Modified NSGA based on Multi Design Optimization of Different Elements

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Abstract—This paper proposes a modified non-dominated Sorting Genetic Algorithm(NSGA) technique. This technique is used for multi objective design optimization of 2-bar truss design and simple gear train. This proposed method reduces computational time as compared to original algorithm.

Keywords—Design, Optimization, GA, NSGA, 2-bar truss, Simple Gear train

I. INTRODUCTION TO OPTIMIZATION

Achieving products with minimum cost and maximum quality is one of the challenges in industries. Optimization can be defined as the process of finding the conditions that give the maximum or minimum value of a function. In addition to the functional requirement if certain objective function is considered then it is called optimum design. Minimizing the effort required or Maximizing the benefits or Combination of both are the examples of optimization. Optimization techniques are used to find the maximum or minimum value of a function.

II. OPTIMIZATION TECHNIQUES

1. Genetic / Evolutionary Algorithm

(Non-Conventional Method)

Genetic algorithms are a part of evolutionary computing, which is a rapidly growing area of artificial intelligence. As you can guess, genetic algorithms are inspired by Darwin's theory about evolution. Simply said, solution to a problem solved by genetic algorithms is evolved. Genetic Algorithms mimic the principles of natural genetics.

Genetic operators are reproduction, crossover and mutation. During reproduction, first occurs recombination. Genes from parents form in some way the whole new chromosome. Crossover selects genes from parent chromosomes and creates a new offspring. The simplest way how to do this is to choose randomly some crossover point and everything before this point copy from a first parent and then everything after a crossover point copy from the second parent. After a crossover is performed, mutation takes place. This is to prevent falling all solutions in population into a local optimum of solved problem. Mutation changes randomly the new offspring.

2. Non-dominated Sorting Genetic Algorithm Relates to the concept of domination $x^{(1)}$ dominates $x^{(2)}$, if $x^{(1)}$ is no worse than $x^{(2)}$ in all objectives x⁽¹⁾ is strictly better than x⁽²⁾ in at least one objective Examples:
3 dominates 2
3 does not dominate 5



P'=Non-dominated (P) Solutions which are not dominated by any member of the set P Pareto-Optimal set = Non-dominated(S)

A number of solutions are optimal



Elites are preserved, Non-dominated solutions are emphasized and NSGA-II can extract Pareto-optimal frontier



III. TWO-BAR TRUSS DESIGN

The Objective of 2-bar truss design is to minimize the volume and minimize stresses in each of the two members.

 $\begin{array}{l} \text{Minimize } f_1(x) = x_1 \sqrt{16 + y^2} + x_2 \sqrt{1 + y^2} \\ \text{Minimize } f_2(x) = \max(\sigma_{\text{AC}}, \sigma_{\text{BC}}) \\ \text{subject to } \max(\sigma_{\text{AC}}, \sigma_{\text{BC}}) \leq 1(10^5) \\ 1 \leq y \leq 3 \quad \text{and} \quad x \geq 0 \end{array}$

$$\sigma_{\rm AC} = \frac{20\sqrt{16+y^2}}{yx_1} \qquad \sigma_{\rm BC} = \frac{80\sqrt{1+y^2}}{yx_2}$$







NSGA-II solutions range $(0.00407 \text{ m}^3, 99755 \text{ kPa})$ and $(0.05304 \text{ m}^3, 8439 \text{ kPa})$.

IV. GEAR TRAIN DESIGN

The objective of gear train design is to minimize the error between the obtained gear ratio and a required gear ratio of 1/6.931.

Design Variables $(x_1, x_2, x_3, x_4) = (T_d, T_b, T_a, T_f)$.

Minimize $f_1(x) = \left[\frac{1}{6.931} - \frac{x_1x_2}{x_3x_4}\right]^2$ Minimize $f_2(x) = \max(x_1, x_2, x_3, x_4)$ Subject to $12 \le x_1, x_2, x_3, x_4 \le 60$, all x_i 's are integers.



Optimized solutions obtained using the NSGA and NSGA-II



NSGA-II solutions range

Solution	x_1	x_2	x_3	x_4	Error	Max. Diameter
E	12	12	27	37	$1.83(10^{-8})$	37
D	12	12	30	30	$2.47(10^{-4})$	30

V. PROPOSED ALGORITHM

The multiple objectives of the design problem will formulated as combined objective function. By minimizing the combined objective function the computational time and effort will be reduced as compared to original algorithm.

Formulation of COF $COF = (OF_1/MOF_1)*WFN +$ $(OF_2/MOF_2)*WFN$ Where, COF = Combined Objective Function OF = Objective Function MOF = Maximum of Objective Function WFN = Weightage for Normalization

VI. RESULTS

C Language coding obtained from Kanpur Genetic Algorithms Lab used to solve the design problems. The Optimized results will be compared with NSGA-II results.

VII. FUTURE SCOPE

This modified Non-dominated Sorting Genetic Algorithm can be applied to solve complex engineering problems and real time engineering problems in order to obtain optimum results.

VIII. REFERENCES

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