ENPM673 – Perception for Autonomous Robots

Project 1

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Due date: 22nd February 2022, 11:59PM

Submission guidelines:

- This homework is to be done and submitted individually.
- Your submission on ELMS/Canvas must be a zip file, following the naming convention
- YourDirectoryID_proj1.zip. If your email ID is abc@umd.edu or abc@terpmail.umd.edu, then your Directory ID is abc. Remember, this is your directory ID and NOT your UID.
- Please submit only the python script(s) you used to compute the results, the PDF report you generate for the project and a detailed README.md file which includes the steps to run your code and any non-standard libraries used
- Include sample outputs in your report
- **Allowed Functions :**
    - Low level functions for matrix operations, computing eigen values and eigen vectors
    - OpenCV functions to read videos and perform image operations
    - Matplotlib functions for displaying and plotting
- **Disallowed Functions :**
    - Functions for high level operations such as SVD, various least square methods, RANSAC, etc
- For each section of the homework, explain briefly what you did, and describe any interesting problems you encountered and/or solutions you implemented.

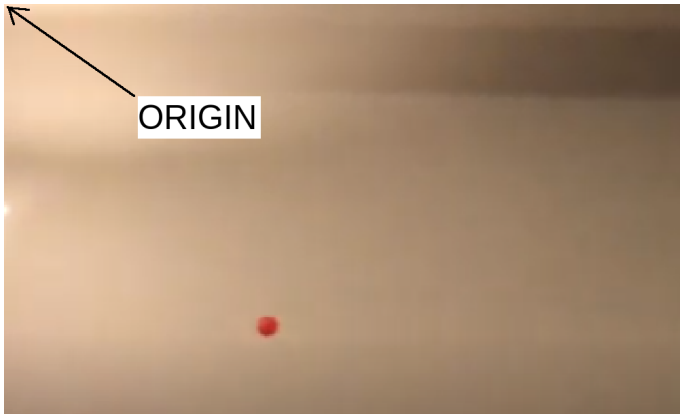
Problem 1:

In the given video, a red ball is thrown against a wall. Assuming that the trajectory of the ball follows the equation of a parabola:

1. Detect and plot the pixel coordinates of the center point of the ball in the video. **[10]**
   (Hint: Read the video using OpenCV's inbuilt function. For each frame, filter the red channel)

2. Use Standard Least Squares to fit a curve to the extracted coordinates. For the estimated parabola you must,
    a. Print the equation of the curve. **[5]**
    b. Plot the data with your best fit curve. **[5]**

3. Assuming that the origin of the video is at the top-left of the frame as shown below, compute the x-coordinate of the ball's landing spot in pixels, if the y-coordinate of the landing spot is defined as 300 pixels greater than its first detected location. **[10]**



Problem 2:

Given are two csv files, pc1.csv and pc2.csv, which contain noisy LIDAR point cloud data in the form of (x, y, z) coordinates of the ground plane.

1. Using pc1.csv:
    a. Compute the covariance matrix. **[15]**
    b. Assuming that the ground plane is flat, use the covariance matrix to compute the magnitude and direction of the surface normal. **[15]**

2. In this question, you will be required to implement various estimation algorithms such as Standard Least Squares, Total Least Squares and RANSAC.
    a. Using pc1.csv and pc2, fit a surface to the data using the standard least square method and the total least square method. Plot the results (the surface) for each method and explain your interpretation of the results. **[20]**
    b. Additionally, fit a surface to the data using RANSAC. You will need to write RANSAC code from scratch. Briefly explain all the steps of your solution, and the parameters used. Plot the output surface on the same graph as the data. Discuss which graph fitting method would be a better choice of outlier rejection. **[20]**