Hybrid Simple Genetic Algorithm (HSGA) and the Effect of using Fitness Functions for Layout Problem

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Received on: 18/11/2009
Accepted on: 7/4/2011

Abstract

In this research there is a wide study about Hybrid Genetic algorithm was presented in addition to Varity in fitness functions and there are effect on used algorithm.

Results occur by using disjoint algorithm with genetic algorithm. We applied on two matters which are the (10) ten objects and the more complex , the (30) thirty objects . This way called hybrid simple genetic algorithm. This way developed to solve this subject of different objects layout.

Keywords: Genetic Algorithm, Layout problem.

الخوارزمية الجينية الهجينة البسيطة و تأثير استخدام دوال الصلاحية في حل مسألة التوطين

الخلاصة

في هذا البحث تم تقديم دراسة واسعة للخوارزميات الهجينة البسيطة بالإضافة إلى التنوع في دوال الصلاحية ومدى تأثيرها على الخوارزميات المستخدمة.

أن النتائج تتحقق من خلال استخدام الخوارزمية الجينية و خوارزمية أبعاد الكيانات (الفصل). تم تطبيقها على مسالتين هما الـ (10) كيان و الأكثر تعقيد الـ(30) كيان . وإن هذه الطريقة يطلق عليها الخوارزميات الجينية الهجينة البسيطة ,حيث طورت هذه الطريقة في حل مسألة توطين الكيانات المختلفة.

1. Introduction (Basic Premise)

Spatial configuration is concerned with finding feasible locations and dimensions for a set of interrelated objects that meet all design requirements and maximize design quality in terms of design preferences[2]. Spatial configuration is relevant to all physical design problems, so it is an important area of inquiry. Research on automation of spatial configuration includes

Component (packing [3–4], route path planning, Hospital [5], process and facilities layout [6–7]). Architectural layout is particularly interesting because in addition to common engineering objectives such as cost and performance, architectural design is especially concerned which are generally more difficult to describe formally. Also, the components in a building layout (rooms or walls) often do not have pre-defined dimensions, so every component of the layout is resizable.

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https://doi.org/10.30684/ etj.29.6.11
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Genetic algorithm(GA) have proven to be a well suited techniques for solving selected combinatorial optimization problems. When solving real-world problems, often the main task is to find a proper representation for
the candidate solutions. Genetic algorithm(GA) based approach is quite simple and involves treating the layout design as problem. This process involves defining an ordering of objects and a placement for obtaining the actual layout by placing objects in the given order . The efficiency and effectiveness of the placement algorithm employed in decoding algorithms lack the requisite efficiency and efficacy required in most layout design problem domains.

These limitations become more pronounced when aesthetic values, such as symmetry, are among the determinants of layout utility. Consequently, an important step in designing and realizing an effective is the development of some improved heuristics, especially ones that may provide layouts with higher aesthetic values [1].

2. Problem description

The objective of the layout problem is to position N square objects with heterogeneous radius (i)into an area. And here used same of **Constraints as follow:**

1-Repetition Constraints: Ensure that no two objects occupy the same space (location).

2- Overlap Constraints: in order to prevent overlap of objects .(For example preventing object i intersecting–overlap object j).The distance between all pairs of objects are optimized according to cost matrix C [8].

3. Definition of the cost matrix(c)[2,9,10]

The cost matrix (C): is the N * N with each corresponding to specific priority of relationship between two objects.(the priority will give according dimensions(distance)).
Equation(1) illustrate to defines the cost of connectivity for each pair of object, with minimal *flow costs* (fc) used equation(2)

$$c = \lfloor c_{i\ j} \rfloor , where \quad i, j = 1 \ldots n \quad ......(1)$$

$$fc = \sum d_{ij} * c_{ij} \quad ,.......(2)$$

Where:
d_{ij} : Represent the distance between objects .
c_{ij} : Represent the cost between objects .

4. Genetic Algorithms in Layout Design

The high degree of subjectivity, multiplicity of evaluation criteria, and combinatorial complexity of the layout design problem indicates the difficulty in automating the layout design process. Intuitively, heuristics have been successfully employed and studies have demonstrated the efficacy and promise of such approaches. GA are the most frequently elected and researched ones . We have elected for GA in developing due to various inherent features, which are advantageous in procuring superior diverse layout alternatives. Incidentally, the diversity in layout alternatives is a critical factor in effective decision-making in the layout design.Indeed, the freedom conferred by relatively relaxed requirements of GA in terms of problem formulation is also a big advantage. GA do not require much knowledge on the underlying rules or search space but simply a fitness function to evaluate how the fitness of solutions. Furthermore, GA may also be used for simultaneous and parallel optimization against several fitness metrics. As such, may be perceived as logically complementing the abilities of a knowledge-based system to reason about the application of different rules in dynamic, subjective, and uncertain scenarios, which is often the case with layout design problem [11,12,1].

5. Proposed Approach

The Hybrid Simple Genetic Algorithm (HSGA) used in this work is defined by three basic operators(binary tournament selection, crossover, and mutation). Through the successive application of these three operators, an initial population of solutions is evolved into a highly fit population.

5.1 Problem Representation

In this work, representation the chromosome is based on object (objects means: representing the buildings or any thinks). This encoding include that will type absolute encoding, where each object had its x and y position directly encoded on chromosome .Figure (1) illustrate the Problem Representation and Figure(2) illustrate a chromosome with six objects.

Where,
L: Length of area.
W: width of area.
X, Y: Coordinate of object
Len: Number of objects

It, Illustrate the Figure (1)the picture of Problem Representation, can be specified either by domain experts or through some algorithm based on a maximum number of objects that could be placed in a given space, amount of white space desired, we have not allowed leaving some objects out of the layout design. Such a representation of a layout solution as problem permits the use of popular manipulation techniques for searching the solution space.

5.2 Fitness Function

This work proposed fitness function to compute the fitness value for each chromosome in the population . There are number of fitness functions are used such as:

1-

$$Er = \sum_{i=2}^{n}\sum_{j=1}^{n-1}\left(\frac{desire - actual}{desir}\right)^2 .....(3)$$

$$Er1 = \frac{Er * 2}{4 * len} ....(4)$$

$$fitness = \frac{1}{1 + Er1} ......(5)$$

Where,
desire: desired distance between object i and object j.
actual: actual distance between object i and object j.
n: number of objects.
Er: sum of error.
Er1: The vector for improvement up to specific value.

2- As we have discussed above, that the fitness function used was not suitable for this problem,(the previous fitness function is used without greedy). For enhancing proposed results the following fitness functions:

a- Er1= (Er1*4)/ (l*w*8)….(6)
Where,
l: the length of area,
w: width of area

Equation (6) replaced with equation (4))for enhancing results and will obtaining the requested value.

b- also the following proposed algorithms are:[2]

The conclusion equations from pervious proposed algorithms as follows:

A=((DS+Sol)*2)/(4*Len*Len)+Er (Non-linear) …… (7)

A=DS+Er (Linear) …… (8)

Fitness= A/Tc …… (9)

Where,

DS: The fitness takes the distance between each pairs of objects,

Er: sum of error computed according to equation (3)

Sol: the distance between each object and every other object.

Tc: total cost

Also used the

Er1=(Er1*2)/(4*Len*Len) ……. (10)

Er1=(Er1*2)/ (4*Len*Len*Len) ……. (11)

Where

Len: No. of objects.

Can be using the previously suggested fitness functions (that include equations (9), (7)).

Notes that:

1- Equations (4) and (6) used with equation (5).
2- Equations (8) and (7) used with equation (9).
3- Equations (10) used with equation (5).
4-Equations (11) used with equation (5).

5.3 Genetic Operators

In this work operators are used:

5.3.1 Selection Operator

The selection operator selects individual layout solutions for genetic evolution. There is a diverse set of selection strategies available in the literature. However, a rank based elitist selection strategy, commonly known as biased Roulette Wheel selection, is one of the most common selection strategies with a bias towards selecting the fitter solutions [13,1]. Selecting fittest individuals is also a popular strategy.

5.3.2 Crossover Operator

In this work, two types of crossover operator are used. These are:

1) Without greedy:

Add a new breakpoint resulting in splitting of a chromosome or layout configuration .Note two-break point (k1< K2& k1, K2 ∈ {0… Len})and exchange genes between these points see Figure (3).

But important thing when used the two-break point that are chosen at random and segment between them are exchanges here may be appearance problem (”repetition”). One good approach to solve this problem is used greedy algorithm.

2- Greedy algorithm [14,2]:

In this work used the following algorithms:-

A-In this work, in this algorithm don’t need probabilitisti’c transition rules to guide their search, therefore the crossover obtain are 100%.

b-This operator constructs an offspring from two parent tours as follows:

-Pick a random object as a starting point for the child's tour.

-Compare the two edge leaving the starting object in the parents and choose the less error edge.

-Continue to extend the partial tour by choosing the less error of the two edges in the parents which extend the tour.

-If the shorter parental edge would introduce a cycle into the partial tour then extend the tour by random edge.

- Continue until a complete tour is generated .

5.3.3 Mutation Operator

In mutation, altering a single solution generates new individuals. In the context of the layout design problem, mutation results in diminutive changes in an existing layout. In itself, mutation amounts to random search of solution space with an incremental random modification of the existing layout and accepting it if there is an improvement.

The following mutation operators are used in the proposed GA and mutation operators are used on two parents (say *Sj* and *Sk*):-

The following steps are :

1- Copy element of the *Sj* at a random position *p* in the new child. It should be noted that *l* L<□ $=p<=len$.

2- Fill up the remaining elements of child with other elements of *Sk* in the same order.

5.3.4 Disjoint Algorithm[2,1]

The following are used in the proposed GA :-

a) The disjoint algorithm first sets a priority schedule according to the distance of the objects from the center of the floor. Those objects close to the center of the floor are considered volatile and thus are given lowest priority, while those in corners of the floor are considered fairly stable. This ranking is also similar to measuring the distance that the machine has changed since the last iteration.

b) Next, objects are placed according to the priority schedule, with highest priority being placed first. If the object overlaps with another machine, it is moved in the direction in which the two machines overlap and is moved as little as possible to remove the overlap. This process is iterated until the object is clear of any other machines. After all objects are placed safely, the algorithm terminates.

6. Experimental Results

The proposed approach is tested on two problems (10 and 30 objects layout) . The descriptions of these are shown in Table (1).

In this work, we started the experiment by executing this algorithm over ten trials and then taking the average of the ten trials in both best fitness and generation. The results are shown in table (1) and table (5).

6.1 case I

The results of applying the proposed way are shown in Table (2). In case greedy used equation (6) with equation (5) , In case without greedy used equation (4) with equation (5) and for both cases used the (10 and 30) objects .

Greedy algorithm with hybrid simple genetic algorithm are clearly performed much better without greedy .The greedy is the reason for much of the success in this project, which can be seen simply from the fact that most of the fitness in the random population with greedy are close to the best value achieved without greedy.

6.2 case II

The results of applying the proposed way are shown in table (4) and table (5) .will show the effected of different fitness function :

From Table (4) and (5), show that is:

- Different fitness function are used.
- Using equation (5) didn't reach optimal solution.
- Using equations (6,7,8,10), that are used greedy, these was used to access the optimal solution.
- linear or non linear equations are affected by the size of population. Will take population size larger (increase) than the other fitness functions .

- Access to the optimal solution where it is almost stable when all fitness functions used, excepted linear, or nonlinear equations .
- Linear or non linear equations are affected by number of generations. Will take number of generations larger (increase) than the other fitness functions .

7. Conclusions

The performance of the suggested approach proves that :

1. Were able to solve the object this layout problem by using Hybrid Simple Genetic Algorithm .
2. The advantage of the proposed algorithm is that the object layout can be determined using minimum amount of data, offering an advantage in areas where the cost of changing from one object to another is noticed to lack availability of data on the cost incurred per distance of movement, also to find the relative location of object in designated areas.
3. Different fitness function are used.
4. Fitness function depends on the dimensions of the problem's area (length, width of area) or the number of objects .
5. In this research where is Application of distributed random where is the distribution of objects will be randomly by creating different density (the distribution will be different density of objects), and the distribution will be in high density in same places and less density in other places and thus continuous, and this changes from case to another (chromosome to another).

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Table (1): Show the parameters values used in proposed methods

	pop size	Pc	Pm
Case II	20	0.8	0.1
	60	0.8	0.1
Case I	20	0.8	0.1

Table (2): Results of HSGA For (10) objects Layout Problem

Operator name	Trails	Best fitness	Gen
greedy	(10/10)	0.922207952000	54.25
Without greedy	(0/10)	0.60006408122	1658.75

Table (3): Results of HSGA For (30) objects Layout Problem

Operator name	Trails	Best fitness	Gen
greedy	(10/10)	0.91498666021	311.5
Without greedy	(0/10)	0.839991202431	871.25

Table (4): Results of HSGA For ten-objects Layout Problem.

Type of crossover	**Best-fitness**	**Gen**	**Trail**	**Pop size**	**Fitness function that used**
greedy	0.935005839573021	38.35	(10/10)	20	Used equation(5) with equation (6)
greedy	0.93535251906984	56	(10/10)	60	
greedy	0.41758255037212	89.375	(0/10)	20	Used equation(8) Linear with equation (9)
greedy	0.859769843017876	247.5	(7/10)	60	
greedy	0.634113862015796	222.222	(2/10)	20	Used equation(7) Non-linear with equation(9)
greedy	0.89424836631 22	400	(9/10)	60	
greedy	0.94518813723248	64.25	(10/10)	20	Used equation(10)with(5)
greedy	0.93518813723248	31.875	(10/10)	60	
Without greedy	0.67101308538098	540	(0/10)	60	Used equation(5) with equation (4)
	0.6086640812200	1478.70	(0/10)	20	

Table (5): Results of HSGA thirteen objects Layout Problem

Type of crossover	Trails	Best fitness	Gen	Fitness function that used
Without greedy	(0/10)	0.835891202431	861.25	Used equations(11) With equation(5)
Without greedy	(9/10)	0.94987661021	340.55	

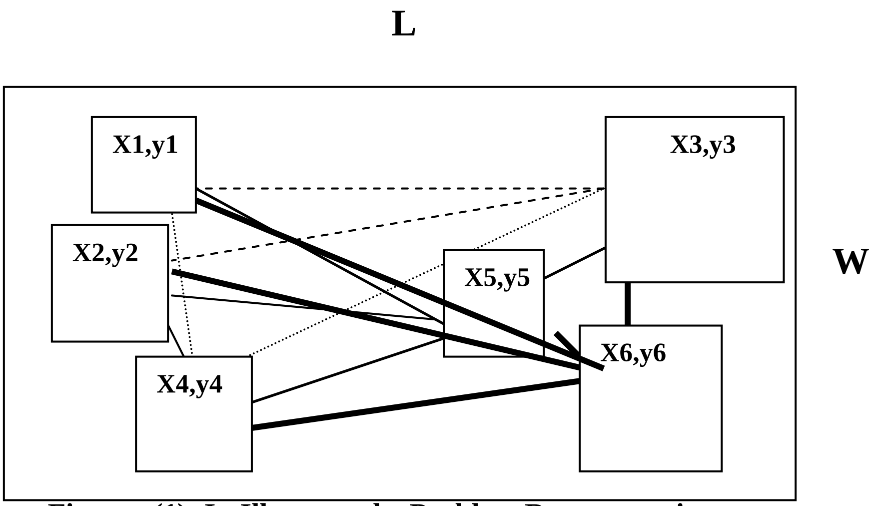

Figure (1): It, Illustrate the Problem Representation

position	X_1Y_1	X_2,Y_2	X_3,Y_3	X_4,Y_4	X_5,Y_5	. . . . .X_NY_N

Figure (2): Illustrated a chromosome with six objects

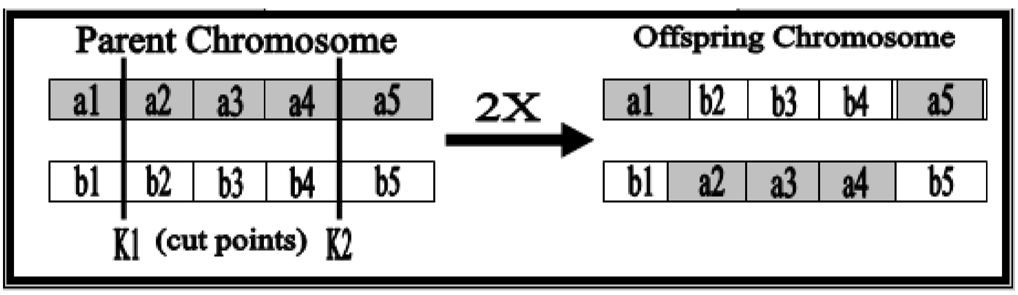

Figure (3): Represent the type of Crossover(without Greedy Crossover)

Algorithms //fitness functions
Input: the distance
Output: fatnesses value

Loop for the distance between each pairs of objects
Finds the percentage of correctness of that distance relative to optimal distance indicated by their cost matrix.

The correctness is simply (1-Er).
This correctness is then multiplied by cost matrix and added to the total fitness for the given layout
End loop (obtained the equations 7, 8)

The total fitness after all cost has been measured is then divided by the total cost represented in the matrix flow cost. (Obtained the equations 9)

End.