ENPM673 - Perception for Autonomous Robots

Homework 1

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Due date: 11th *February 2020, 11:59 p.m.*

Submission Guidelines

- The homework is to be completed in groups of three or less and submitted individually.
- Your submission on ELMS/Canvas must be a zip file, following the naming convention **YourDirectoryID_hw1.zip**. If you email ID is abc@umd.edu or abc@terpmail.umd.edu, then your DirectoryID is **abc**. Remember, this is your directory ID and **NOT** your UID. Please provide detailed instructions on how to run your code in README.md file.
- For each section of the homework, explain briefly what you did, and describe any interesting problems you encountered and/or solutions you implemented. Your report **MUST** be typeset in LaTeX.
- For Problem 3, you are not allowed to use built in functions for computing SVD and Pseudoinverse directly. However, use of low level inbuilt functions like function for computing eigen vectors and tranpose is allowed.

The file tree of your submission SHOULD resemble this:

```
YourDirectoryID_hw1.zip
├── Code
│   ├── .py files
│   └── any subdirectories that you may have
├── Report.pdf
└── README.md
```

Problem 1 **[20 POINTS]**

Assume that you have a camera with a resolution of 5MP where the camera sensor is square shaped with a width of 14mm. It is also given that the focal length of the camera is 15mm.

1. Compute the Field of View of the camera in the horizontal and vertical direction. **[10 POINTS]**
2. Assuming you are detecting a square shaped object with width 5cm, placed at a distance of 20 meters from the camera, compute the minimum number of pixels that the object will occupy in the image. **[10 POINTS]**

Problem 2 **[60 POINTS]**

Two files of 2D data points are provided in the form of CSV files (Dataset_1 and Dataset_2). The data represents measurements of a projectile with different noise levels and is shown in figure 1. Assuming that the projectile follows the equation of a parabola,

- Find the best method to fit a curve to the given data for each case. You have to plot the data and your best fit curve for each case. Submit your code along with the instructions to run it. **[40 POINTS]**
- Briefly explain all the steps of your solution and discuss why your choice of outlier rejection technique is best for that case. **[20 POINTS]**

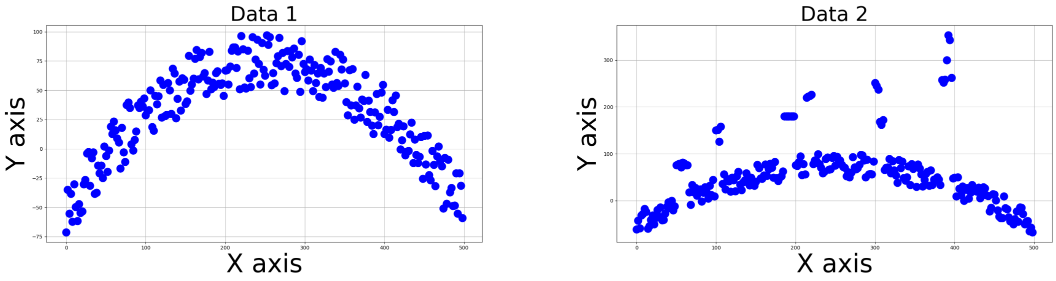

Figure 1: from left to right (a) Dataset 1 and (b) Dataset 2

Problem 3 **[20 POINTS]**

The concept of homography in Computer Vision is used to understand, explain and study visual perspective, and, specifically, the difference in appearance of two plane objects viewed from different points of view. This concept will be taught in more detail in the coming lectures. For now, you just need to know that given 4 corresponding points on the two different planes, the homography between them is computed using the following system of equations Ax = 0, where:

$$A = \begin{bmatrix} -x1 & -y1 & -1 & 0 & 0 & 0 & x1*xp1 & y1*xp1 & xp1 \\ 0 & 0 & 0 & -x1 & -y1 & -1 & x1*yp1 & y1*yp1 & yp1 \\ -x2 & -y2 & -1 & 0 & 0 & 0 & x2*xp2 & y2*xp2 & xp2 \\ 0 & 0 & 0-x2 & & -y2 & -1 & x2*yp2 & y2*yp2 & yp2 \\ -x3 & -y3 & -1 & 0 & 0 & 0 & x3*xp3 & y3*xp3 & xp3 \\ 0 & 0 & 0 & -x3 & -y3 & -1 & x3*yp3 & y3*yp3 & yp3 \\ -x4 & -y4 & -1 & 0 & 0 & 0 & x4*xp4 & y4*xp4 & xp4 \\ 0 & 0 & 0 & -x4 & -y4 & -1 & x4*yp4 & y4*yp4 & yp4 \end{bmatrix}, x = \begin{bmatrix} H_{11} \\ H_{12} \\ H_{13} \\ H_{21} \\ H_{22} \\ H_{23} \\ H_{31} \\ H_{32} \\ H_{33} \end{bmatrix} \qquad (1)$$

For the given point correspondences,

	x	y	xp	yp
1	5	5	100	100
2	150	5	200	80
3	150	150	220	80
4	5	150	100	200

find the homography matrix H = $\begin{bmatrix} H_{11} & H_{12} & H_{13} \\ H_{21} & H_{22} & H_{23} \\ H_{31} & H_{32} & H_{33} \end{bmatrix}$

- Show mathematically how you will compute the SVD for the matrix A. **[10 POINTS]**
- Write python code to compute the SVD. **[10 POINTS]**