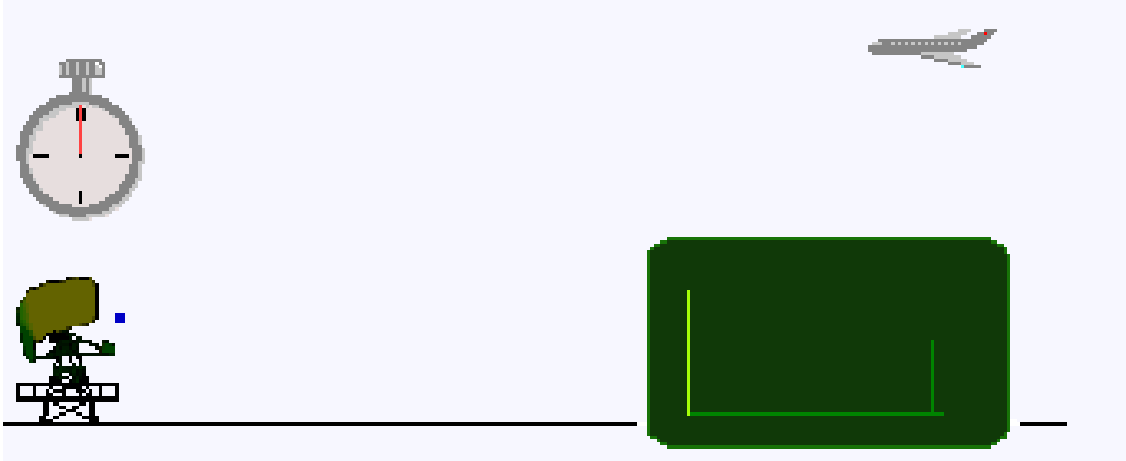
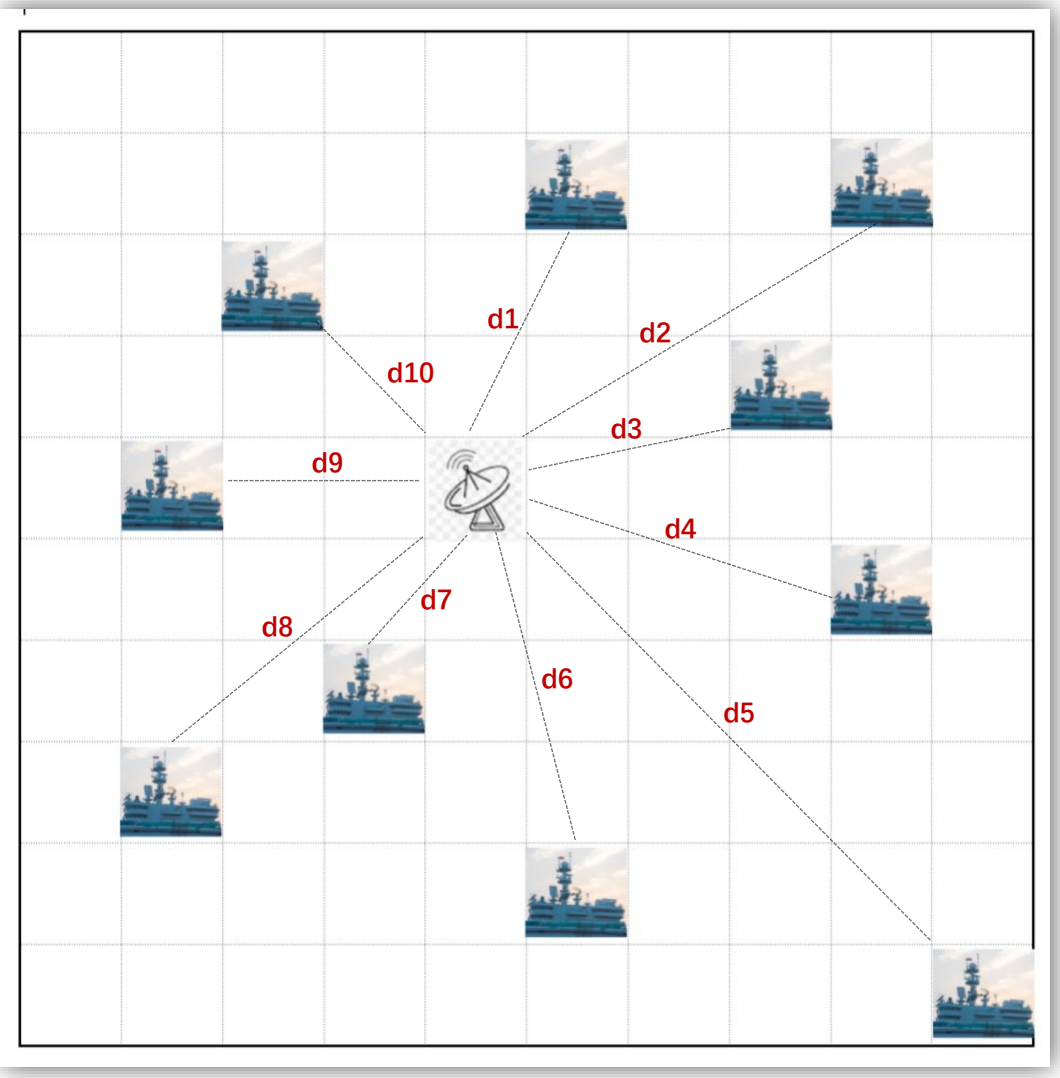
Background

Radar is a detection system that uses radio waves to determine the range, angle, or velocity of objects. Radio waves (pulsed or continuous) from the transmitter reflect off the object and return to the receiver, giving information about the object's location and speed. It is used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and so on.
Radar was developed secretly for military use by several nations in the period before and during World War II. Now the military of Country A plans to have a military exercise in B state. He has set up several military bases and for the next step, he wants to establish a Radar system to satisfy the needs of these bases. However, considering the efficiency and other factors, the relationship between the sum of distance from Radar to bases and infeasibility score is parabola. Military will find the best location of Radar by using genetic algorithm.



Specific Aims



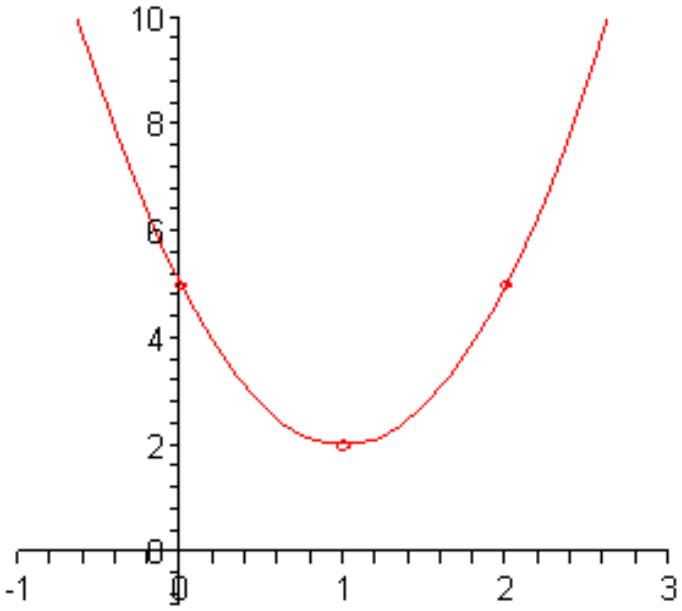
a) **Calculate the sum of distance between Radar and ten military bases by using Euclidean Metric.** We design a graph which the size of both X and Y axis are 1024. Each of Radar and the bases is the distinct point on the graph.

$$\rho = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

D denote the sum of ten distance, (x_i, y_i) denote the coordinate of each bases.

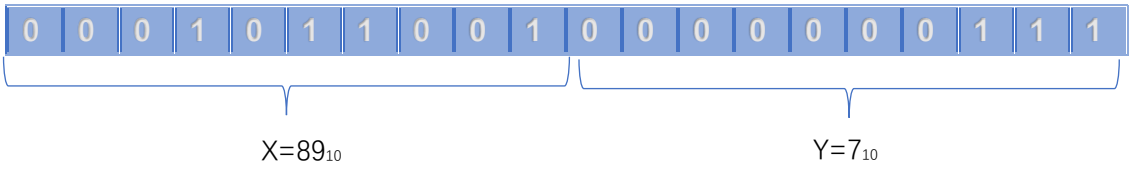
$$D = \sum_{i=1}^{10} \sqrt{x_i{}^2 + y_i{}^2}$$

b) **Find the relationship between sum distance D and the infeasibility score.**
It is a quadratic function and the trend is like the below:



c) **The five concepts of genetic algorithm:**

- **Genotype:** the set of replicable and heritable information contained within the cells of an organism. Because of $2^{10}=1024$, we use ten Binary-coded bits to present the coordinates on X-axis and Y-axis. The total length is 20 bits. For example: $0001011001_2=89_{10}$.

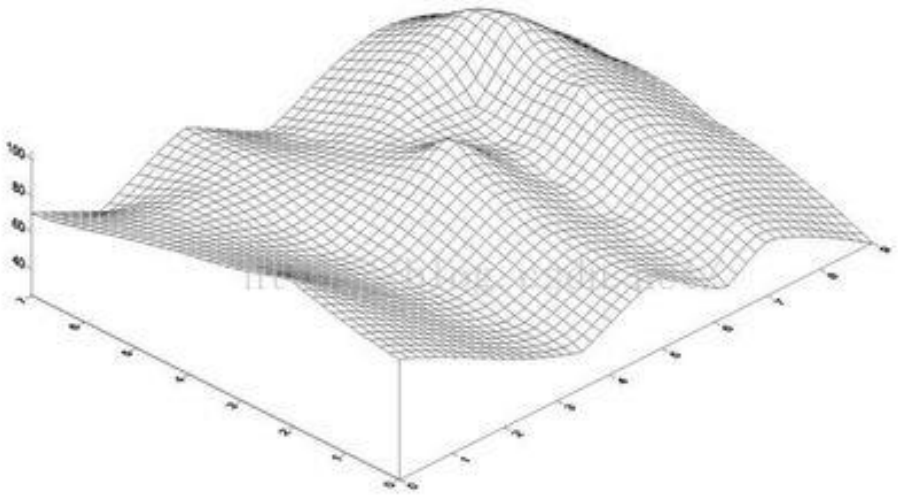


- **Expression:** the first 10 bits is the coordinate on X-axis, and the last 10 bits is the coordinate on Y-axis.

- **Phenotype:** infeasibility score.

- **Problem:** figure out the point which has the minimum infeasibility score.

- **Fitness:** the point with lower infeasibility score has the higher chosen probability.



d) **Encoding:** coding can be seen as a mapping from genotype to phenotype. Use an array to store the point (X, Y). Combine the value of X and Y into one integer and add it into array.

e) **Decoding:** separate the value into two parts. The first part is coordinate of X and the second part is the coordinate of Y.

f) **Generate data:** Randomly select 10 points from 1024*1024 size as the military bases.
The size of initial group is 1000 and we randomly generate 1000 integer. For each integer, we encode and decode it to get the coordinates.

g) **Selection:** Calculate the weight of each points in the initial group and according to the weight, we decide the genetic probability. As the weight is smaller, the point has higher probability to be chosen.

h) **Recombination/Crossover:** randomly pick up two points and find their genotypes. Randomly choose the number from 0-19, which 0-9 means to exchange the coordinate on X-axis and 10-19 means to exchange the coordinate on Y-axis. We only exchange one bit once.

i) **Mutation:** randomly choose the number from 0-19, which 0-9 means to change the coordinate on X-axis and 10-19 means change the coordinate on Y-axis. If the bit we find equals to 1, then we change it into 0. And if it equals to 0, we change it into 1.

Summary

Our target is to help Country A find the best point to set up the Radar System, which ensures that each of the military bases have an efficient utilization of Radar system for detections.
We randomly choose 10 points from the grid 1024*1024 as the 10 military bases and randomly generate 1000 integer as the initial group. Because the efficiency is related to the sum of distance between Radar and 10 military bases, then we calculate the distance by using Euclidean Metric and calculate infeasibility score of each individual in the initial group. After the process of selection, crossover, mutation and reproduction, we find the points scattered elsewhere with lowest infeasibility score, which means we find the optimize area to establish the Radar System.