1 \quad (8)$$

When maxson> = 99.9 in Equation 7, the GA stops working. Because, as shown in equation 8, the error decreases to 0.1.

Selection

Tournament selection algorithm (with 2) was used as selection algorithm. (Daban and Ozdemir, 2004). Randomly two chromosomes are selected and one of them is taken which has better fitness value. This process is repeated once more and two chromosomes are selected for crossover.

Crossover

The data is crossed between two selected chromosomes with reference to a randomly determined point. Thus, a new individual is created.

Mutation

After crossover, randomly selected genes are changed randomly selected chromosomes from within the population.

In this study, the problem specific mutation process has been applied by changing the robot that takes the target material. In this way, it is possible to examine different areas in the research space and increase the diversity of the population.
After the mutation process, a new population is created. GA returns to the calculation step and the suitability value of the solutions is recalculated. If the result has been reached, the algorithm is terminated.

Results and Discussion

Three different experiments were performed with the developed algorithm (Figure 3). In these trials, it is seen that the best solution in the initial population starts with a score in the range of 83-88 and results in the iteration range of 24-38.

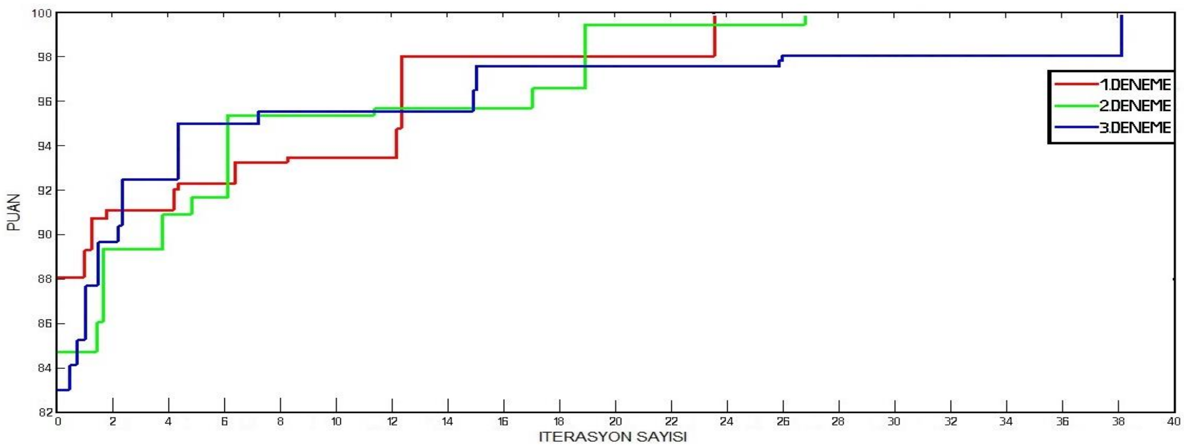

Figure 3. 3 different results obtained by GA

Table 2. Information on the best chromosomes in the first and last population

Robot2	item1	Robot2	item2	Robot2	item3	Robot2	item4	Robot1	item5
Robot2	item6	Robot2	item7	Robot1	item8	Robot1	item9	Robot2	item10
Robot1	item11	Robot2	item12	Robot2	item13	Robot1	item14	Robot2	item15
Robot1	item16	Robot1	item17	Robot2	item18	Robot1	item19	Robot1	item20
Robot1 bought 9 items		Robot2 bought 11 items		Robot1 travels 393,12 units		Robot2 travels 476,94 units		Score 67,440	
Best chromosome in the first population									
Robot1	item1	Robot1	item2	Robot2	item3	Robot2	item4	Robot2	item5
Robot2	item6	Robot2	item7	Robot1	item8	Robot2	item9	Robot2	item10
Robot1	item11	Robot1	item12	Robot1	item13	Robot1	item14	Robot1	item15
Robot2	item16	Robot2	item17	Robot2	item18	Robot1	item19	Robot1	item20
Robot1 bought 10 items		Robot2 bought 10 items ı		Robot1 travels 486,38 units		Robot2 travels 486,45 units		Score 99,984	
Best chromosome in the last population									

The best chromosomes in the first and last population are shown in Table 2 above. The information in the table shows which robot has received the target item, number of materials taken by robots, the total distance covered by the robots and chromosome score is given. The blue color is given for the first robot, the green is given for the second robot, and the red color contains the target item information.

Conclusion

The control and sharing of the robots' task was done with genetic algorithms. A success of 99.98% was achieved.

When the results of the study are examined, it is seen in Table-2 that 33% improvement can be achieved.

This work continues to develop functions including image processing and collision avoidance of robot arms in real time.

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Conflict of Interest: The authors declare that they have no conflict of interest.
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