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# FORMULATION OF CIRCLES ARRANGE IN THE RECTANGULAR SHEET FOLLOWING GENETIC ALGORITHM

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***Abstract: In this paper, we concentrated on resolving the problematic of circles arrangement in the rectangular plate. We formulate the equations for circles arrange in the rectangular plate as per use of Genetic Algorithm(GA) and it's variants for the various field of the Mechanical engineering & other engineering discipline. Genetic algorithm is method for optimization based on the mechanics on the natural selection and the natural genetics. This method is also used for solving nonlinear, non-smooth, non-continuous problems and this problem is nonlinear problem.This paper discoursesa small number ofthe formulae of GA and put on the function optimization and System Identification and the application and limitations.***

***Keywords: Genetic algorithm, Optimization, Variant of GA***

## I. INTRODUCTION

*1.1 Introduction of problem*

In many industries have to cut the circles from the rectangular plate but they have a problem like how to cut circles which cannot overlay each other and no more waste material goes. There are some real problems like this is given below.

*1.1.1 Light pipes packing problem*

In this problem it is necessary to both put circles inside circles and circles inside a rectangle the problem is as shown in figure [13]. Here shows the wire pipes are packed into a pipe which carry the wire pipes or trucks. In building or automobile vehicle this packing is very necessary for compact size of wire fitting and making good layout of vehicle.

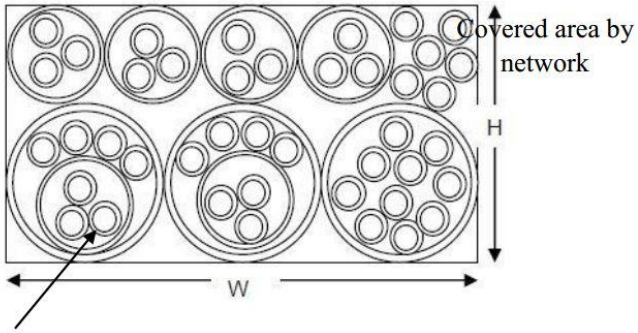


Fig 1: lighting pipe packing problem

Here shows the wire pipes are packed into a pipe which carry the wire pipes or trucks. In building or automobile vehicle this packing is very necessary for compact size of wire fitting and making good layout of vehicle.

*1.1.2Coverage problem for wireless sensor network*

In this problem it is necessary to put circles inside undefined area or a rectangle area but there is difference from above problem is, In this circles can overlap each other.

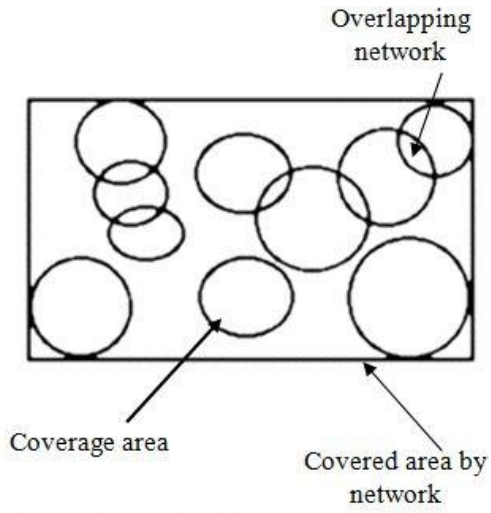


**Fig 2:** Example of Coverage problem

In this problem we can't use equation (7) for solving this, we have to neglect this equation and solve by another equations of this formation.

*1.1.3 Metal part of car wheels cutting from rectangle sheet*

In this problem it is necessary to put circles inside rectangle metal sheet and after it cut from there. The part is as shown in figure.

**Fig 3**: Metal part of wheels

The metal part of car's wheels through generally round but often they have underlying pattern based on rectangular polygon. Mostly this problem solve as a packing problem.

  

*1.1.4Packing different sized circular pipe into a rectangular shipping container*

In this problem it is necessary to put circles of different sizes into a rectangular shipping container. Here taking the cross-section view of container, so this problem is converted into a two dimensioned problem [12]

*1.2 Introduction to genetic algorithm*

Genetic algorithm have a wide-ranging of a global optimization method. [1] The genetic algorithm is constructed by John Holland and his collaborators in 1960-70. Genetic algorithm is a research and optimization methodology rest on the standard of the natural genetics and selection.[2] Genetic algorithm are used to resolve multi-optionality problems of the optimization in the mechanical engineering, where optionality function and constraints are definite as terms of decision variables using the different reproductions. GA is motivated by the Charles Darwin theory of the evolution – "survival of the fittest" [1]. GA is a deterministic method which is guarantee for the optimization determination. Genetic algorithms are typically used to discover solutions to optimization and search problems by relying on bio-inspired operators such as selection, mutation, and crossover.

Many real life problems from the fields of engineering applied science, and management science are produced as a non-linear optimization problem. These problem are very difficult to solve using traditional optimization methods for the reason that of their non-continuous, non-linearity, non-smooth and non-differentiable [3].These problems are solved by the Constructive algorithm heuristic, greedy algorithm, genetic algorithm, Dspur algorithm etc. Constructive algorithm and Dspur algorithm is part & expansion of greedy algorithm, where greedy algorithm have a main disadvantage is that it is not give always optimal solution in all local and global problem. Hence, genetic algorithm is used for solution and it have parts of selection, crossover and mutation. Since then many variants of genetic algorithm are developed and uses to an optimization problem [4].

*1.3 Process of Genetic Algorithm*

Genetic algorithm is popular heuristic for solving the optimization problem. It fits in the evolutionary algorithm [5]. GA are search procedures that Generated on the natural selection and natural genetics. GA does not guarantee for give optimal solution will found, but it gives a good result [6]. GA have the terms like selection or the generation techniques, crossover and mutation or simulation operator. This operations creates a loop as shown in the figure.

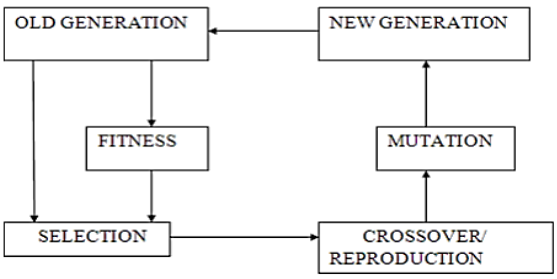


Fig. 4: Genetic loop

As per figure genetic algorithms is start with the set of solutions called as generation or chromosome. Then the solution are go ahead as a selection best solution of them and after mutation it gives optimal solution. Here selection, crossover, mutation are known as the genetic operators.

Selection: Mechanism for selecting the good solution as per their fitness. Fitness is the optimality of the function.

Crossover: crossover is merging the two individual's information [11]. The efficiency of the crossover is depended on the phenotype and genotype.

Mutation: Mutation is changes the chromosomes or other deformations genes [11]. Mutation is used to stand genetic Steersity from one generation population to the following.

After completing these all operators as per loop chromosome comes close to the optimal solution and further the loop is started. After many iterations optimal solution is given out by this genetic algorithm. This amount of repetition is depend on the fitness of the chromosome which certain and the robustness of the resolution. Here fitness of the selected chromosome and the robustness is inversely & directly proposal to the number of iteration respectively. The vocabulary genetic algorithm to engineering as below [2].

| Genetic algorithm | Explanation |
|---|---|
| Chromosome(individual) | Solution |
| Genes | Part of solution |
| Phenotype | Decoded solution |
| Genotype | Encoded solution |

Advantage of genetic algorithm over usual optimization heuristic are as the ability to deal with the complex functions and parallelism. Genetic algorithm is solve the problems which objective function is stationary or non-stationary, linear or non-linear, continuous or non-continuousand also for non-differentiable [4]. Because chromosome in population act like independent variable, so population may go in many direction simultaneously. This characteristic include parallelize feature in the algorithm for optimization.

However, Genetic algorithm have some disadvantages. The formulation of the 'fitness function', usage of 'population size', 'rate of mutation' and 'crossover' and 'selection criteria of the population'occupied carefully. Any incorrectselection will make it hard for the algorithm or it will be become a worthless [4].

Application of genetic algorithm are as use in solving the problem of distributing a plant or facility [2]. Flow shop sequencing problem or assembly line problem are optimized by genetic algorithm and also use for the designing the suspension system of automobile [2].genetic procedure uses for resolve of the cutting factors in machining operations is recommended [7]. Flywheel project and development has control in many request where minimalizing mass is critical, so genetic attitude is used [9].the stability of cutting tool is depend on the cutting force, so for reducing the cutting force genetic heuristic is used [8].

*1.4 Variants of Genetic Algorithm*

*1.4.1Real coded genetic algorithm*

In this algorithm, the chromosome must be remain same

  

length for the optimization solution of the problem. It is the expansion of the binary coded genetic algorithm, so it have many advantages on the counterpart of the binary coded genetic algorithm when it have a large quantity to search[2,6]. Here, algorithm works with the large quantity domains so it sacrifices precision as the binary genetic algorithm. As well as the same size of chromosome is not possible in all problems like – circular cutting, distribution of resources. Further, RCGA increase the capacity of local tunning, so the knowldge of the domain problem is increase. Hence performance of genetic algorithm is increase.

*1.4.2 Binary coded genetic algorithm*

The binary coded genetic algorithm is repeatively alternation a set (individual or population) of a matematical form, each with a related fittest value. Into the new generation as per darwinian theorem, fittest value and robustness of old generation are may be seen. This algorithm need to solve with very carefully, because it have repeatively steep of mathematical model and this heuristic is difficult to solve long and different algorithm - like in problem have some differentiable chromosome and some non-linear then problem is difficult.

*1.4.3Differential algorithm*

Differential algorithm is interchange the crossover and mutation method of genetic algorithm by substitute differential operators. It has skill to resolve non-differentiable and nonlinear and multimodal cost functions. Differential algorithm ease of use, i.e.somecontrol variables to direct the minimization. These variables should also be robust and easy to choose [10]. But there is Parameter tuning of necessary. Similarconstraints may not assurance the global optimum solution [10].

*1.4.4Least mean square algorithm*

Least mean square (LMS) algorithm, toorecognised as the "delta rule" or the "Widrow-HofSrule" (Widrow and Hoff, 1960). LMS are used convenient filters to find the co-efficient that interact to producing the least mean squares of the error signal (difference between the actual value and desired value) [2].The LMS algorithm has set up itself as an important functional block of convenient signal [6]. It provides some highly desirable features like Simplicity of functions and ability to operate satisfactorily in an unknown environment so robustness is increase.

*1.4.5 Saw-tooth genetic algorithm*

In the technique,take a variable population mass with periodic initialization is used that follows a saw-tooth scheme byexact amplitude and period of variation.In each period, the population size reduces linearly and at the start of the following period arbitrarilyproduced individuals are attached to the population [6]

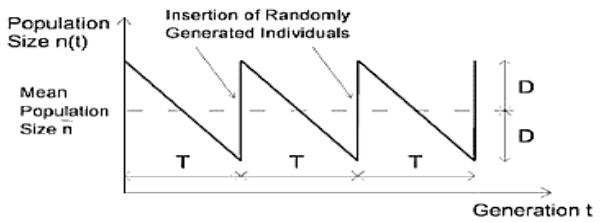


Fig. 5: Variable population of the saw-tooth GA

## II. SIMPLE ALGORITHM FOR SOLVING PROBLEM

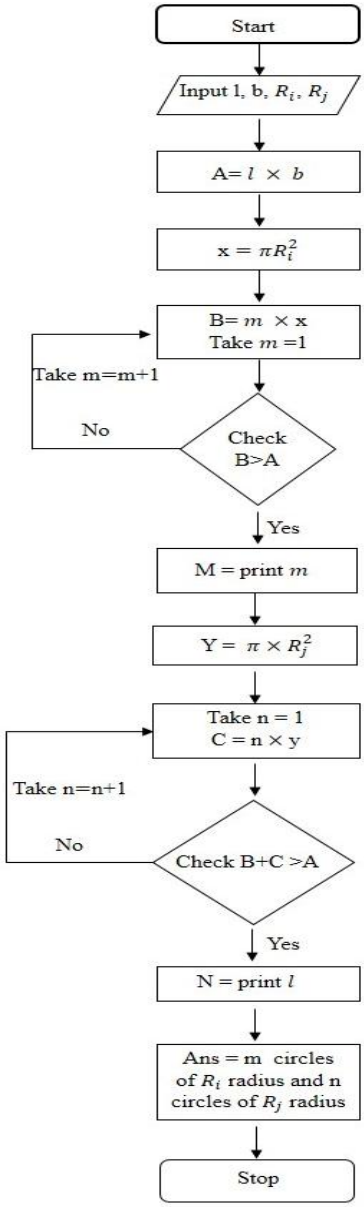


Fig 6: Algorithm for arrangement of circle

*3.1 Assumption*

For solving this type of problem we need to create a simple algorithm which can solve this problem. Also there is value or conditions to solve the algorithm, here as below flowchart is given for solving the problem.

- Take an index set $I$ for the circle radiuses arranged in the rectangle and $i$ is the element of this set.
- Let $R_i$ be the radius of the $i$-th circle (in cm). While there will be some circles with the same radius, they are each indexes separately and the range taken for the radius is 0 to 37 cm.
- Let $l$ and $b$ denoted respectively for vertical and horizontal dimensions of the rectangular plate.
- For$i \in I$ , let $G_i$ represent the benefit of the $i$-th circle is stated in the rectangular plate. $G_i$ is the objective function co-efficient for the formulation. The value of the $G_i$ is taken as below-

  

- $G_i = \frac{\pi R^2}{l \times b}$, shows the density of the circle.
- If there is question of priority then $G_i$ is a measure of priority for the $i$-th circle.
- $\delta_i$ is the decision variable for the formulation.
- $\delta_i =$ 1 , if the $i$-th circle is in the
- rectangle
- 0 , if not in the rectangle
- If the $i$-th circle is in the rectangle, then $(x_i, y_i)$ is co-ordinate of the centre of the $i$-th circle. as shown in the fig. below.

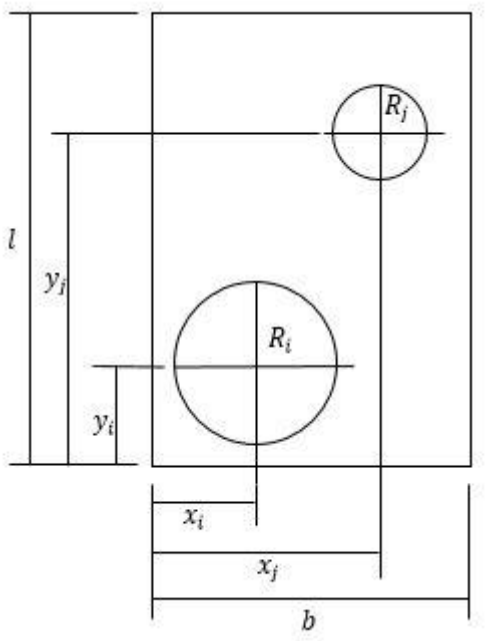


Fig 7: Notation for formation

*3.2 Formulation*

Using the nomenclature and assumption of above, the formulation of the circle arranging for cutting problem can be written as below.

Maximize $\sum_{i \in I} G_i \delta_i$ (1)

Subjected to

$\delta_i R_i \le x_i \le \delta_i (b - R_i)$ , $\forall i \in I$ (2)

$\delta_i R_i \le y_i \le \delta_i (l - R_i)$ , $\forall i \in I$ (3)

$\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \ge \delta_i \delta_j (R_i + R_j)$ , $\forall (i,j) \in I$ (4)

$x_i > 0$ , $y_i > 0$ (5)

$\delta_i \in \{0,1\}$ (6)

Here, constraints (2) & (3) is gives the surety of that the no portion of the circle is extend outside the rectangle area and the constraint (4) is for the any pair of circle inside the rectangle is not overlap each other. It said that the Euclidian distance between the centre of this circle is must equal to the sum of radius of this circles. Constraint (5) is for the centre of the circles are nonnegative. Constraint (6) is specify the condition that the circle is located in rectangle or not.

*3.3 Constancy of the circle*

A stable solution is express as the circle is touching any side of the rectangle or any circle or resting on the two supporting circles.

Using the notations introduced in section 3.1, let the index set $J \subset I$ represent the set of circles previously arranged. It is assume that the circles in the set $J$ is in stable condition, so take $i, j \in J$ but the third circle $k \notin J$ but $k \in I - J$. At this $i$-th and $j$-th circle is in stable condition and $k$-th circle is to be trace in rectangular with stable condition.

$t_k(i) = \sqrt{(x_i - x_k)^2 + (y_i - y_k)^2} = (R_i + R_k);\ i \in I, J\ ;\ k \in I - J$ (7)

If equation (7) is satisfied than the $k$-th circle is traced in the rectangle but this circle is stable if any one condition is satisfied from following conditions.

The conditions for stable are:

- $x_k = R_k$ and $y_k = R_k$ (left corner of the rectangle)
- $x_k = b - R_k$ and $y_k = R_k$ (right corner of rectangle plate)
- $y_k = R_k$ and $t_k(i) = 1$ (bottom and touch to $i$-th circle)
- $x_k = R_k$ ; $t_k(i) = 1$ and $y_k > y_i$ (touch to left side and on the $i$-th circle)
- $x_k = b - R_k$ ; $t_k(i) = 1$ and $y_k > y_i$ (touch to right side and on the $i$-th circle)
- $t_k(i) = 1$, $t_k(j) = 1$ and $\text{Min}(x_i, x_j) \le x_k \le \text{Max}(x_i, x_j)$,
- $y_k > y_j + (x_k - x_j)[(y_i - y_j)/(x_i - x_j)]$

The position is also a feasible position for the $k$-th circle does not intersect with other circles of any circle of the set $J$ due to the following of the equation (2) – (5)in section 3.2.

A unstable solution is express as the circle is not follow any one condition of above.

## III. LITERATURE REVIEW

Ms.Trupti Bhoskar, Mr. Omkar K Kulkarni[1] reviewed the genetic algorithm and the variants of the genetic algorithmand application of the genetic algorithm in mechanical engineering.

Mohammad Zahid Rayaz Khan , Dr. A K Bajpai [2] reviewed the variant of the genetic algorithms with its operators, also reviewed the need, benefits and application of the genetic algorithm in mechanical engineering

B.A. Sawyerr , A.O. Adewumi , M.M. Ali [3] investigated the brief in real coded genetic algorithm using 30 test problems . also includes the random local search in genetic algorithm improves the genetic algorithm improves the quality of genetic algorithm.

Xin-She [4] reviewed the genetic algorithm, role of genetic algorithm and variants of genetic algorithm.

Mhand Hifi, Rym M'Hallah [5], investigate about the algorithms are used about the circular cutting problem by constraints and genetic algorithms heuristic. They conclude that the best heuristic for circular cutting with respect to time. The use of parallel approaches will increase the size of the problem that can be solved.

Rakesh Kumar Patnaik [6] reviewed about the genetic algorithms and variant of genetics algorithms LMS gives the better result than the binary algorithm. Each variable investigated by differential method and real coded genetic

  

algorithm. Doriana M. , Roberto Teti [7] investigate the GA based optimization of turning parameters and find out the capability of performed multi-object optimization, minimum machining time while considering technological and material constrains. MOuleeswaran senthil Kumar, Yogesh Kumar [9] investigate the optimization is carried out to find out the minimum mass and respective values of the radius and angular velocity. Mahamad Nabab Alam [10] researched about the genetic algorithm coding system MATLAB codes discussed here can be extended to solve any type of optimization problem of any size. Sharapov R.R [11] reviewed about to basic ideas of the genetic algorithm and also about the variants of the genetic algorithm. After analysis about the variation of the genetic algorithm with evolutionary and real coded genetic algorithm. They also reviewed about the fuzzy genetic algorithms with neutral network and natural genetics.

## IV. CONCLUSION

The study covered in this paper came from a problem of packing pipes of various diameters length-wise in a shipping container. The problem was formulated as a non-linear, integerprogramming problem. Since such a formulationis extremely difficult to solve but genetic algorithm are applicable to mechanical engineering as very large range of problem, so this problem is easily solved by genetic algorithm. This is very easy to implement in every real problems. It has own advantages and disadvantages as explained above. Every variants of the GA is gives the better performance than GA because of some govern technique. The paper has presented a new methodology to adaptive exploration heuristics for packing problemsby using a string constructed on position numbers. The speediness of decoding the string rest onthe nature of the decoding heuristicwhich in our application was simple andfast. Theheuristic we presented, did not overcome the difficultyof needful a decoding heuristic and theloss of information from parent tochild which is a feature of many genetic algorithmsin problems like this.

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