**CECS 451**
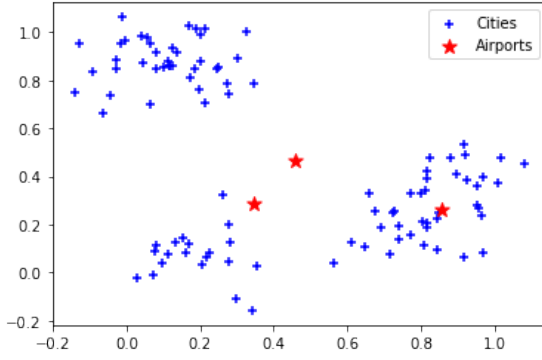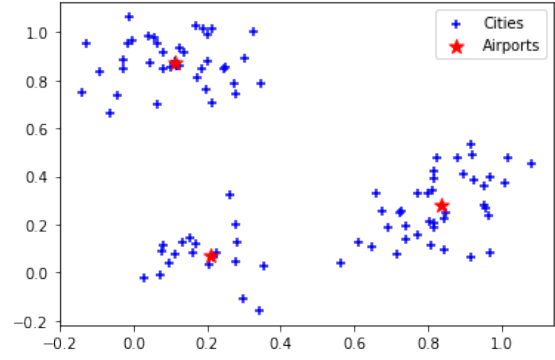**Assignment 4**
**Total: 40 Points**

General Instruction

- Submit uncompressed file(s) in the Dropbox folder via BeachBoard (Not email).

1. (40 points) Solve the $n$-airports problem using gradient based optimization algorithm.

    i. Find `n-airports.ipynb`.

    ii. A random initial state is given as Figure 1a.



| (a) An initial state | (b) An optimal state |

Figure 1: $n$-airports problem state

    iii. The objective function is given by

$$f(x_1, y_1, x_2, y_2, x_3, y_3) = \sum_{i=1}^{n} \sum_{c \in C_i} (x_i - x_c)^2 + (y_i - y_c)^2$$

    where $n$ is the number of the airports and $C_i$ is the set of cities whose closest airport is airport $i$.

    iv. The goal of the program is determining the locations of airports that minimize the objective function using gradient based optimization. By updating

$$(x_1, y_1, x_2, y_2, x_3, y_3) \leftarrow (x_1, y_1, x_2, y_2, x_3, y_3) - \alpha \nabla f(x_1, y_1, x_2, y_2, x_3, y_3)$$

    where $0 < \alpha \ll 1$ is a constant, find an optimal location of the airports as Figure 1b.

    v. As shown in Figure 2, plot the objective function at every time of updating the locations to terminate the algorithm. (The objective values may be different than the example.)
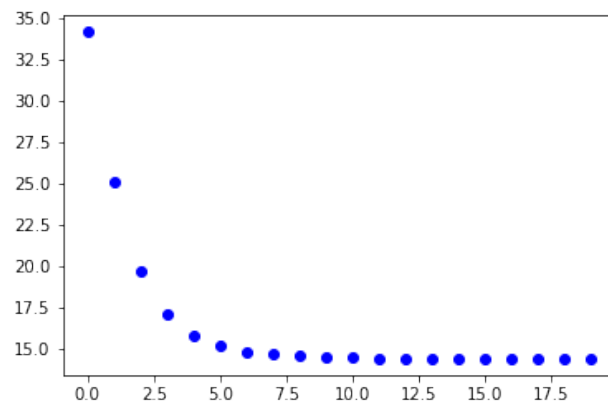
    vi. Submit your `n-airports.ipynb`.

Figure 2: Objective as a function of epoch