Intelligent Systems

Tutorial: Week 3

Dr. Parham Moradi

Dr. Nameer Al Khafaf

Genetic algorithm

- Exercise 1 – perform core operations in GA step by step
- Objective function:

$$min: f(x) = (x - 11)^2, x \in [0, 15]$$

- Perform the following core steps with the given parameters:
  1. Initialize 6 individuals and evaluate each individual
  2. Perform crossover with specified crossover point
  3. Perform mutation with specified mutation point
  4. Perform selection
- The best individual (i.e., optimal solution x) and its fitness (i.e., f)

Genetic algorithm

- Step 1 – Initialization 6 individuals
  - Finish the x values, fitness f in the table

Individual number	Individuals	x values	Fitness f
1	0100		
2	1110		
3	1000		
4	0010		
5	1100		
6	0001		

Genetic algorithm

- Step 2 – Perform one point crossover with the labelled data points
  - Finish offspring, x values

Individual number	Individuals	Crossover points	Offspring	x values
1	01|00	2	1100	
2	11|10	2		
3	1|000	1		
4	0|010	1		
5	110|0	3		
6	000|1	3		

Genetic algorithm

- Step 3 – Perform mutation
  - Finish offspring generated from crossover operation, offspring after mutation, x values, fitness f with the new offspring

Individual number	Offspring	Mutation point	Offspring after mutation	x values	Fitness f
1	1100	No mutation	1100		
2	0110	2			
3	0000	No mutation			
4	1010	4			
5	0000	No mutation			
6	1101	No mutation			

Genetic algorithm

- Step 4 – Perform selection

Individual number	Offspring	x values	Fitness f	Probability
1	1100	12	1	
2	0010	2	81	
3	0000	0	121	
4	1011	11	0	
5	0000	0	121	
6	1101	13	4	

- Output the best individual and its objective function
- The optimal x and minimal f?

Genetic algorithm

- Exercise 2 – programming with GA
- Objective function:

$$min\colon\ f(x) = (x - 0.5)^2, x \in [0, 2]$$

- Find the optimal solution x and the minimal $f(x)$ with default parameters in GA

- The optimal solution of x and minimal $f(x)$?

Genetic algorithm

- GA package in Matlab:
  - $[x,\ fval]$ = ga(fun, *nvars*, *A*, *b*, *Aeq*, *beq*, *lb*, *ub*, nonlcon, options)
    - fun: objective function
    - *nvars*: the dimension (number of design variables) of fun
    - *A* and *b*: *A*=[] and *b*=[] if no linear inequalities exist
    - *Aeq and beq: set Aeq=[] and beq=[] if no linear equalities exist*
    - *lb* and *ub*: range of decision variables, set lb=[] and ub=[] if no bounds exist
    - nonlcon: nonlcon=[] if no nonlinear constraints exist

Genetic algorithm

- Exercise 3 – programming with GA
- Objective function:

$$min:\ f(x_1, x_2) = x_1 \cos(2\pi x_2) + x_2 sin(2\pi x_1), x_1 \in [-2, 2], x_2 \in [-2, 2]$$

- The optimal solution of x_1, x_2 and minimal $f(x_1, x_2)$ using default parameters in GA?
- Show the update of the best fitness $f(x_1, x_2)$ in each generation with graph?

Genetic algorithm

- Exercise 4 – programming with GA
- Objective function:

$$min: f(x_1, x_2) = -3x_1^3 + \ 2\,x_2^3 + 2x_1^2 \ - 5x_2^2 + 2x_1x_2 + \ x_1 - 2x_2 + 10,\ x_1\epsilon[-3, 2], x_2\epsilon[-5, 3]$$

- Constraints:

$$2x_1 + 3x_2 \ \leq 8,$$
$$5x_1 - 2x_2 \ \leq 2,$$
$$x_1 + x_2 \ \geq -6$$

- The optimal solution of x_1, x_2 and minimal $f(x_1, x_2)$ using default parameters in GA?
- Show the update of the best fitness $f(x_1, x_2)$ in each generation?