School of Information Technology

Indian Institute of Technology Kharagpur

IT60108: Soft Computing Applications

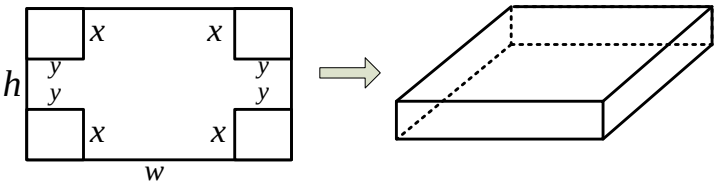
End-Spring Semester Examination

F.M. 100 Session 2014 – 2015 Time: 3 hrs

Answer ALL Questions

You can make any reasonable assumptions, if any, while you are giving answers

Q-1. Given a plan sheet of size $h \times w$. You have to cut the sheet at four corners each of size $x \times y$ so that it can be folded into a box. We are to determine x and y so that the volume of the box is maximum.



Precisely state the problem with standard notation of stating an optimization problem. Your statement should include the following.

(a) Objective function

(b) Constraint

(c) Design parameters

(d) Constraint on design parameters

(e) To solve the above problem, what type of GA encoding scheme can be considered?

[2+2+2+2+2]

Q-2. The *Rod Cutting Problem* can be stated as follows.

Given a rod of length L and you have to cut into a number of maximum n pieces. The cost c_i of a piece p_i of length l_i is given. You have to cut the rod into a number of pieces so that the cost of cutted ensembles is maximum.

Length	l_1	l_2	l_3	$\cdots$	l_m
Cost	c_1	c_2	c_3	$\cdots$	c_m

With respect to the above problem, answer the following questions.

(a) Is the *Rod Cutting Problem* satisfy the duality principle ? Justify your answer.

(b) It is proposed to solve the problem using binary coded GA. State the genotype of the chromosome to be followed.

(c) State a criterion to evaluate the fitness of an individual.

(d) Choose any two parent chromosomes of length 10 say. Explain the mechanism of *Half uniform binary crossover* (HUX) to generate at least two offspring.

[(1+2)+2+2+3]

Q-3. A hybrid framework of Genetic Algorithm(HGA) is suggested as shown in the flowchart (see Figure 1)

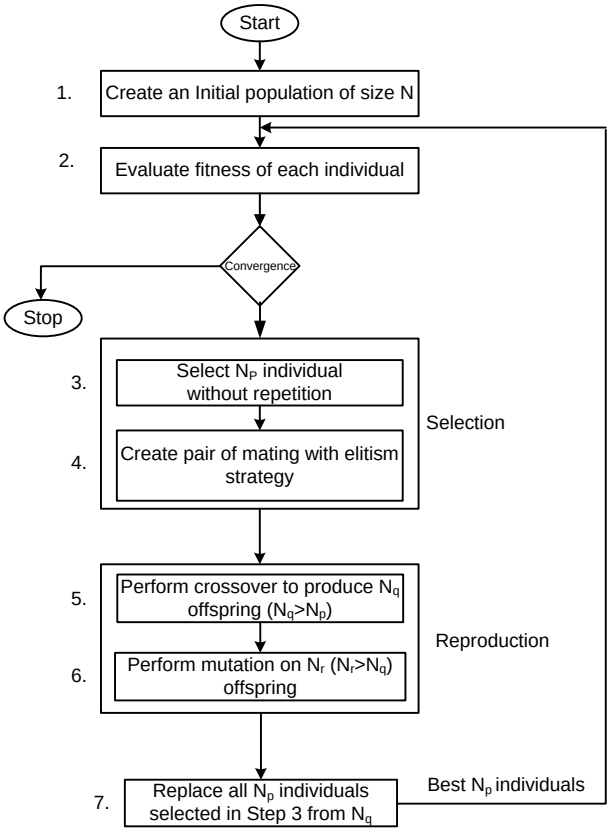


Figure 1: Framework of Hybrid GA

Obtain a subjective comparison among HGA (Hybrid GA), SGA (Simple GA) and SSGA (Steady-State GA). You are

advised to give your answer in the form of a table, whose structure is given in Table 1. **[5×2]**

Table 1:

Sr. No.	**Parameter for comparison**	**SGA**	**SSGA**	**HGA**
(a)	Selection strategy			
(b)	Mating pool creation strategy			
(c)	Creation of next generation			
(d)	Generation gap			
(e)	Convergence rate			

Q-4. Four selection strategies are very much common in GA implementation. The strategies are

S1: Roulette-wheel selection
S2: Rank-based selection
S3: Tournament selection
S4: Steady-state selection

Compare the above mentioned four selection strategies. The points of comparison is given for your ready reference (see Table 2). You are advised to furnish your answer in the form of recommended Table 2.

Table 2:

Point of comparison	**S1**	**S2**	**S3**	**S4**
Applicability				
Population diversity				
Selection pressure				
Chance of premature convergence				
Chance of stagnation				

[5×2]

Q-5. Consider a multiobjective optimization problem with M objectives and defined as follows.

$$\textbf{Minimize } f_k(X),\ k = 1, 2, \cdots M$$

$$\textbf{Subject to } X \in S$$

where X denotes input vector and S is the decision variable solution space.

(a) With reference to the above multiobjective optimization problem, **clearly define** the following.

i. Ideal objective vector(Z_I^*)

ii. Utopian objective vector(Z_U^*)

iii. Nadir objective vector(Z_N^*)

iv. Worst objective vector(Z_W^*)

(b) Out of the above vectors, which are corresponding to non-existent solutions?

(c) In the following graph (Figure 2), for two objective optimization problem, mark the ideal, Utopian, Nadir and worst solutions. Also, mark the Pareto-optimal solution.

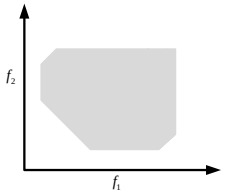


Figure 2: Graph of Q.5(c)

[4×1+2+(4×0.5+2)]

Q-6. (a) In the following graphs (Fig. 3), solution space plotted versus design variables spaces(x) for a single objective optimization problems.

For each, identify whether a global optimum solution exists or not. What solution GA will return in each case.

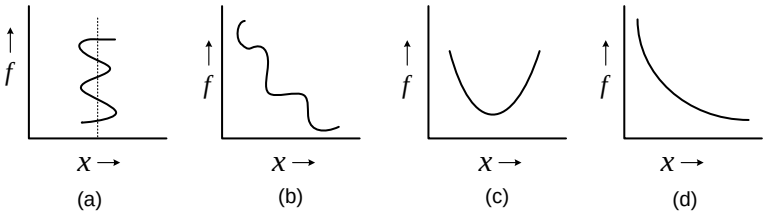


Figure 3: Graph of Q.6(a)

Assume that all objective functions are to maximize the cost. Also, locate the global optimum solution, if it exists in each case.

(b) Following graphs (Fig. 4) shows the variation of solution vectors for a two-objectives optimization problem.

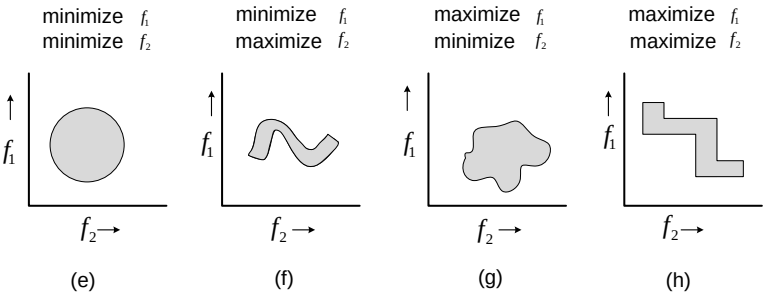


Figure 4: Graph of Q.6(b)

Categorize the above with respect to the following.

i. A unique optimal solution exist(A).

ii. No solution exist (B).

iii. A number of optimal solutions exist (C).

Justify your answer in each case.

(c) How an objective function(f) varies with input vector(x) for an optimization problem P is shown in the following graph (Figure 5).

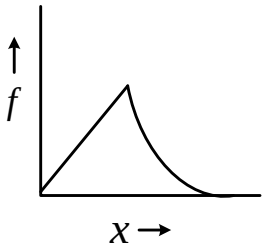


Figure 5: Graph of Q.6(c)

Draw the graph of f' versus x, where f' is the objective function of dual optimization problem of P.

[(4×1)+(4×1)+2]

Q-7. (a) Given a multiobjective optimization problem with M objective functions $f_1, f_2, \cdots, f_M$. If x_i and x_j are any two feasible solutions, then when x_i is said to dominate x_j ?

(b) A Set of five solutions with two objective function (maximize) f_1 and (minimize) f_2 is shown in Fig. 6.

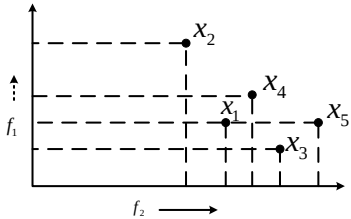


Figure 6: Figure for Q.7(b)

i. Furnish a table showing which solution(s) dominate(s) other.

ii. Also, show the non-dominated fronts.

iii. Can we conclude a Pareto optimal front in this case. If so, identify the Pareto optimal front.

[2+2+(2×3)]

Q-8. Answer the following questions with respect to the Elitist Multiobjective Genetic Algorithm (NSGA-II).

(a) Define crowding distance and show graphically the crowing distance in 3D space (i.e. for a solution x_i with three objective functions f_1, f_2 and f_3).

(b) Tell the steps precisely, how to calculate crowding distance for a finite set of solutions F. Assume that a solution $x_i \in F$ is a M-component vector, that is, $x_i = [f'_1, f'_2, \cdots, f'_M]$.

(c) What is the use of crowding distance d_i of x_i, for all $x_i \in F$ in NSGA-II?

[2+5+3]

Q-9. In the following, multiple choice type questions, where one or more choice(s) may be correct. You have to select the correct choices only.

[**Give your answer on the answer script**] [10×2]

(a) Solving a multiobjective optimization problem with Genetic Algorithm always yield

i. single solution.

ii. multiple solution.

iii. single solutions, which is also global optimal solution.

iv. multiple solutions, which are also global optimal solutions.

(b) An NP-Complete problem can be solved using an evolution algorithm in

i. polynomial time.

ii. non-polynomial time.

iii. can not be solved.

iv. can be solved in polynomial time but not necessarily giving optimal solutions.

(c) Pareto domination tournament selection is followed in

i. NSGA

ii. NSGA-II

iii. NPGA

iv. VEGA

(d) Vector-Evaluated Genetic Algorithm (VEGA) is a

i. Naive approach to solve multi-objective optimization problem

ii. Non-aggregating approach

iii. Pareto-based approach

iv. Evolutionary algorithm using weighted sum aggregation.

(e) Following Multiobjective Evolutionary Algorithm (MOEA) is not a Pareto-based approach

i. SOEA

ii. MOGA

iii. NPGA

iv. NSGA

(f) Which of the following encoding scheme would give faster execution

i. Binary encoding

ii. Real vale encoding

iii. Order encoding

iv. Tree encoding

(g) Solving the Traveling Salesman Problem, which crossover technique can be followed

i. Half uniform crossover(HUX)

ii. Precedence Preservation Crossover(PPX)

iii. Blend crossover

iv. Shuffle crossover

(h) Which of the following mutation scheme is followed in Real-coded GA?

i. Interchanging
ii. Random mutation
iii. Flipping
iv. Polynomial mutation

(i) Which selection techniques gives a better selection when the individuals are with a wide range of fitness values.

i. Roulette-wheel selection
ii. Rank-based selection
iii. Tournament selection
iv. Cannot be said until distribution of fitness values are known.

(j) Multiobjective optimization problem (MOOP) can be solved with GA with a change in

i. Encoding scheme
ii. Selection operation
iii. Crossover operation
iv. All of the above

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