DEEC
DEPARTAMENTO DE ENGENHARIA ELETROTÉCNICA E DE COMPUTADORES
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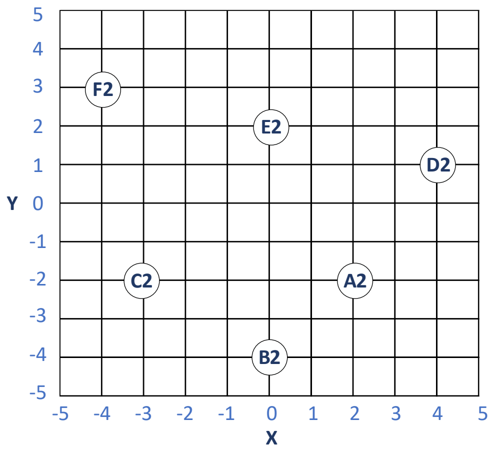
Applied Computational Intelligence 2023/2024

Mini Test 3 (MAP45) Thursday, October 26th, 2023

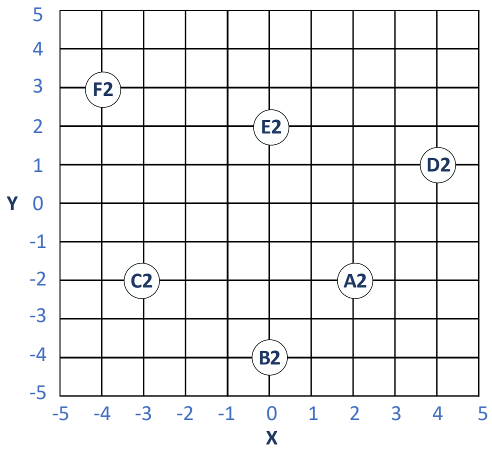
1. [**2P**] When using the ACO algorithm, and considering the rectilinear distance between points, e.g., the distance between A2 and B2 is 4 (2 horizontal + 2 vertical), the distance between A2 and D2 is 5, etc. **Determine the probability of an ant in A2 moving to E2,** if the ant has already visited F2. Assume the ph(i,j) is set to 1. Justify!



ph=1 para todos

Remover F2 dos nós possíveisp=20/6

2. [**2P**] Consider the DE algorithm and the following XY plan with the population elements from A2 to F2. **Determine the new candidate position/coordinates for E**, E3. Assume, the 3 selected elements are C2, A2 and B2 (respectively as X1, X2 and X3 in DE expression), a = 1, d = 2 (corresponding to the 2nd dimension represented by Y), pc = 0.5, u1 = 0.8, u2 = 0.2. Justify!



só muda em u2 uma vez que d=2 ou que pc>u2

logo E3x=E2x

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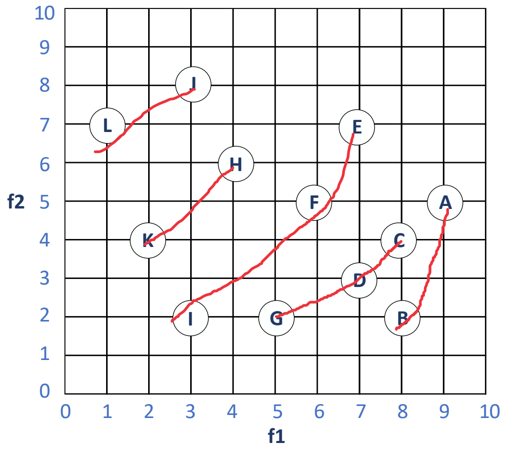
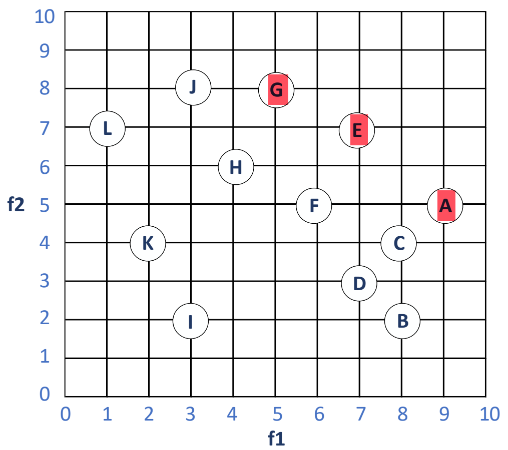
Number: _______ Name: ____

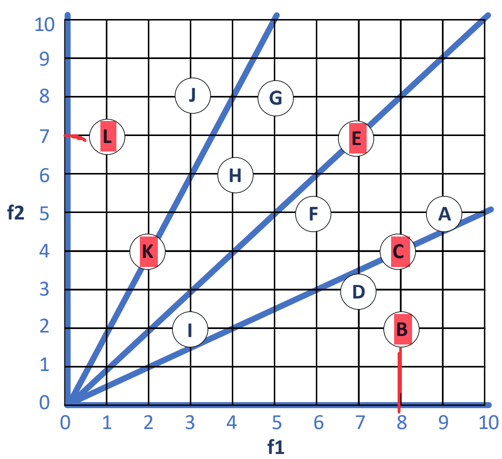
3. [**2P**] Considering the objective of **maximizing f1** and **minimizing f2**, draw all levels of non-dominated fronts by connecting elements in the same front. Justify!



4. [**2P**] Consider the NSGA – II Algorithm and the objective space in the figure below, where both objectives are being **maximized**. Assuming a population of **6** elements, **which would be the selected elements for the next generation**? Justify!



5. [**2P**] Consider the NSGA – III Algorithm and the objective space in the figure below. Consider 5 reference lines and a population of 5. **Determine which elements should be selected for the next generation**. Justify!



6. **[5P]** Consider the 25 square puzzle, receive as input a set of 25 squares pieces numbered with integers between 1 and 25, with no repetitions. The objective is to form a square puzzle with 5-by-5 square pieces where **the sum** of the value of the pieces in the 2 large diagonals should be **minimized** and **the sum** of the middle row (row 3) with the middle column (column 3) should also be **minimized**.

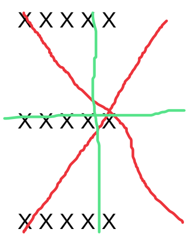
   a. which would be the size of the chromosome to efficiently represent the possible solution?

   25

   b. which is the size of the search space? Justify.

   25!

   c. which is the range of values possible for each objective?

   Cruz -> 9 elementos

   1+2+3+4+5+6+7+8+9= Menor
   25+24+23+22+21+20+19+18+17= Maior

   d. which is the maximum number of elements in the Pareto front?

   (109,45) até (45,109) somando (-1,+1)

   e. which is the ideal point?

   (45,45) -> Menor das duas dimensões possível

7. **[5P]** Consider that you are trying to optimize the sizing of an analog integrated circuit, with the unique objective of maximizing the value given a function, named figure-of-merit (FOM). Assume the circuit has 20 components to be sized, each of those components has 2 independent parameters to define its size. Each of those parameters can assume an integer value from a normalized range from 1 to 100 inclusive. Finally, consider the PSO as the optimization algorithm with a population of 50 elements.

   a. which is the size of the search space.

   b. which would be the time required to perform 100 generations if the evaluation of the FOM for each candidate solution takes 1s and the algorithm operations required to determine each new candidate solution takes 1 ms.

   c. for this problem and in the condition of b) how long, in seconds, how long would it take to implement an exhaustive search.

   d. Assume that you want to have the velocity parameter decaying with an inverse proportionaly to the number of generations and starting with the value 1. In which generation the velocity coefficient has decayed 90% from the initial value?

   e. which would be the set of parameters a, b and c that consider, statistically, an equal contribution of velocity, the distance to personalBest and the distance the neighborhoodBest.

Mathematical Forms

- **Particle Swarm Optimization Approach**

$$v_i(t+1) = a \times v_i(t) + b \times U_1 \times (\text{PersonalBest}_i - x_i(t)) + c \times U_2 \times (\text{NeighborhoodBest}_i - x_i(t))$$

$$x_i(t+1) = x_i(t) + v_i(t+1)$$

- **Differential Evolution Optimization Approach**

First, we pick a random dimension of the problem, d, uniformly from 1 to n, where the problem has n dimensions. We'll remember that dimension. Then, for each dimension i=1,…,n , we create a uniform random number ui ~ U(0,1). If ui < pc or i=d, then the new value of the solution in the ith dimension is given by:

$$x_{0i} = x_{1i} + a(x_{2i} - x_{3i})$$

where a is a scalar value between [0, 2] called a differential weight; otherwise, the new value of the solution in the ith dimension is retained from x_0.

- **Ant Colony Optimization Approach**

$$p(i,j) = \frac{ph(i,j) \times cost(i,j)^{-1}}{\sum_{k \in All} ph(i,k) \times cost(i,k)^{-1}}$$

$$\text{new } ph(i,j) = \alpha ph(i,j) + \Delta ph(i,j)$$

$$\Delta ph(i,j) = \sum_{k=1}^{50} \begin{cases} Q, & \text{if kth ant traveled between city i and city j} \\ 0, & \text{else} \end{cases}$$

- **NSGA II**

Crowding Distance Assignment Procedure: Crowding-sort$(\mathcal{F}, <_c)$

Step C1 Call the number of solutions in $\mathcal{F}$ as $l = |\mathcal{F}|$. For each i in the set, first assign $d_i = 0$.

Step C2 For each objective function $m = 1, 2, \ldots, M$, sort the set in worse order of f_m or, find the sorted indices vector: $I^m = \text{sort}(f_m, >)$.

Step C3 For $m = 1, 2, \ldots, M$, assign a large distance to the boundary solutions, or $d_{I_1^m} = d_{I_l^m} = \infty$, and for all other solutions $j = 2$ to $(l-1)$, assign:

$$d_{I_j^m} = d_{I_j^m} + \frac{f_m^{(I_{j+1}^m)} - f_m^{(I_{j-1}^m)}}{f_m^{max} - f_m^{min}}.$$