CPS 843 (CP 8307) Problem Set 3

(25 points)

Purpose

- Familiar with the algorithm in computer vision
- Understand the basic concepts for 2D projective geometry
- Understand the code and principle for robust data fitting with outliers

Requirements

- The assignment is due on Monday, November 8th @ 11:59 pm. Late submissions will not be accepted.
- Submit all your work in one PDF file through D2L, including the source code (multiple submission is allowed, but only the last submission will be kept and evaluated).
- Highly recommend using IEEE double-column format. The Word and LaTeX template can be found at http://www.ieee.org/conferences_events/conferences/publishing/templates.html
- Please resize all images properly in line with the text of your report.
- Submit the source code, if any, along with the report of each part in one PDF file.
- You can directly use available functions or software packages of Matlab in your work.
- Complete the report by yourself. We will use Turnitin® for similarity check.

Part 1:

Problem 1. (1) Compute the intersection point of the following two lines using the cross product: y = -0.5x + 2, 3x + 6y = 5; (2) Give the general homogeneous forms of an ideal point and the line at infinity, and verify that the ideal point is on the line at infinity; (3) Give the equation of a conic in inhomogeneous, homogeneous, and matrix forms. (4 points)

Problem 2. (1) Verify that under a general 2D transformation, an ideal point is mapped to a finite point; (2) Given point transformation $\mathbf{x}'_i = \mathtt{H}\mathbf{x}_i$, verify that a line and a conic are mapped respective by $\mathbf{l}' = \mathtt{H}^{-\mathsf{T}}\mathbf{l}$ and $\mathtt{C}' = \mathtt{H}^{-\mathsf{T}}\mathtt{C}\mathtt{H}^{-1}$. (4 points)

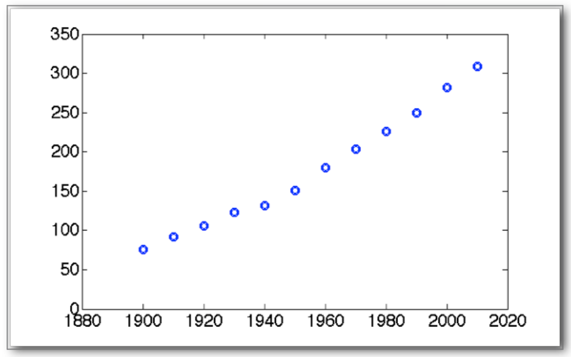
Problem 3. (1) Give the general forms, degrees of freedom, and invariant properties of the projective, affine, and similarity transformations; (2) Verify that an affine transformation maps an ideal point to an ideal point; (3) Verify that an affine transformation maps a line at infinity to a line at infinity. (4 points)

Problem 4. (1) Verify that any circle in a 2D plane intersects the line at infinity at the two circular points; (2) Verify that the line at infinity is a null vector of the dual conic; (3) Verify that two orthogonal lines are conjugate with respect to the dual conic, i.e., $\mathbf{l}^{\mathsf{T}}\mathtt{C}^{*}_{\infty}\mathbf{m} = 0$. (4 points)

Problem 5. The data below are the total population (millions) of the United States for the years 1900 to 2010. Model the population growth by LS fitting and predict the population for 2020.

Use both linear line model and quadratic parabola model (show your results of necessary steps). (4 points)

t	y
1900	75.995
1910	91.972
1920	105.711
1930	123.203
1940	131.669
1950	150.697
1960	179.323
1970	203.212
1980	226.505
1990	249.633
2000	281.422
2010	308.748



Part 2: (4 points)

Inspired by the RANSAC algorithm, there are many extensions and follow-up studies in the research field. One influential extension is MLESAC:

- Torr, P. H. S. and A. Zisserman. "MLESAC: A New Robust Estimator with Application to Estimating Image Geometry." Computer Vision and Image Understanding. 2000.

The paper can be downloaded from the author's homepage:
https://www.robots.ox.ac.uk/~vgg/publications/2000/Torr00/torr00.pdf

Software:
Sphere fitting from 3D point cloud:
https://www.mathworks.com/help/vision/ref/pcfitsphere.html
Note: the code requires Matlab R2015b or later.

Work to do:

- Have a read of the MLESAC paper, and make a brief technical overview (no more than one page, in your own words) of the MLESAC algorithm.
- Follow the instruction and example of sphere fitting https://www.mathworks.com/help/vision/ref/pcfitsphere.html and fit a sphere from the dataset 'object3d.mat'. You may choose different parameters based on your understanding.
- Include a brief description of each step, the source code, and the results.

Part 3: (1 point)

Please tell me the progress of your final project (in one very short paragraph).