Homework 2

-- Course: *Intelligent Robot – Professor: Qi Hao*

Homework Submission Instructions Please write up your responses to the following problems clearly and concisely. We require you to write up your responses with A4 paper. You are allowed and encouraged to work together. You may discuss the homework to understand the problem and reach a solution in groups. However, each student must write down the solution independently. You must understand the solution well enough in order to reconstruct it by yourself. (This is for your own benefit: you have to take the exams alone.)

Written Homeworks. All calculation problems must be written on single-sided A4 paper. The scan version of the paper will also be accepted.

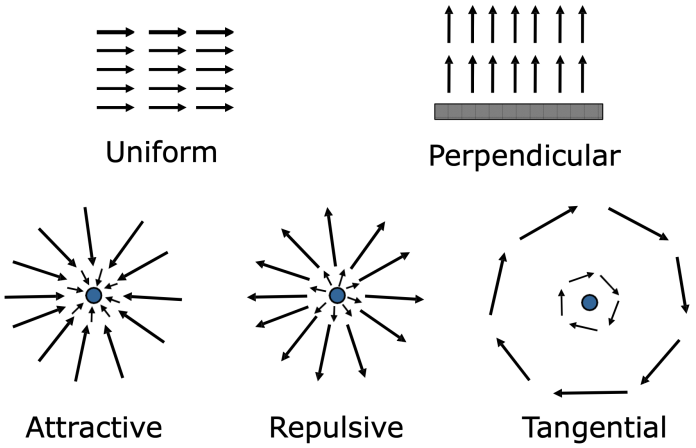
Coding Homeworks. Most of coding assignments will be done by Python(>=3.5) under a simple robotics simulator. You can follow the Coding instruction to use this simulator to complete the coding part in question2 and question3. Your final submission should be a compressed package with extension .zip, which includes your codes and explanations (you need to know how to write the manuscript with Markdown or LATEX). Your code should be run step-by-step without any error. Real-time animation is also recommended.

Question 1

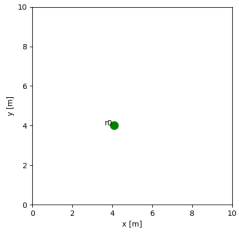
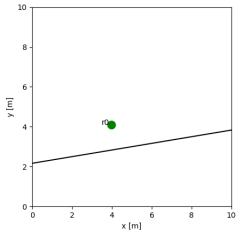
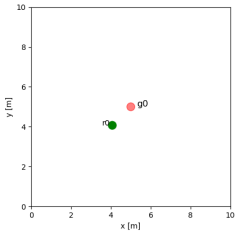
- (a) Imagine you want your robot to perform navigation tasks, which approach would you choose?
- (b) What are the benefits of the behavior based paradigm?
- (c) Which approaches will win in the long run?

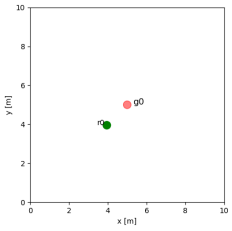
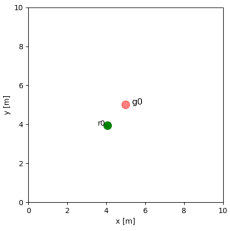
Question 2

- (a) How to generate uniform, perpendicular, attractive, repulse, tangential forces for a robot and obstacles with known positions? Provide related mathematical formulas.
- (b) Please simulate the motions of a robot with the given force fields from the following figure.



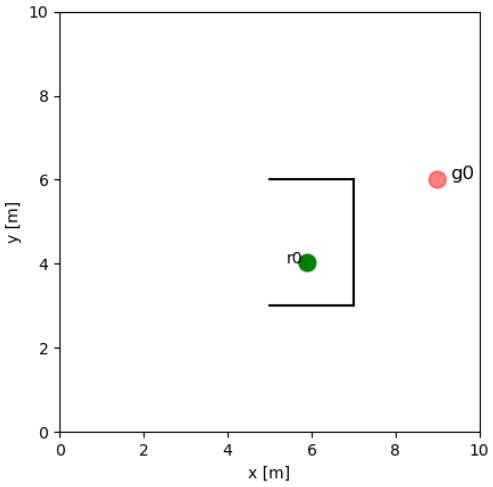
Provide codes and plots of simulation results. You can follow the instruction to complete the file *potential_fields.py* and run *question2_run.py* in source folder to generate the gif as shown below:

Uniform	Perpendicular	Attractive
		

Repulsive	Tangential
	

Question 3 - Extra Credit

Simulate a robot can reach the goal without sticking into a local trap. Provide codes and plots of simulation results. You can follow the instruction to complete the file *question3_run.py* in the source folder to generate the animation as shown below:



Coding instruction

All the assignments are performed based on intelligent robot simulator, which provides the common robot motion model and plot functions that we can focus on the robotics algorithm directly.

Install the intelligent robot simulator

```
git clone -b edu https://github.com/hanruihua/intelligent-robot-simulator.git
cd intelligent-robot-simulator
pip install -e .
```

Note: Please confirm that this repository is under the *edu* branch.

Common used API

- *env.robot.state:* 2*1 matrix, The position of the robot with x and y
- *env.obs_line_states:* A list of line coordinates. Each line includes the position of two points (x1, y1, x2, y2).
- *env.robot.goal:* 3*1 matrix, The goal of the robot with x, y and theta.
- *env.render():* Show current figure at each step

Code for question2

There are three files for question2 in the source folder, *question2.yaml*, *question2_run.py*, and *potential_fields.py*.

- First is the parameter set for the simulation environment.

- Second is the run file to show perform the robot and potential field algorithm.
- Third is the potential field class which defines the primitive potential fields as shown in the mentioned figure.

You should complete the file *potential_fields.py* and run *question2_run.py* to show the simulation results. You can set the parameter *animation = True* in *question2_run.py* to generate the gif file. In addition, you can change the number of arguments of coefficient in the *potential_fields.py* by your need.

Note1: *we provide the function which calculates the minimum distance between a point and a segment.*
Note2: *The robot is with omnidirectional wheel for simplicity*

Code for question3

There are two files for question3 in the source folder, *question3.yaml*, *question3_run.py*. The potential_fields.py that completed in question2 can also be used for this task. You should complete the file *question3_run.py* to simulate a robot to reach the goal without sticking into a local trap.

Note: *The robot is with omnidirectional wheel for simplicity*