HW1 – submission 28.11.18 23:55

Guide lines

1. Include all your personal details including name, id, and e-mail address.
2. You should submit all function and script files written in MATLAB or Python. Your code should be well documented and clear. The code should run from **any** computer and include all path definitions (You should take care of this in the code). For python – please use numpy, scipy, matplotlib and pillow (PIL) packages. If any other packages were used please attach a requirements.txt file.
3. Please divide the code by questions.
4. **Final report – should include explanations on the implementation and the execution, answers to the questions, results, conclusions and visual results. Do elaborate on all parts of the algorithms/solution. Please submit a PDF file and not a DOC file.**
5. Please post question regarding this HW on the facebook group: https://www.facebook.com/groups/294298727746314/
6. The grades are highly depended upon the analysis depth of the report.
7. HW could be submitted in pairs.
8. Eventually submit one compressed file including the code and the PDF.

Good luck!

Photometry

Q1 (15 points)

A Lambertian ball of radius 10, is centered at the origin. An ideal camera, located at (0,0,100) looks down at it, *i.e.* the camera looks at the negative Z direction (all coordinates are in world coordinate system). A point illumination source is located in some unknown place (Lx,Ly,Lz>0), far from the ball.

A. Draw a schematic diagram showing the ball, the camera and the light source

B. Draw a schematic description of the image taken by the camera
Note: Pay attention to visibility situations (which points are illuminated, which points are seen by the camera)

C. Suggest an algorithm for finding the illumination source direction.

Geometry

Q2 (10 points):

An ideal percpective camera (f=1m) is located at the origin (in the world coordinate system). The camera is directed to the z axis, so the image plane is parallel to the XY plane. A center of a cube of dimensions $1m^3$ is located at (0,0.5m,10m). The cube is rotated, so one of its edge create an angle of θ with the z-axis. Describe the locations of the vanishing points related to the cube.

Q3 – Geometry (15 points):

For each of the following, prove the statement, and discuss if there are any exceptional:

a. A straight lines in the 3D world is projected to a straight line in the image
b. Parallel lines in the 3D world are projected to gathering lines in the image which meet at the vanishing point.
c. All vanishing points of parallel lines which are also parallel to a plane, are projected onto the same straight line.

Camera Calibration

Q4 –(30 points)

This question deals with a controversy from the qualification games of the European Championships in soccer, 7 October 2006. After a corner kick in the game between Sweden and Spain it was hard to tell if **the ball crossed the goal line or not**.

Here is an image from that scene (also included in the exercise files):

Your task is to find the camera location relative the field. To your help, we provide you a matlab script (called inl1.m) which gives you some measures of the goal area.

a. Compute the camera matrix M which generated the image points x according to the camera equation.

   Use the linear DLT method which was presented in the tutorial.

b. Re-project all the real world point X to their estimated corresponded points $\tilde{x}$ on the image plane using the estimated matrix M. Define a way to compute the estimation error based on $\tilde{x}$. Explain the error measure you defined. What are its units?

We will now determine the intrinsic parameters K and the extrinsic parameters R and X_0

c. Use the given function “rq.m” to reconstruct R, K .

1. Describe the goal of this function. What is the difference between the given function and the matlab function called “qr.m”? Why didn’t we use the qr function?
2. Explain the operation done at each of the function's lines.

d. What can you say about the camera's characteristics, from the matrix K? Are the intrinsic camera parameters reasonable?

e. What can you say about the orientation of the camera from the matrix R? Is that reasonable?

f. Compute the translation vector. Is it reasonable?

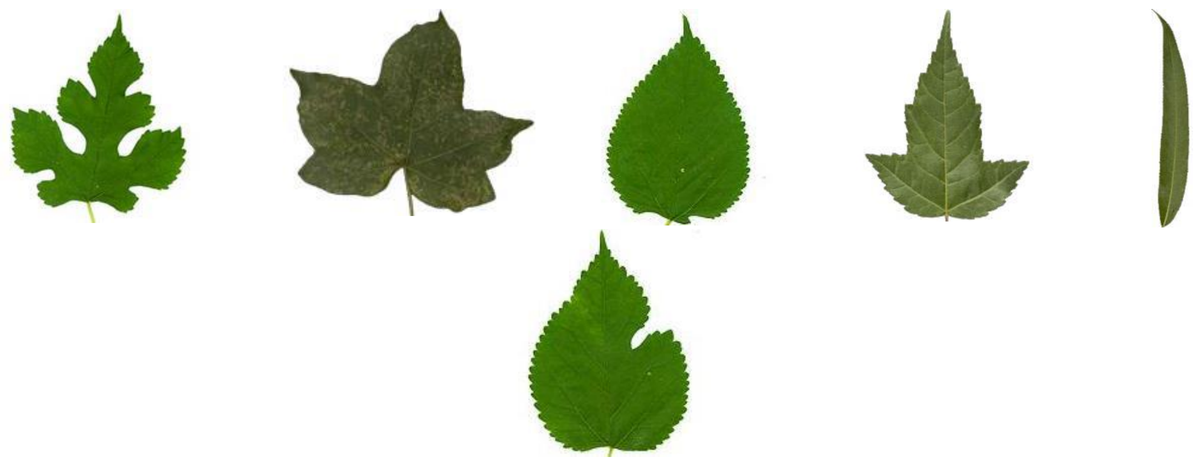
g. Plot the camera location onto the given 3D field model.

h. Using all the above information, can you determine if the ball actually crossed the goal line? If yes, give an explanation and calculation. If not, explain why.

Morphologic Operation

Q5 – (30 points):

Applications such as LeafSnap (http://www.leafsnap.com) use plant-leaf classification algorithms to identify different plant species in nature.



Design and implement an image processing algorithm to automatically determine which of the 5 training images (named leaf{1,2,3,4,5}) is most similar to the testing image (lef6), using **morphological operations** only (of course, other simple image operations are allowed as well).

Clearly describe the steps of your algorithm, including intermediate results if they help to explain the process.

Your algorithm should generate a numerical similarity score, or alternatively a distance score, between a pair of leaf images, e.g., similarity(training image #1, testing image) = 0.8, similarity(training image #2, testing image) = 0.6, etc.

Report the similarity score or distance score between every training image and the testing image, i.e., 5 numbers. Does your algorithm assign the highest similarity score, or equivalently lowest distance score, to the correct training leaf?

Try to use as least structuring elements as possible.