EE6227

NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2020-2021

EE6227 – GENETIC ALGORITHMS AND MACHINE LEARNING

April / May 2021   Time Allowed: 3 hours

INSTRUCTIONS

1.   This paper contains 5 questions and comprises 3 pages.

2.   Answer all 5 questions.

3.   All questions carry equal marks.

4.   This is a closed book examination.

5.   Unless specifically stated, all symbols have their usual meanings.

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1.   (a)   Describe the two-point and uniform crossover operators with examples showing how these two crossovers operate on binary strings. Give reasons why these two operators are preferred over the one-point crossover operator.

(10 Marks)

(b)   Explain the stochastic universal selection operator and state why it is usually preferred over the roulette wheel selection operator.

(5 Marks)

(c)   A population contains the following strings and fitness values at the end of generation t:

String #	String	Fitness
1	1 0 0 0 1	15
2	0 0 1 0 1	5
3	0 1 1 1 0	10
4	1 0 0 1 0	20

The simple GA uses crossover and mutation probabilities of 0.8 and 0.2, respectively. Compute the expected number of schemas of the form 1 * * * * at the end of generation $t+1$.

(5 Marks)

2. (a) Describe the heterogeneous comprehensive learning particle swarm optimization algorithm. Your description should include the nature of the two subpopulations and their preferred parameter and operator settings.

(12 Marks)

(b) The elitist non-domination sorting genetic algorithm (NSGA-II) is applied to solve a two-objective minimization problem using a six-member population. Table 1 shows the combined parent-offspring population in one generation. You are asked to apply the non-dominated sorting and the crowding distance concepts to select 6 members to remain in the next generation. Clearly show your workings leading to the selected 6 solution candidates.

Table 1

Solution #	Minimization Objective 1	Minimization Objective 2
S1	1	4
S2	4	1
S3	6	7
S4	3	2
S5	7	6
S6	9.5	9.5
S7	8	5
S8	5	8
S9	10	10
S10	6.5	6.5
S11	5.5	7.5
S12	9	9

(8 Marks)

3. (a) Using an illustrative example, describe the partially mapped crossover (PMX) operator used to solve the traveling salesman problem (TSP) by genetic algorithms.

(6 Marks)

(b) Niching algorithms are used to discover multiple global and/or local optimal solutions on a multi-modal objective function. Describe the neighborhood-based differential evolution algorithm paying attention to its modifications to solve niching problems effectively.

(6 Marks)

(c) Describe the multisurface proximal support vector machine (MPSVM) and how it can be used as a two-class classifier. Your description should include important equations.

(8 Marks)

4. (a) Describe the construction of a bagging-based axis-orthogonal random forest ensemble in detail. Your descriptions should include the bagging process, data partitioning in each internal node, and important parameters to tune.

(10 Marks)

(b) Oblique random forests can be constructed using two-class linear classifiers in the internal nodes of the decision trees. Explain how you would modify the axis-orthogonal random forest to become an oblique random forest.

(5 Marks)

(c) Oblique random forests constructed using two-class linear classifiers are known to increase the computational complexity. Can you suggest some strategies to reduce the computational complexity?

(5 Marks)

5. (a) Describe the convolutional neural networks (CNN) in detail. Your descriptions should include illustrative structure, invariances, and main training steps.

(10 Marks)

(b) Cluster the two-dimensional data given in Table 2 by the K-means algorithm using three clusters (K=3) and the first 3 samples as the three initial cluster centers.

Table 2

Sample #	1	2	3	4	5	6	7	8	9
Dimension 1	0	0	1	6	7	6	1	0	1
Dimension 2	0	1	0	1	0	0	7	6	6

(10 Marks)

END OF PAPER

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Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.