Homework 0

16-311: Introduction to Robotics

Contents

Learning Objectives

1. Ensure understanding of vectors and matrices.
2. Ensure basic C proficiency.
3. Ensure basic programming proficiency.
4. Introduce basic website creation and hosting.
5. Introduce basic academic formatting.

1 C

This section will be submitted on Autolab and graded by an autograder.

This section is not meant to teach students C or proper coding style. It is meant to provide a refresher to concepts like pointers, header files and compiling. You will not be graded on style.

You can start from these files or create your own, provided that they match this format and can be compiled and run by the autograder, which will use files similar to this (recall that you can copy files into your private directory on AFS using cp and then starting from the /afs part of the following addresses):

- `https://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/p1.c`,
- `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/p1.h`
- `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/main.c`
- `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/makefile`

Write a program in C that can perform 1x3 vector and 3x3 matrix arithmetic including:

1. Assign vectors and matrices:

   - For vectors, a lower case letter, then a space, followed by an = sign, and then followed by three numbers separated by spaces sets the value for the vector. Ex: a = 1 2 3
   - For matrices, an upper case letter, then a space, followed by an = sign, and then followed by nine numbers (separated by spaces) sets the value for a matrix. Ex: A = 1 1 1 1 1 1 1 1 1

   To make things easier, assume there could only be 26 vectors and 26 matrices. Hint: there is a nice relationship between chars and ints in C.

2. Print a formatted vector or matrix:

- A vector on a line by itself followed by return should print the vector in its appropriate forms. Ex: a
- A matrix on a line by itself followed by return should print the matrix in its appropriate forms. Ex: A

3. Addition:

   - c = a + b stores the sum of vectors a and b to c.
   - C = A + B stores the sum of matrices A and B to C.

4. Multiplication:

   - c = a . b should compute the dot product of a and b and store in it in the first component of c (Set the other components of c to zero).
   - c = a * b should store the cross product of a and b in c.
   - C = A * B should perform matrix multiplication of A and B.
   - d = v * M should perform the vector times matrix scalar multiplication.

Only submit the p1.c file. Do not put a main function in this file. The autograder will have a main function.

Here are some example inputs and expected outcomes: `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/hw0_clarifications.html`,

2 MATLAB

This section will be submitted on Autolab and graded by TAs using an autograder.

This section is not meant to teach students MATLAB or proper coding style. It is meant to provide insight for image manipulation skills that will be useful in the coming assignments.

You can start from this file or create your own, provided that it matches the specified format: `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/p2.m`.

Write a function (not a script) called p2 takes in the file name of a colored .png image saved in the same directory that can manipulate an image in the following ways:

1. Take just the top left 5x5 pixels of the image. Save this as topleft.png.

2. Change every other column starting with the first column of the original image to be black. Save this image as stripes.png.

An example function call would be p2('image7.png') where image7.png is saved in the same directory as p2. The function would create topleft.png and stripes.png and save it in the same directory. Do not hard code an image. You code should work with any image we call.

3 Python

This section is submitted on Autolab and graded by an autograder.

This section is meant to ensure that students have the ability to create and run Python files.

You can start from this file or create your own file, provided that it matches the specified format: `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/p3.py`.

Using any stable version of Python 3, create a function that takes in a number as an input and returns the Fibonacci number corresponding to that input. The 0th Fibonacci number is 0, the 1st is 1. From there, a Fibonacci number is found by adding the two previous Fibonacci numbers. For example, the 2nd Fibonacci number is 1 (or 0+1). You can find additional information about Fibonacci numbers here: `https://en.wikipedia.org/wiki/Fibonacci_number`.

Name your file p3.py. This function should be able to be run by entering p3(12), for example.

4 Creating and Hosting a Website

The website you create will be linked from the next section and graded by TAs by inspection.

You can start from this empty file or create your site another way: `http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/homework/hw0/p4.html` (if this opens in your browser, right click and view page source). Tips for creating and publishing websites are included at `https://www.cs.cmu.edu/~16311/current/homework/hw0/hw0.html`.

Make and publish a simple webpage with the following information:

1. Your drawing of what you imagine when you think of a robot.
2. At least three headers: one for 'Sensing', one for 'Planning' and one for 'Acting'.
3. At least one sentence under each header explaining how your robot would do each of these things.
4. A hyperlink to your favorite real robot video or article.

Ensure that your webpage is viewable for at least a week after submission to allow for grading.

5 LaTeX

This section will be submitted on Gradescope and graded by the TAs.

You can start from this file or create your own: `https://www.cs.cmu.edu/~16311/current/homework/hw0/p5.tex`

Use LaTeXto create a document called p5.pdf with the following information:

1. Title
2. Name
3. Date
4. An image of you (one with your face visible) with a caption.
5. A clickable reference to the picture in the text that would update if you were to add more images.
6. Any equation to demonstrate understanding of math notation in LaTeX.
7. The URL of the website you created for Section 4 (make sure it can be accessed from any computer using this web address).
8. The answers to the six questions in Section 6 (Linear Algebra)

6 Basic Linear Algebra

This section will be submitted in the .pdf created in Section 5 (LaTeX).

This section is designed to make sure that students recall basic linear algebra skills and intuition.

6.1 Vectors

Use the right-handed coordinate system below to answer these questions:

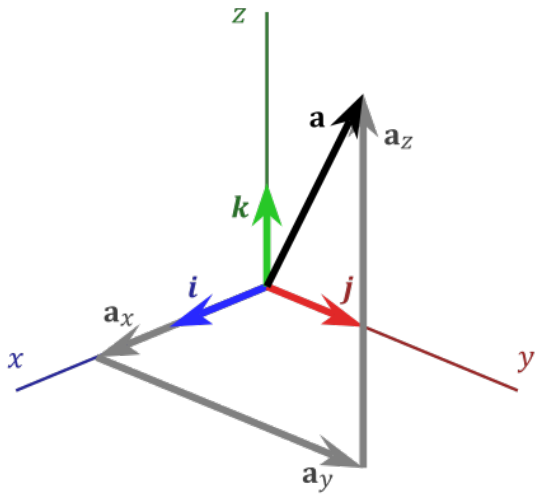

Figure 1: Coordinate system with representative vector $\vec{a}$.

1. What is the dot product of $\vec{i}$ and $\vec{j}$?
2. What is the cross product of $\vec{i}$ and $\vec{j}$?
3. Which of these is a vector? Speed, distance, or velocity?

6.2 Matrices

Perform the following by hand:

1. $$\begin{bmatrix} 1 & 2 & 3 \\ 1 & 1 & 1 \\ 7 & 1 & 1 \end{bmatrix} + \begin{bmatrix} 8 & 0 & 1 \\ 8 & 3 & 4 \\ 7 & 2 & 3 \end{bmatrix}$$
2. $$\begin{bmatrix} 1 & 2 & 3 \\ 1 & 1 & 1 \\ 7 & 1 & 1 \end{bmatrix} * \begin{bmatrix} 0 & 0 & 1 \\ 1 & 3 & 4 \\ 0 & 2 & 3 \end{bmatrix}$$

3. What is the determinant of:

$$\begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 4 \\ 0 & 2 & 3 \end{bmatrix}$$

What To Submit

Submissions are due on Autolab by the date specified in the Syllabus.

1. You will submit three files to Autolab, one for each of the first three sections. Additionally, you will submit one .pdf to Gradescope for the last three sections.

2. Please ensure that all files are named as described.