In the Name of God

Sharif University of Technology - Department of Computer Engineering

Artificial Intelligence - Mr. Samiei

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Practical Assignment(Particle Filtering)

Deadline: Ordibehesht 29th - 23:59
Cheating is Strongly Prohibited

Please run all the cells.

Personal Info

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Libraries

In [ ]:

```
! pip install numpy
! pip install matplotlib
```

Particle Filter (50 Points)

Author: Erfan Sadraiye
Please run all the cells.

This notebook demonstrates the use of a particle filter to estimate the location of an object moving on a 2D map using a noisy sensor.

In [1]:

```
import numpy as np
import matplotlib.pyplot as plt
```

ParticleFilter Class

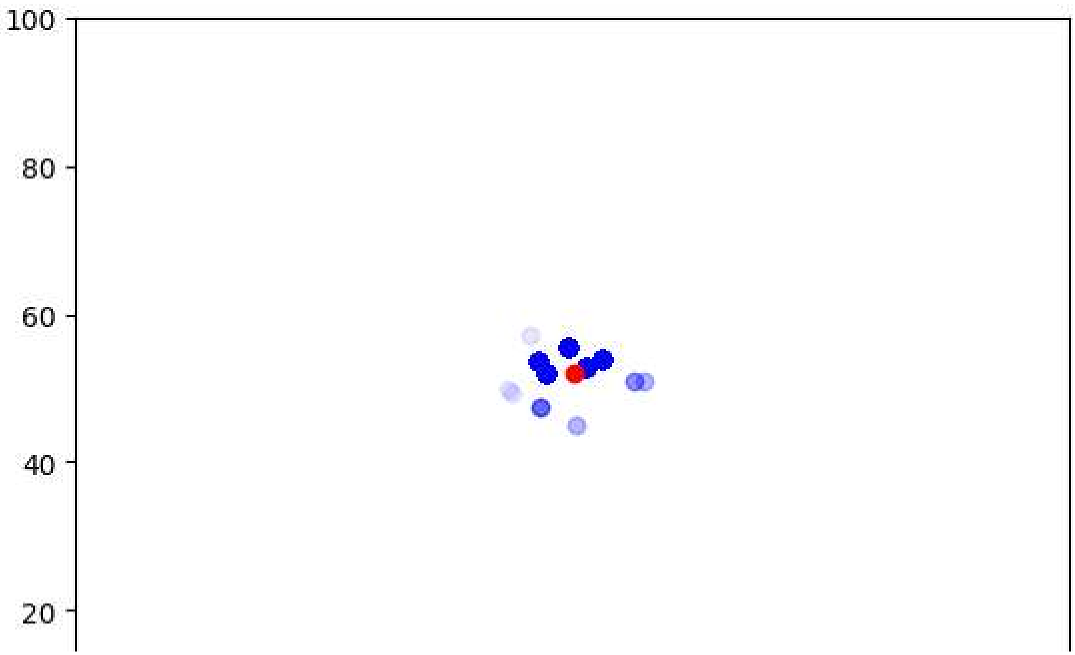
The ParticleFilter class implements a particle filter for the given problem. It contains the following methods:

In [10]:

```python
import random

import numpy as np


class ParticleFilter:

    def __init__(self, num_particles, map_min, map_max, std):
        """
        :param num_particles: Number of particles to use in the filter.
        :param map_min: Lower bounds of the 2D map.
        :param map_max:  Upper bounds of the 2D map.
        :param std:  Standard deviation of the sensor noise.
        """
        self.num_particles = num_particles
        self.map_min = map_min
        self.map_max = map_max
        self.std = std
        self.particles = None
        self.weights = None
        self.initialize_particles()

    def initialize_particles(self):
        """
        Implement the initialization of particles by creating an array of size (num_particles, 2) and setting
        """
        self.particles = np.zeros((self.num_particles, 2))
        for i in range(self.num_particles):
            x = random.uniform(self.map_min[0], self.map_max[0])
            y = random.uniform(self.map_min[1], self.map_max[1])
            self.particles[i] = (x,y)

        self.weights = np.ones(self.num_particles) / self.num_particles

    def predict_particles(self):
        """
        Implement the prediction step of the particle filter by updating the x and y values of each particle
        """
        for i in range(self.num_particles):
            noise = np.random.normal(0, self.std, size=2)
            self.particles[i] += noise
            if self.particles[i][0] > self.map_max[0]:
                self.particles[i][0] = self.map_max[0]
            if self.particles[i][0] < self.map_min[0]:
                self.particles[i][0] = self.map_min[0]
            if self.particles[i][1] > self.map_max[1]:
                self.particles[i][1] = self.map_max[1]
            if self.particles[i][1] < self.map_min[1]:
                self.particles[i][1] = self.map_min[1]

    def update_weights(self, z):
        """
        Implement the weight update step of the particle filter by updating the weights for each particle bas
        """
        for i in range(self.num_particles):
            particle_pos = self.particles[i]
            distance = np.linalg.norm(particle_pos - z)
            # use gaussian weight which is popular in particle filtering
            weight = np.exp(-0.5 * (distance / self.std) ** 2)
            self.weights[i] = weight
        self.weights /= np.sum(self.weights)

    def resample_particles(self):
        """
        Implement the resampling step of the particle filter by choosing new particles based on the current w
        """
        new_particles = np.zeros((self.num_particles, 2))
        for i in range(self.num_particles):
            index = np.random.choice(range(self.num_particles), p=self.weights)
            new_particles[i] = self.particles[index]
        self.particles = new_particles
        self.weights = np.ones(self.num_particles) / self.num_particles


    def run(self, measurements):
        for z in measurements:
            self.predict_particles()
            self.update_weights(z)
            self.resample_particles()
            self.plot_particles(z)

    def plot_particles(self, z):
        plt.scatter(self.particles[:, 0], self.particles[:, 1], color='b', alpha=0.1)
        plt.scatter(z[0], z[1], color='r')
        plt.xlim(self.map_min[0], self.map_max[0])
        plt.ylim(self.map_min[1], self.map_max[1])
        plt.show()
```

In [11]:

```
num_particles = 1000
map_min = [0, 0]
map_max = [100, 100]
std = 2.0
number_of_moves = 8
start_location = np.random.normal((map_max[0] - map_min[0]) / 2, 2.0, size=(1, 2))
measurements = np.empty((number_of_moves, 2))
measurements[0, :] = start_location
for i in range(1, number_of_moves):
    measurements[i, :] = measurements[i - 1, :] + np.random.uniform(-5, 5, size=(1, 2))
    measurements[i, :] = np.maximum(measurements[i, :], map_min)
    measurements[i, :] = np.minimum(measurements[i, :], map_max)
measurements += np.random.normal(0, 2.0, size=measurements.shape)
particle_filter = ParticleFilter(num_particles, map_min, map_max, std)
particle_filter.run(measurements)
```



This generates a sequence of 8 sensor measurements and initializes the particle filter with 1000 particles. The run method of the ParticleFilter object is then called with the sequence of measurements to run the particle filter and display the particle locations at each step.