

## Problem set 1 for CS 498 GC

- ☐ This homework consists of a written and coding part. Both must be submitted individually at Gradescope.
- ☐ The coding part must be developed in python. When submitting this section, only upload the python file *problem\_set1.py* (see attached template).
- ☐ The written part must be submitted in PDF format. When submitting this file, Gradescope will ask you to select the pages where each question is. Please do it precisely.

Total points: 100

### Written section

**Question 1** (15 points): In this exercise, we will train our brains to think about robots and the challenges associated with them. Pick a real (mobile) robot of your choice, and

1. Very briefly describe the robot, include pictures, diagrams, etc., with appropriate citation
2. Briefly describe the environment in which the robot operates.
3. How does the robot move around? What are its motion mechanisms?  
How did the environment affect the design choices?
4. How does the robot sense the world around it? What are its sensing mechanisms?
5. What do you think the main motion challenges are for that robot?
6. What do you think the main sensing challenges are for that robot?

**Question 2** (15 points): In this exercise, we will go a bit more into flexing our abstract design muscles for robotics. Pick your favorite (field) robot character from the movies (Hollywood, Bollywood, whateverwood), and:

1. Describe the robot, include pictures, diagrams, etc., with appropriate citation.
2. Describe the environment in which the robot needs to operate.
3. How does the robot move around? What are its motion mechanisms?  
Guess if it doesn't.
4. How does the robot sense the world around it? What are its sensing mechanisms? Guess if it isn't clear, what sensors do you think the robot could be using?
5. Are the motion and sensing mechanisms appropriate for the environment? Why, or why not? How would you improve them?
6. What do you think the main motion challenges are for that robot?
7. What do you think the main sensing challenges are for that robot?

**Question 3** (15 points): Now we bring out our real big creativity muscles: Imagine a field environment, design a robot in your mind that would be ideal for this field environment. Do not constrain yourself with what is possible with today's state-of-the-art in engineering in the design, i.e. go nuts with the Science Fiction, but provide a physical mechanism that is at least somewhat plausible. For example, your robot could levitate using anti-gravity, or it could sense using minute variations in electromagnetic radiation spectra. Think about:

1. How the robot moves around in its environment, is it the most optimal way of moving around? Is it fast, is it efficient, does it have sufficient maneuverability? If there are tracks or wheels, how should they be designed?
2. What does the robot need to sense to perceive and operate successfully in its environment? How could it do this?
3. How does it manage power? How does it manage computation?
4. How much range/endurance would it have? Is it enough?
5. How does it deal with heat generated inside its body?

### **Coding section**

*See attached file **problem\_set1.py** for further details.*

**Question 1.** Implement a function to multiply two matrices using for loops (5 points).

**Question 2.** Write a function to transpose and add two matrices using for loops (5 points).

**Question 3.** Solve the equation  $Ax = b$ , given a matrix  $A$  and vector  $b$ . Your script should return 0 if there is no solution or there are infinite solutions (10 points).

**Question 4.** Implement a function that given a matrix  $A$ , return its inverse if and only if all the eigenvalues of  $A$  are negative. It returns 0 otherwise (10 points).

**Question 5.** Write a script to integrate the following function for  $N$  seconds using Euler integration with  $x(0) = 1$ , and a time step of  $\Delta T$  seconds. Provide a labeled plot of  $x$  versus time and include it in your written submission (25 points).

$$\dot{x} = -2x^3 + \sin(0.5t)x$$