The Enhanced Genetic Algorithms for the Optimization Design

Ms. M. M. Ade, Prof. P. A. Bhalge

***Abstract*— Three different kinds of the novel enhanced genetic algorithm procedures including the hybrid genetic algorithm, interval genetic algorithm and hybrid interval genetic algorithm are respectively presented. As the results of the proven systems show, the hybrid genetic algorithm can determines the better optimum design than the traditional optimization algorithms and genetic algorithm. The interval genetic algorithm and hybrid interval genetic algorithm can avoid calculating system slope in traditional interval analysis and determines the optimum interval range of the parameters under allowable corresponding objective error boundary.**

***Index Terms*— Optimization, Genetic algorithms, Hybrid genetic algorithm, Interval genetic algorithm, Hybrid interval genetic algorithm.**

I. INTRODUCTION

Optimization is the process of making something better. In engineering, optimization algorithms have been extensively developed and well used in all respects for a long time. An engineer or a scientist conjures up a new idea and optimization improves on that idea. Optimization consists in trying variations on an initial concept and using the information gained to improve on the idea. Many optimization problems from the industrial engineering world, in particular the manufacturing systems, are very complex in nature and quite hard to solve by conventional optimization techniques [1]. Genetic Algorithm (GA) is one of the optimization algorithms, which is invented to mimic some of the processes observed in natural evolution. The GA, differing from conventional search techniques, start with an initial set of random solutions called population. Each individual in the population is called a chromosome, representing a solution to problem at hand. The chromosomes evolve through successive iterations, called generations. During each generation, the chromosomes are evaluated, using some measures of fitness. To create the next generation, new chromosomes, called offspring, are form by either merging two chromosomes form current generation using a crossover [3]. A new generation is form by selecting, according to the fitness values, some of the parents and offspring; and rejecting others so as to keep the population size constant. After several generations, the algorithms converge to the best chromosome, which hopefully represents the optimum or suboptimal solution to the problem. There are three major advantages when applying the GA to optimization problems.

● The GA do not have much mathematical requirements about the optimization problems. Due to their evolutionary nature, the GA will search for solutions without regard to the specific inner workings of the problem.

Ms. Mohini M. Ade, Computer Science and Engineering, Sant Gadge Baba Amravati University, B. N. college of Engg, Pusad ,India.

Prof. P.A Bhalge, , Computer Science and Engineering, Sant Gadge Baba Amravati University, B. N. college of Engg, Pusad ,India.

● The evolution operators make GA effective at performing global search. The traditional approaches perform local search by a convergent stepwise procedure, which compares the values of nearby points and moves to the relative optimal points. Global optimum can be found only if the problem possesses certain convexity properties that essentially guarantee that any local optimum is a global one.

● GA provide a great flexibility to hybridize with domain dependent heuristics to make an efficient implementation for a specific problem.

In the above statement indicate, the GA have much advantages. Even though the GA can locate the solution in the whole domain [2].

II. GENETIC ALGORITHM

A genetic algorithm (GA) is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

A. *Coding to Strings*

In GA, each individual in a population is usually coded as a fixed-length binary string. The length of the string depends on the domain of the parameters and the required precision. For example, if the domain of the parameter x is [-2,5] and the precision requirement is six places after the decimal point, then the domain [-2,5] should be divided into 7,000,000 equal size ranges. The implies that the length of the string requires to be 23, for the reason that 4194304=222<7000000<223=8388608 The decoding from a binary string <b22b21…b0> into a real number is straightforward and is completed in two steps.

(1) Convert the binary string <b22b21…b0> from the base 10 by

$$x' = \sum_{i=0}^{22} b_i 2^i$$

(2) Calculate the corresponding real number x by

$$x = -2.0 + x' \frac{7}{2^{23} - 1}$$

B. *Initial Population*

The initial process is quite simple. We create a population of individuals, where individual in a population is a binary string with a fixed-length, and every bit of the binary string is initialized randomly.

C. *Evaluation*

In each generation for which the GA is run, each individual in the population is evaluated against the unknown environment.

D. Genetic Operators

The most widely used genetic operators are reproduction, crossover and mutation.

To perform genetic operators, one must select individuals in the population to be operated on. There are many different selection strategies based on fitness. The most popular is the fitness proportionate selection. After a new population is formed by selection process, some members of the new populations undergo transformations by means of genetic operators to form new solutions. Because of intuitive similarities, we only employ during the recombination phase of the GA three basic operators: reproduction, crossover and mutation, which are controlled by the parameter *pr*, *pc* and *pm*(reproduction probability, crossover probability and mutation probability), respectively.

Let us illustrate these three genetic operators. As an individual is selected, reproduction operator only copy it form the current population into the new population without alternation. The crossover operator starts with two selected individuals and then the crossover point (an integer between 1 and *L*-1, where *L* is the length of strings) is selected randomly.

Assuming the two parental individuals are *x*1 and *x*2, and the crossover point is 5 (*L*=20). If *x1*=(01001|101100001000101)
x2=(11010|011100000010000)

Then the two resulting offspring are
x'1=(01001|011100000010000)
x'2=(11010|101100001000101)

The third genetic operator, mutation, introduces random changes in structures in the population, and it may occasionally have beneficial result. In our GA, mutation is just to negate every bit of the strings, i.e., changes a 1 to 0 and vice versa, with probability *pm*.

III. ENHANCED GENETIC ALGORITHMS

A. Hybrid Genetic Algorithm (HGA)

The GA and the traditional optimization algorithms have defects respectively. Most traditional optimization methods applied in engineering design require a better set of initial values for the design variables, and then converge rapidly to generate good results. However, most of those optimization algorithms face the same difficulties, such as a long trial-and error process in finding a better set of initial design variables or slow convergence. The set of initial design variables is determined by engineering intuition in generally and different sets of initial design variables will in general give different optimum results. Therefore, how to select better initial values of the design variables is a critical step for those traditional methods. As for using the GA, it has the advantage of working in a random population. In order to overcome these difficulties, a new hybrid optimization procedure, which combines the GA with traditional optimization methods, is presented in this study. In the first step of the procedure, the GA is applied to provide a set of initial design variables, thereby avoiding the trial process; thereafter, traditional algorithms are employed to determine the optimum results [4]. This hybrid algorithm, which can be termed a Hybrid Genetic Algorithm (HGA), is more effective than traditional algorithms. The flow chart of HGA is described in fig.1 as shown below.

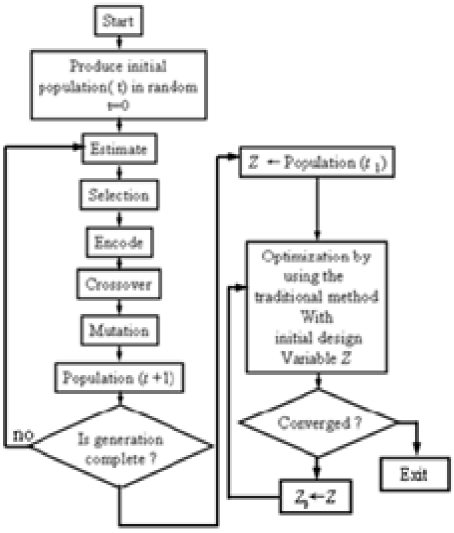

Fig.1: flow chart of HGA

B. Interval Genetic Algorithm (IGA)

Most optimization algorithms deal with methods with which to derive the design variables for an optimal design. Nevertheless, it usually is not easy to manufacture exact design variables in engineering, because of measurement inaccuracies or errors within the manufacturing process itself. Furthermore, to exact manufacturing is often more costly. Interval optimization is one of the algorithms that can overcome these difficulties [2].The interval method for solving optimization problem consist of main algorithm. The purpose of interval analysis is to provide upper and lower bounds on the effect of all such errors on a computed quantity. A complex interval can be a rectangle or a circle in the complex plane; or intervals on magnitude and phase can be used. The interval analysis is necessary and important for most interval optimizations. By using the interval analysis, it is easy to understand the relationship between the system performances and system parameters. The flow chart of IGA is described in fig.2 as shown below.

C. Hybrid Interval Genetic Algorithm (HIGA)

With the advancement of the computer ability, the interval analysis and interval optimization are respected and applied in all respects during the recent years. The hybrid interval genetic algorithm is the combination of both hybrid genetic algorithm and interval genetic algorithm. In engineering, the interval optimization is extensively applied in structure design. For the original IGA in the above section, the objective error *E* is calculated from the formulated equation. In fact, it is easy to describe and formulate the system equations for an uncomplicated system, but complicated systems sometimes are not easy to achieve.

Furthermore, the simplified system equation sometimes is difficult to determine the accurate solutions. To overcome those difficulties, the technology combines the IGA with Finite Element Method (FEM) software for the interval optimization is presented in this section [2],[7]. The fig.3 shows the flowchart of HIGA which contain detailed working of the algorithm.

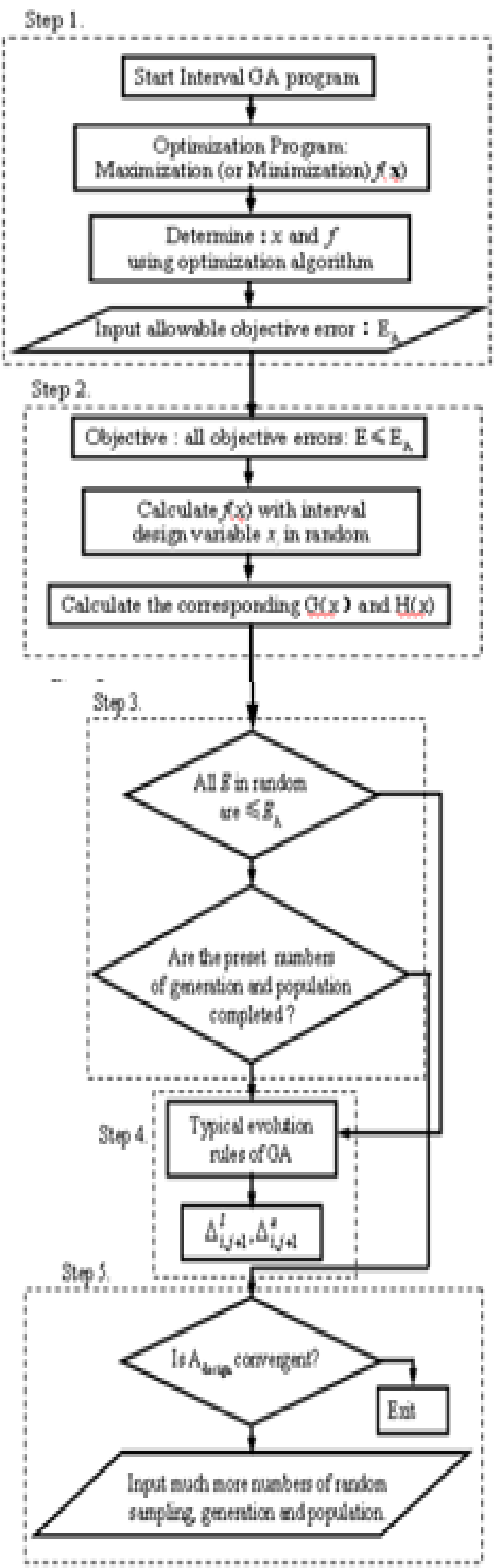

Fig.2: The flow chart of IGA

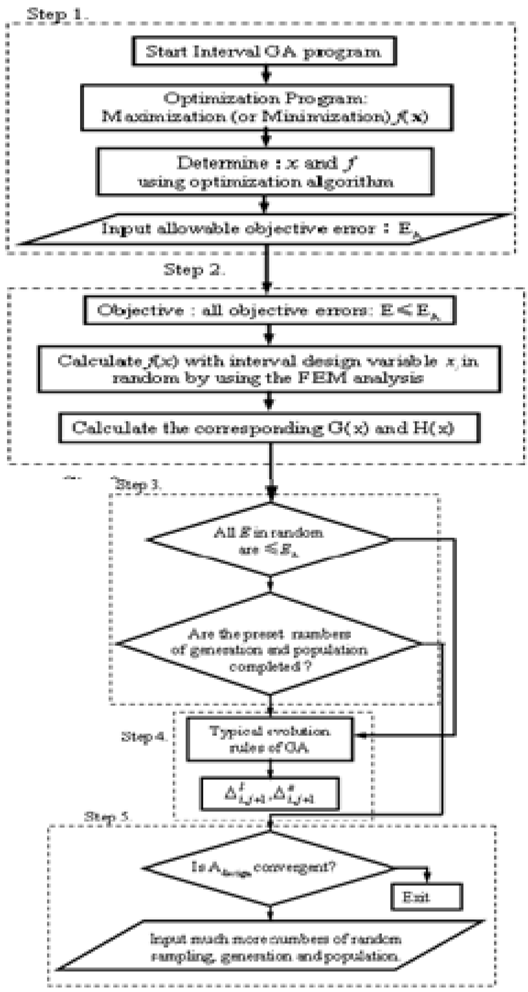

Fig.3: flow chart of HIGA

IV. NUMERICAL EXAMPLES

Example 1: Simple global optimization problem of the polynomial. One global optimization problem is presented to prove the ability of the HGA and which is shown in Fig.4 (a).

$$f(x,y) = -20\frac{\sin\sqrt{0.1+(x-4)^2+(y-4)^2}}{\sqrt{0.1+(x-4)^2+(y-4)^2}}$$

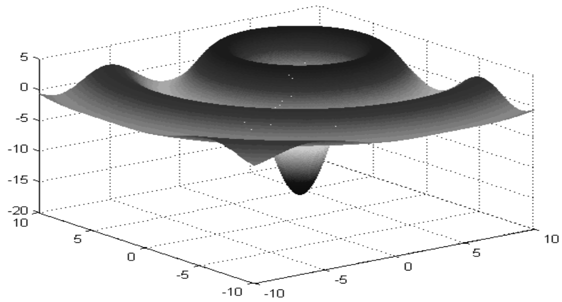

Fig.4 (a) the global optimization problem

The global minimum is at ($x1$, $x2$) =(4, 4) with the objective f *=−19.6683. As the results show in Fig.4 (b), the optimization approach using the SQP got one local optimum value f(4, −3.75) = − 2.5662. Because of the random initial value are inferior and the SQP cannot determine the global optimum value with the inferior initial value. This example shows that the HGA can determine the global optimum value effectively [6].

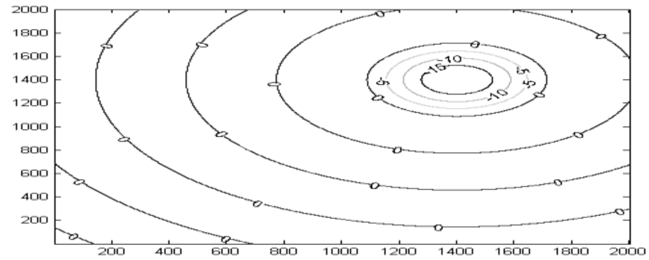

Fig.4 (b) Optimization with the HGA

Example 2: Single-objective interval optimization of the polynomial.

One two-dimensional polynomial function is presented in this example, which is expressed as the following:

$$f(x,y)=3(1-x)^2 e^{-x^2-(y+1)^2}-10\left(\frac{x}{5}-x^3-y^5\right)e^{-x^2-y^2}$$

This is shown in Fig.5 (a) and the contour map of this polynomial function in the design scope is shown in Fig.5 (b).

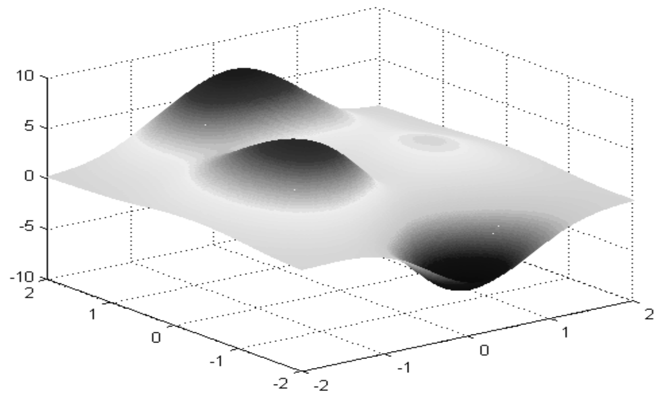

Fig.5 (a) the interval optimization of the polynomial.

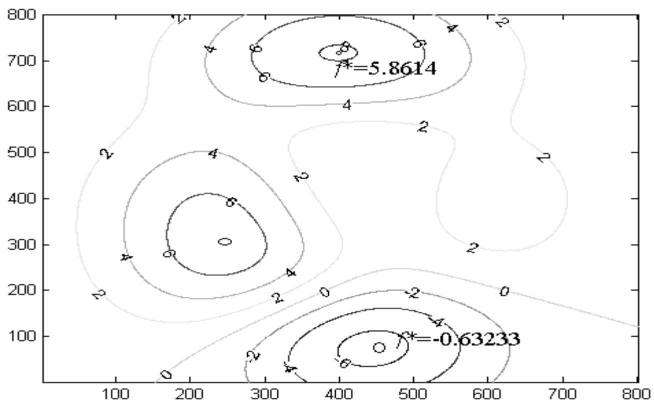

Fig.5 (b) Optimization with the IGA

V. Conclusion

Three kinds of enhanced genetic algorithm are presented to overcome different engineering problems. In HGA, the genetic algorithm is applied to provide a set of initial design variables, thereby avoiding the trial process; and another optimization algorithm is employed to determine the final optimum results. This new interval optimization procedure is referred as the Genetic Algorithm and denominated as an Interval Genetic Algorithm (IGA). As opposed to former interval optimization algorithms, interval analysis can be excluded in this interval optimization process. In addition to the IGA, the Hybrid Interval Genetic Algorithm (HIGA) even combines the IGA with the Finite Element Method (FEM). This hybrid algorithm can exclude equations formulation and interval analysis, and determines the optimum interval parameters.

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Ms. Mohini M. Ade received the B.E degree in Computer Science and Engineering from Babasaheb Naik College of Engineering Pusad And now she is pursuing her M.E degree in Computer science and Engineering under S.G.B.A.U university in Babasaheb Naik College of Engineering, Pusad, M.S. India.

Prof. P. A. Bhalge, He is an Assistant Professor of Computer Science and Engineering Department, Babasaheb Naik College of Engineering, Pusad M.S, India. He has published many research papers in international conferences and Journals.