Master CIMET and 3DMT - Computer Vision course

Exam April 2014 - 2h without documents

(3 parts with a total of 13 questions accounting for 21 points, the exam will be scored for 20 points)

Part 1: 3D reconstruction

Question 1 *(2 points)***:** Show how to map the coordinates of a 3D point in the scene to the coordinates of a 2D point in the image.

See course

Question 2 *(1 point)* : Is it possible to recover depth from a monocular point of view? Justify

See course yes. Depth cues → linear perspective,

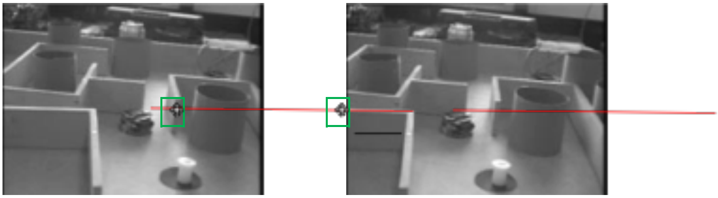
Question 3 *(2 points)*: Show how to map the coordinates of interest points in multiple 2D images of the same 3D scene viewed from different points of view.

See course

Question 4 *(1 point)*: Is it possible to recover depth from a binocular point of view?

See course

Question 5 *(2 points)*: The two images below are a stereo pair taken using parallel cameras, aligned horizontally. Describe a framework (i.e. a solution) for matching corresponding features in the two images and estimating their disparities. State clearly how your method exploits the epipolar constraint.



See course: epipolar lines are parallel to the baseline. Using a block matching technique (correlation measure) we can easily match corresponding features (computed from interest point technique) along epipolar line

Question 6*(2 points)*: Explain how to obtain estimates of the 3-D positions of the objects in the scene above from stereo disparities. What information about the cameras is required for this?

See course: if f= focal, T= translation, X= horizontal disparity, Z=depth, b=baseline then
$Z= f.T/X$ Idem for Y (vertical disparity if any)

Question 7 *(2 points)*: If only one of the two images in the pair above was available, what computational processes might be used to make inferences about the 3-D structure of the scene? What assumptions are involved in applying these processes?

Solution: if we can detect shadows and can estimate lighting orientation, if we can model surfaces of vertical plane and detect occlusions, if we can estimate the ground surface and perpendicular vertical planes (Mahattan world assumption), etc. then we can infer the 3D structure of this scene.

Part 2: pinhole model

Question 1*(1 point)***:** What is the name of the mathematical equation of a thin lens which models the relationship between the focal f, the distance Z of a point in the scene to the camera frame and the distance z of its 2 projection in the image frame? Write this equation.

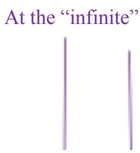
See course

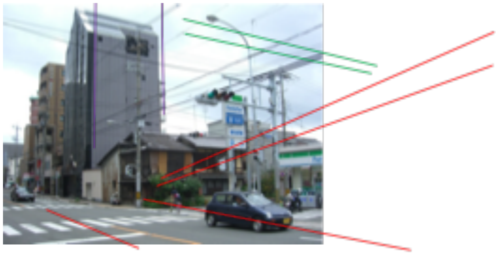
Question 2 *(2 points)*: With the pinhole model the most distant objects appear smaller, why? With the pinhole model parallel lines in the scene can intersect in the image, show with a graphic why?

See course

Question 3 *(1 point)***:** For the Kyoto Street image, shown below, estimate manually the positions (in the image plane) of the three major vanishing points, corresponding to the building orientations.

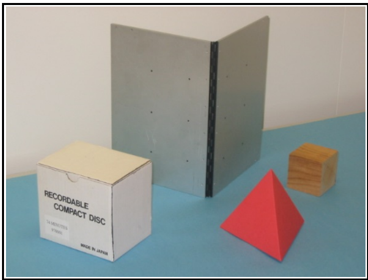
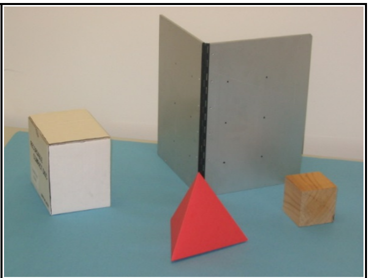
Solution





Part 3: 3D reconstruction (related to lab sessions)

Consider the pair of image shown below which you have used in **Lab-4** for the purpose of Fundamental matrix computation (1^{st} part) and 3D reconstruction (2^{nd} part).

	
Left Image	Right Image

During the lab you manually selected several corresponding points from both images. Now let us suppose that we want to perform this task (finding corresponding points) automatically.

Question 1 *(2 points)***:** How will you do that using the knowledge and tools that you have developed during the lab sessions 1-5?

Solution:
1**st step:** detect the interest points in the image. For this purpose, apply a corner detection method 1.
2nd step: perform matching among the detected corners/points. To perform the matching, use for example a technique similar to block matching in order to compute the pairwise distance among the interest points. For each point in one image select the point which has minimum distance in the second image. In order to measure the distance use the SSD/SAD etc.

Question 2 *(1 point)***:** How will you verify (using objective measure) if the matching algorithm that you developed is correct?

Solution:
In order to verify the matching points, First compute the Fundamental matrix F and then check whether the epipolar constraint: $x'Fx=0$ is satisfied for the matched points.

Question 3 *(2 points)***:** The 3D reconstruction that you performed in this lab was sparse. Now you are planning to reconstruct dense 3D map for which you need to obtain dense disparity from these images. How will you do it (i.e. compute dense disparity)?

Note:
- The sparse 3D reconstruction process involved several steps: calibration, projections, reconstruction.

- If you need any additional tool to perform this task then do not hesitate to mention it. However, you must specify why you need it.

Solution:
In order to obtain dense disparity we can use a block matching technique. However, the block matching technique requires the images to be rectified.

Therefore two steps have to be performed:
1. Rectify the images. This can be done by using the individual calibration matrices and using the stereo calibration from checkerboard images.
2. Apply the block matching technique with the following specifications:
    a. block size: 9
    b. Disparity range: 0-15
    c. Distance measure: SSD