ECE449: Lab 5 - Genetic Algorithm

November 21th, 2019

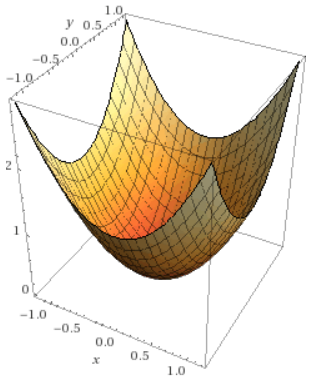
Genetic Algorithm

- **Genetic algorithm**
  - Optimization algorithm
  - One of evolutionary algorithms
- **Domains of use**
  - Scheduling, timetabling
  - "Automatic" (evolutionary) design
  - Generally: problems with many local optima

The 2006 NASA ST5 spacecraft antenna.

Parts of GA

- **Optimization problem**
  - Select the best performing solution for our problem.
    - Example: Minimize an equation $g(x, y) = x^2 + y^2$
    - Example: Find the best combination
- **Solution**
  - Represented as a vector
    - Equation: [2, 1], [0, 0], [0.3, 1.6]
    - Combination: [0, 1, 0, 1, 1, 0, 0, 0, 0, 0]
  - Optimal solution
    - The *best*



Parts of GA

- **Fitness function**
  - Evaluates the quality of a solution
  - Gives a single value
    - Higher value = better solution

$$f(solution) = quality$$

$$f(x, y) = -g(x, y) = -(x^2 + y^2)$$

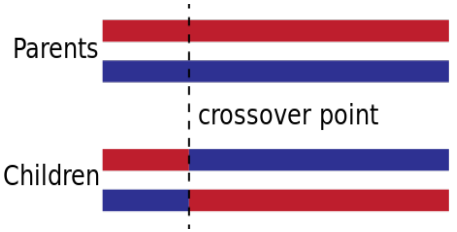
$$f(1,1) = -2$$
$$f(0,0) = 0$$

Parts of GA

- **Population**
  - Set of solutions
  - Size of the population
    - number of solution in the population
  - Example:
    - Population of size 5
    - [[1,4], [2.1, 8], [0.2, 3.1], [6.1, 4.8], [1.2, 0.3]]
  - Members of a population are called **individuals**

Operations on individuals

- **Crossover**
  - Takes 2 or more individuals
  - Combines them to produce new individuals
  - [0.2, 0.4], [0.8, 0.5] -> [0.2, 0.5], [0.8, 0.4]



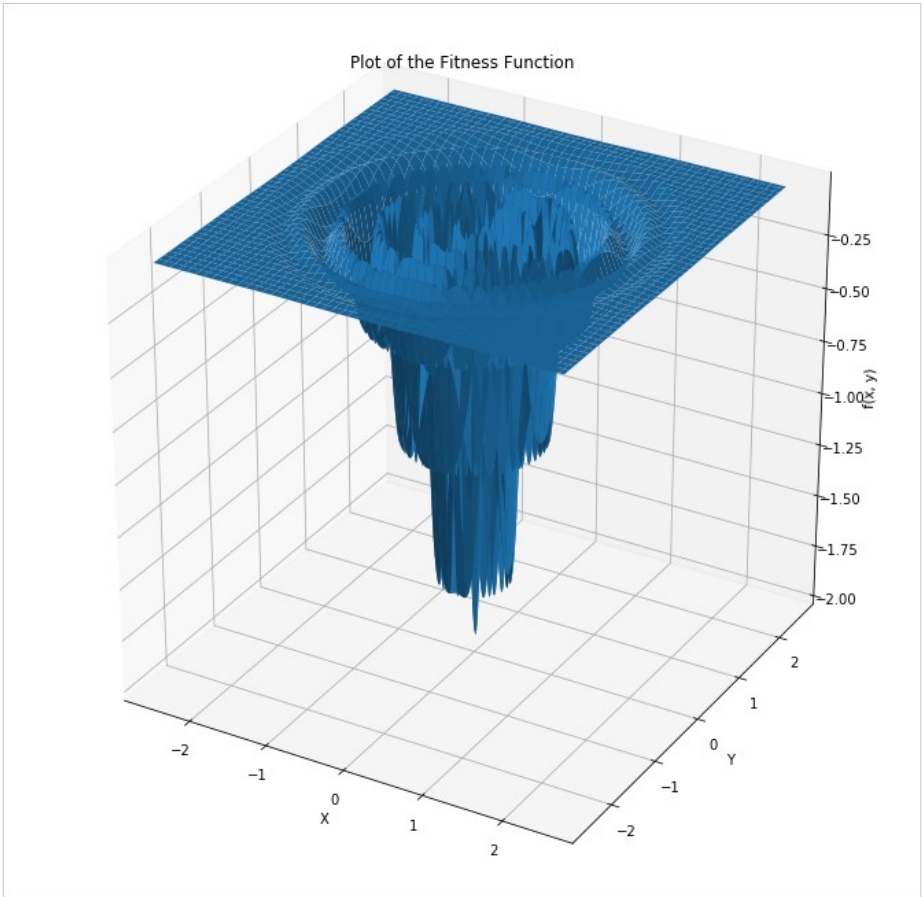
- **Mutation**
  - Applied on one individual
  - Randomly change a portion of an individual
  - [**0.2**, 0.4] -> [**0.25**, 0.4]

Algorithm

1. **Randomly create a population (f ŕst generation)**
2. **Iterate:**
    1. Evaluate the fitness of the each individual
    2. Stochastically perform **crossover**
    3. Stochastically perform **mutation**
    4. **Select** the new population (next generation)

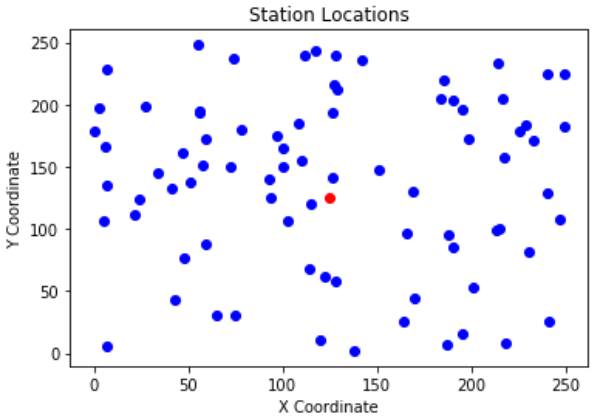
The lab

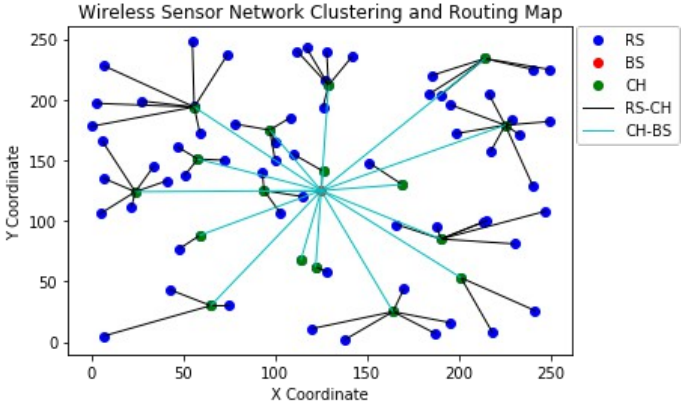
- **Exercise 1**
  - Minimize a function
  - The structure of the algorithm is from a library
    - We will implement the operators
    - Create, crossover and mutate are done
    - You will program the fitness function
  - How to use the library?
    - Look at Python Supplement



The lab

- **Exercise 2**
  - Wireless Sensor Network
    - Node sends message to the cluster head
    - Cluster head forwards the message to the sink
    - User access the data at the sink
  - Find the optimal positions of cluster heads






```
Solution =  [0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 1 0 0 0
1
 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0
 0 0 0 0 0 0 0]
```