

Presentation of a New and Beneficial Method Through Problem Solving Timing of Open Shop by Random Algorithm Gravitational Emulation Local Search

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Abstract

One of the most important problems of timing in engineering and industry is timing of open shop. The problem of timing of the open shop induces big and complicated solve space. So, this problem is a kind of NP-Complete. In timing of the open shop, there some works, that each work has several operation. Each operation should do in machine whit should do in the same machine the aim of timing of the open shop is to catch a suitable timing for doing all of the operation, how that enough time to minimize to make-span. In problem solve of timing of the open shop. Until now different algorithm were presented. In this article, a new algorithm that is called TIME_GELS is presented which used of a random. Algorithm Gravitational Emulation Local Search (GELS) for following problem solving. This algorithm is basic of the random local search use of two of the four main parameter of speed and the power of gravity in physics. A suggestive algorithm compared with Genetic Algorithm and result is show that a proposed algorithm has a better efficient and finding the answer very soon.

Keywords: *Timing; Open Shop; Genetic Algorithm; Velocity; Newton law; Gravitational force*

1. Introduction

One of the most important problems of timing in engineering and industry is timing of open shop. This problem was used widely in industry activity. For example imagine the making of an aircraft. To doing of all of the stage this work needs a precise and suitable timing. This problem is a kind of timing of open shop. Problem of timing of open shop includes of a big and complicated solve space, for this reason this is kind of NP-Completed problem. The aim of timing of open shop is catch a suitable timing for make-span operation so that to minimize for enough time to make-span. Unit now

different kinds of algorithm one presented that we hot iced some of them:

Dorndorf et al [1] used the bound branch method and innovative algorithms to solve Open System problems. They applied limiting branch methods to avoid non-optimal solutions. Brasel et al [2] presented some innovative algorithms based on adaptation algorithms and interpolation operations. Adaptation and interpolation operations mean which of the operations is used during combined timing with a search method. Other algorithms are also presented by Guerest and Prins [3]. Alcaide et al [4] presented a Tabu search algorithm to minimize make-span in Open Shop timing problem. Liaw [5] also presented a hybrid genetic algorithm, to minimize make-span in open shop timing problem. In addition Prins [6] presented a genetic algorithm cause find a proper solution.

In thin article a new method is presented basic of gravitational force algorithm (GELS) for timing of open shop. A proposed method has more attention on a better and best timing.

In the second part of the problem is expressed the gravitational force algorithm described in Section 3 and 4 in the proposed algorithm In Section 5 simulation results and the conclusions are stated.

2. Problem Description

There some work in timing of open shop that work will has several operations, in the other hand each work contains of some operations. In open shop systems each operation should have done in smellier machine, it means that the first operation of the work of j in should have done in the first machine and the search operation of the work of j should have done in second machine. The aim of timing of

open shop catching a timing of doing of whole of operation, so that as to minimize of the enough time to make-span. The problem of timing of open shop has a following limitation:

- 1) Each operation should have done in its corresponding machine.
 - 2) Each operation should have processed by one machine at the specific time.
 - 3) every time only one operation of one work can present.
 - 4) There isn't any priority of choosing of performer, it means the presentation of performer happen in each order.
- Table 1 is the sample of a timing of open shop that in includes 3 works and each work includes 3 operations that should present through 3 machines.

Table 1: A sample system of open shop

<i>Problem</i>	<i>Machine1</i>	<i>Machine2</i>	<i>Machine3</i>
<i>Job1</i>	7	12	16
<i>Job2</i>	13	10	13
<i>Job3</i>	18	14	2

For example, here the second operation of first work that enough time for performance is 12 should present by second machine. Fig 1 show Gant chart sample system table 1. The same as in Gant chart in fig 1 is identified j 1 o 1 (action 1 work 1) processed in time zero by machine 1, and also j 1 o 3 (work1, action 3) processed in time 23 by Machine 3 during 16 item. The time of make-span in this case would be sample of 39.

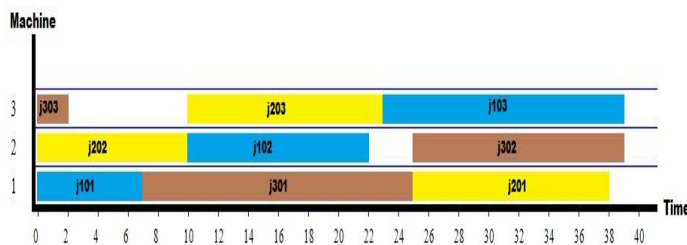


Fig. 1 Gant chart system sample table

3. Gravitational Emulation Local Search (GELS)

In 1995, Voudouris and Tesang [7] offered the algorithm GLS for searching in a search space and solving the example NP-complete for the first time, and in 2004, Barry and Webster [8] offered the algorithm as a powerful

algorithm and it was called GELS. This algorithm introduced randomization concept along with two of four primary parameters i.e. velocity and gravity in physics through swapping in terms of groups by using random number in the existing local search algorithm GELS in order to avoid local minima. GELS take as its basis the natural principles of gravitational attraction. Gravity works in nature to cause objects to be pulled towards each other. The more massive the object, the more gravitational “tug” it exerts on other objects. Also, the closer two objects are to each other, the stronger the gravitational forces are between them. This means that a given object will be more strongly attracted to a larger, more massive object than to another object of lesser mass at a given distance, and it will also be more strongly attracted to an object close by than to another, more distant object having the same mass. In GELS the formula of Newton gravitational force theorem between two objects, are involved in:

$$F = \frac{Gm_1m_2}{r^2} \quad (1)$$

In which m_1 and m_2 are the mass of the first and second object respectively. G is equal to a constant gravitational force which is 6.672; R is the radius of the distance between two objects.

GELS also emulate these processes of nature for searching in a search space. The idea is to imagine the search space as being the universe and object in this universe are the possible solution for the search. Each of these solutions has a “mass” that is represented by its objective function value. The better the solution’s objective function value, the higher its mass is. Locations within the search space that do not contain valid solutions are assigned a zero mass [8-10].

In this method, the possible solution in the search space has divided into some sets based on criteria that depend on the kind of problem and each of these sets is called a dimension of the problem solution and for each dimension of the problem solution a value entitled initial velocity has been intended, that it will be explained in continuation. GELS computers the gravitational force between the solution or the objects in the search space by two methods. The first method which is a solution from the local neighborhood space is selected as a current solution and the gravitational force between these two solutions can be computed. The second method applies the formula to all solutions within the neighborhood and tracks the gravitational force between each of them and the current solution individually all solutions. In the movement through the search space, GELS acts in two modes, too. The first mode, allows movement only to solutions within the current local search neighborhood. Each of these

movement modes can be used with each of the computation gravity forces and as a result those four models GELS are made.

GELS maintains a vector, the size of which is determined by the number of dimensions in a solution. This vector's values represent the relative "velocity" in each dimension. The algorithm begins by initializing the current solution, velocity vector and direction of movement. For each dimension, in the velocity vector, random integer between one and the maximum velocity is chosen, and this becomes the value of the element at that dimension. The initial solution can be made as current solution either with user or randomized. For each dimension in the initial velocity vector, concerning the initial velocity vector of the solution dimensions, a direction is selected for the movement that the direction is equal to the solution dimension which has the largest value in the initial velocity vector.

Algorithm includes a pointer object that can move through the search space and a mass which is intended for the pointer object is stable in the whole computations and this object refers to a solution with the largest mass. The algorithm will terminate when one of following two conditions occurs: either all of the elements in the initial velocity vector have gone to zero, or the maximum allowable number of iterations has been completed. In each algorithm iteration as the first method a candidate solution will be selected from the local neighborhood space of the current solution based on the direction of the current movement and the gravity force between the current solution and the candidate solution is computed and then the velocity vector concerning this force will be updated. For the next frequency, the velocity vector is checked and concerning it the movement direction can be chosen. Each iteration algorithm by the second method is completely as similar as the first method, but there is a little difference, as the gravity force and the initial velocity of the update action is computed for each of the candidate solutions instead of the gravity force computation and the update action of the velocity vector for only an obtained candidate solution from the current direction. Newton's formula is used with the alteration that the two masses in the numerator of the equation are replaced by the value of the difference between the objective function value of the candidate solution and that of the current solution. The value of the gravitational force between the two solutions then becomes:

$$F = \frac{G(CU - CA)}{R^2} \quad (2)$$

That, in which, CU and CA are the value of the current solution and the candidate solution. This formula is designed to be a positive value if the objective function

value of the current solution is larger than that of the candidate solution and negative if the candidate value is larger. Then the value of this force, positive or negative, can be added to the velocity vector in direction of the current movement. If doing so makes the value exceed the maximum velocity parameter setting, it is set to the maximum. If the update makes the value to go negative, it is set to zero.

Some parameters which can be accessible are as follows:

- Maximum Velocity: the maximum value that any elements within the velocity vector can have been used to prevent velocities that become too large for being usable.
- Radius: it is a radius that can be used in the formula of the gravitational force computation.
- Iteration: the number of iterations of the algorithm that will be allowed to complete before it is automatically terminated [11].

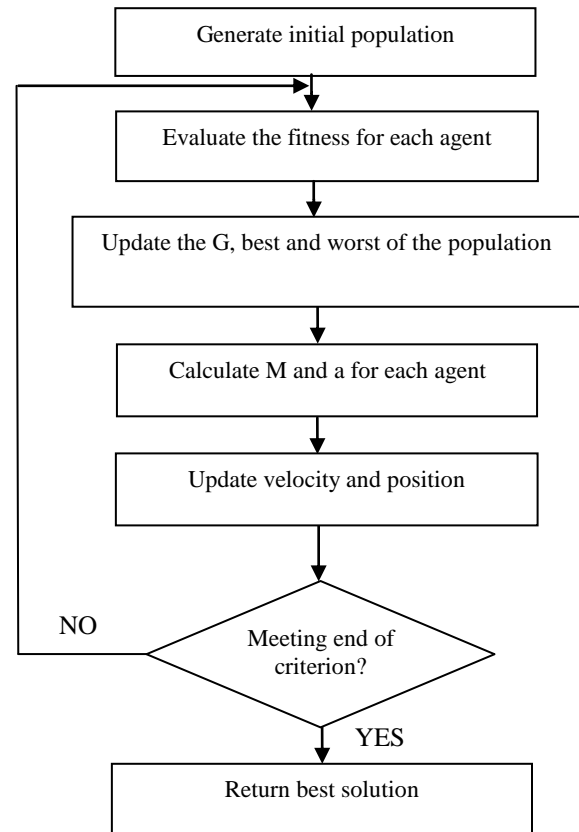


Fig. 2 Gravitational force algorithm steps [10]

4. Proposed Algorithm

In the proposed method of the random algorithm of gravitational emulation local search, (GELS), used as a strategy for problem solving of the open shop. The aim of this algorithm to catching a suitable and benefic timing for

doing of whole operation of work so that to minimize the enough time for make-span.

Proposed method of algorithm of the gravity power as a strategy used for problem solving of timing of the open shop systems. And it's aim is to minimize final time of performance of finishing work. To understanding proposed algorithm better, methods are explained on the sample table 1. In this case of sample, there are 3 works which each works has 3 operations and works should be presented by 3 machines.

4.1 The show of the produced primary chromosome

In proposed algorithm used for showing chromosomes of one dimension length of the number of whole operation. In this method the showing of chromosome, each gene is a unique integer which is produced following fig:

The operation of each work like a line numbering orderly and gives to each operation a unique number. Table 2 is presented the way of the numbering for sample system table 1.

Table 2: One sample of open shop timing

<i>Problem</i>	<i>Machine1</i>	<i>Machine2</i>	<i>Machine3</i>
<i>Job1</i>	(1)7	(2)12	(3)16
<i>Job2</i>	(4)13	(5)10	(6)13
<i>Job3</i>	(7)18	(8)14	(9)2

Fig 3 is presented a sample chromosome for sample system of the table 1.

9	5	6	1	2	7	3	8	4
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Fig. 3 The structure of sample chromosome

As in the structure of the chromosome you can see in fig 3. Each adornment number will show operation number that should processed by machine. For example the first gene contents is the number of nine that indeed noticed the operator or 3 from work 3. Each chromosome shows timing for make-span.

4.2 The fitness of function

The competence of chromosomes is noticed according to needful time for doing make-span. In proposed algorithm to catch the competence of integral has used formal 3.

(3)

$$Fitness = Max_{1 < i \leq n} \{ T_i \}$$

In this formula n is the number of work. T_i is the time of make-span in timing.

4.3 Definition of dimension solution

In proposed method answer dimensions can imagine equal to the number of presented operations to each machine so that to minimize enough time for make-span. Each operation should have done in a same machine is one dimension of answer, and the answer of neighbor in this dimension is equal to answer that the next operation of the same work should have done in the next machine.

4.4 Definition of neighborhood

In GELS algorithm doesn't do unlike the others algorithm of random searching for the answer of neighbor, so each answer have different neighbors which each one of them is the manner of the special change.

It's called side of movement to word the answer of neighbor and all of the neighbors which used this method, is only the manner of this neighbor.

In proposed method to find the answer of neighbor use this method. Each work contain some operations that in open shop system. Each work contain some operations that in open shop system. Each operation should have done in the same machine, it means first operation of j work should have done in first machine and the second operation of j work should have done in second machine.

In other word the current answer of the neighbor in this dimension equal of the answer which in next operation of same work should have done in next machine.

4.5 Solution problem

In proposed method of random algorithm of the gravitational emulation local search (GELS) used as a strategy for problem solving of open shop systems.

The aim of this algorithm is catching a suitable and benefic timing for make-span so that to minimize the enough time for make-span, so that each operation of the one work should present in the same machine and also each operation will process by one machine in the special time, more over in each time only one operation of one work can present. Solve of this problem, even though it doesn't have much difficulties for less number and machine. So algorithm of gravitational emulation local search is swayable way to solve this problem.

For problem solving of the open shop systems at first we showed notice three the distance, the primary speed and

time of Matris that distance and primary speed Matris create randomly. In speed Matris each one of operation of work is a density and will give a primary speed and then in the next steps speed will change and also time Matris in manner of distance and speed Matris are made by the following this relation:

(4)

$$T = \frac{\sqrt{(Y_B - Y_A)^2 + (X_B - X_A)^2}}{V_{in_{A,B}}}$$

By the use of GELS algorithm in this situation should define a suitable reservation factor. Reservation factor is the number of reserved operations from different work for machines in the future time. The collection of operation transfers only should process by the same machine and there is one solution. This solution can be like two Matris (n*n) that equals to the number of operation of each work and machines to show one answer used. In each line and column of this Matris it has shown one of the operation which is related to it self and the quantity which has kept in each line and column is shown the number of operation which should process by the machine that is related to it. When algorithm completed, the solution for each one of operation, some reservation machines with reservation factor is shown.

5. Simulated Results

To landing algorithm use of language of programming C#.NET and program is presented on the computer with processor GHZ Pentium. Iv 2.4 and Ram with GB 1. Proposed algorithm (TIME_GELS) has compared with GA algorithm. To compare the following algorithm, there are 8 collection of the designing test that covers small, average and big systems. Giving the name to the this data of the test is Test-J-o. In this giving the name method J shows number of the work, o shows the number of operation in each work in data of the test. The data of the designing test is shown in table 3.

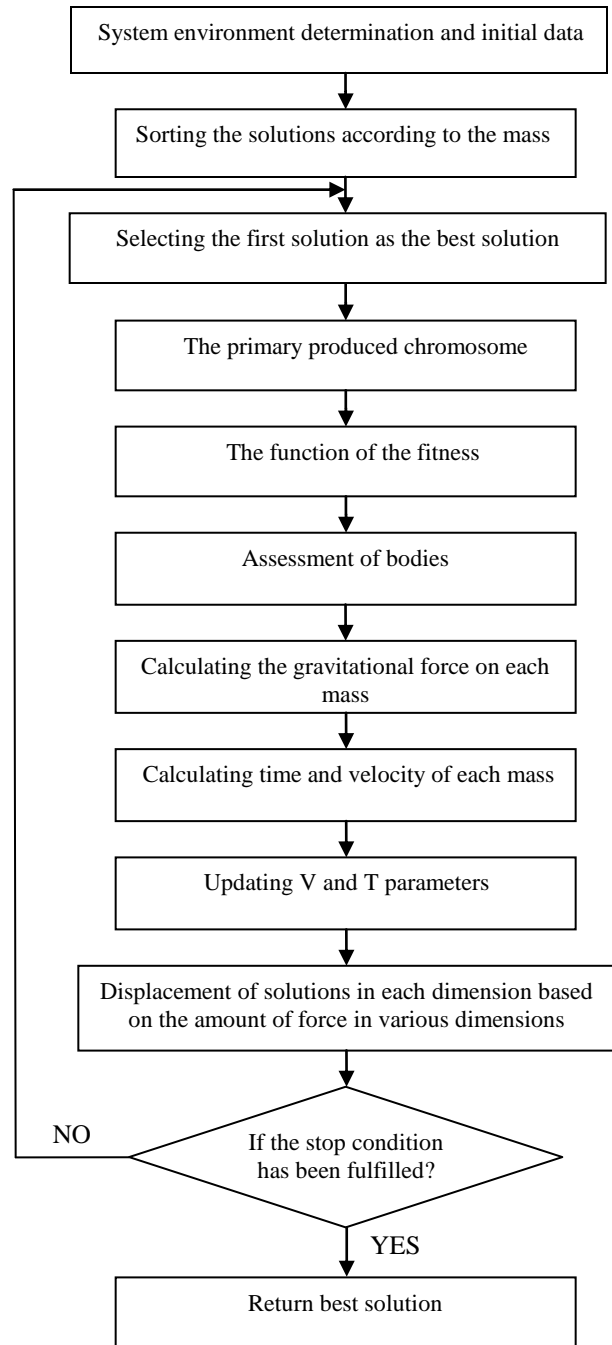


Fig. 4 The proposed algorithm

Table 3: The data of the designing test

Problem	TIME_GELS		GA	
	Time	Fitness best	Time	Fitness best
Test_4_4	5	175	18	266
Test_5_5	12	192	43	279
Test_8_4	17	341	80	485
Test_8_8	28	410	131	566
Test_10_10	31	598	245	702
Test_15_5	37	767	108	804
Test_20_10	46	842	268	1285
Test_20_20	54	1216	625	1896
Test_30_20	69	906	1832	1042

Table 4 will show the conclusion of presentation of proposed algorithm on the data of the test in table 3. So that you can see, the proposed algorithm finds a good and benefit answer in suitable time.

Table 4: The conclusion of the presentation of proposed algorithm

Test	The number of the work	The number of operation	The number of generation
Test_4_4	4	4	500
Test_5_5	5	5	600
Test_8_4	8	4	1000
Test_8_8	8	8	1200
Test_10_10	10	10	1500
Test_15_5	15	5	1000
Test_20_10	20	10	1000
Test_20_20	20	20	1000
Test_30_20	20	20	2000

Fig 5 Shows the table of competence of comparing of the two algorithm show by collection of the data of the test which is called 8-8. In this data of the test has 8 work that each works has & operation.

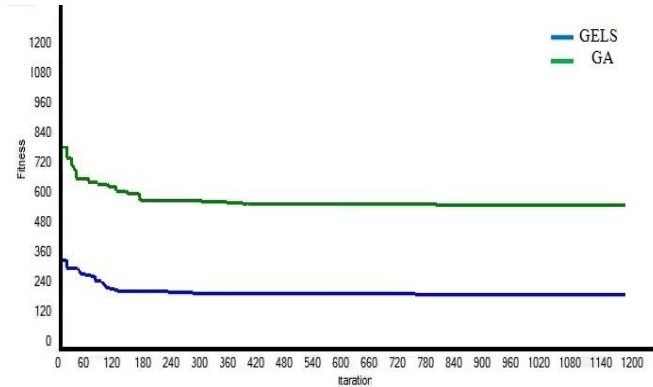


Fig. 5 Table of the competence of comparing of the two algorithm GELS and GA with collection of the data of the test 8-8

Fig 6 Shows the table dispersion of the compared of two algorithms by collection of the data of test which is called 8-8.

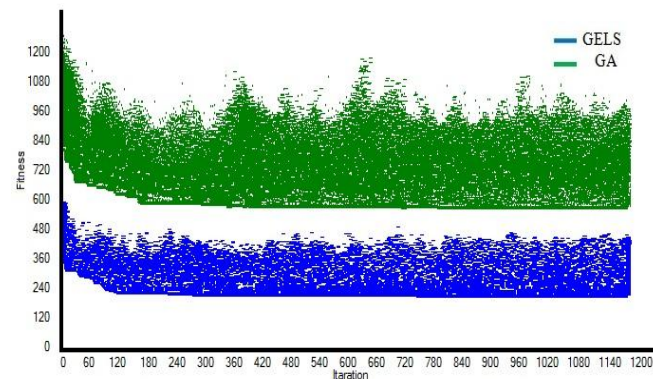


Fig. 6 Table of the dispersion, f the comparing of two algorithms by collection of the data of the test 8-8

Fig 7 Shows the table of competence of compared of the two algorithm show by collection of the data of the test which is called 20-20. In this data of the test has 20 works that each works has & operation.

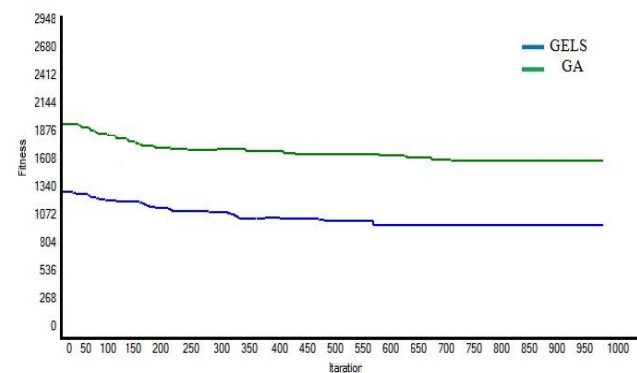


Fig. 7 Table of the competence of comparing of two algorithm GELS and GA with the collection of the data of the test 20-20

Fig 8 Shows the table of dispersion of the comparing of two algorithms by collection of the data of test which is called test 20–20.

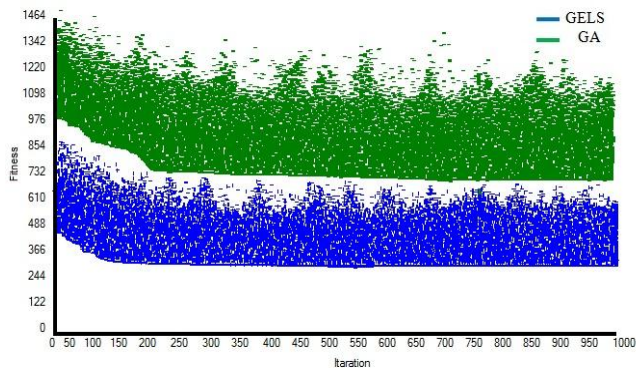


Fig. 8 Table of the dispersion of the comparing of two algorithms by collections of the data of the test 20–20

6. Conclusions

In this article one algorithm of gravitational force which is called TIME_GELS is presented for problem solving of timing of open shop. The lack of speed, time and number are the advantages of this algorithm. The aim of this algorithm to decrease the time of presentation and to catch a benefit and suitable timing for make-span so that to minimize the enough time to make-span. The efficiency of this algorithm has compared with GA algorithm and the finding has shown that a proposed algorithm has high efficiency and recovery rather than genetic algorithm. And the amount of this recovery is more visible in the big systems. Because of the enough time to find answer and optimum timing is important in problem solving of the timing of the open shop so spending less time in proposed algorithm is one of the disadvantages of this algorithm.

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