CS 6320, 3D Computer Vision
Spring 2012, Prof. Guido Gerig
Solutions Assignment 2

Out: Wed Feb-15-2012
In: Wed Feb-29-2012

Summary Grading Assignment 2

Theory:	1+1+2	=4
Practical (Harris Corner (9)+Image Stitching (11):	9+11	=20
(*Additional points for excellent discussion)		
Total		24

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1. Pinhole camera [1 total]

How does an image change if the focal length is varied?

Using the perspective camera model, x = f.X/Z, and y = f.Y/Z. The image size changes linearly with the focal length f, the larger f the larger the image, and vice versa. The image area changes quadratically with f. There are two effects:

- size and shape of object images changes linearly with focal length f
- field of view (FOV) is increasing with decreasing f and vice versa, i.e. with shorter f we see more of the scene

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2. Perspective Projection [1 total]

Use the perspective projection equations to explain why, in a picture of a face taken frontally and from a very small distance, the nose appears much larger than the rest of the face. Can this effect be reduced by acting on the focal length?

Let us discuss the perspective equation: x = f*X/Z. Let's assume two points in the scene ΔX apart: The resulting Δx observed in the image is inversely proportional Z, i.e. for large distances Δx gets small, whereas for small distances Δx becomes large. The nose is closer to the camera and therefore becomes much larger than parts lying more distant.

$x_1 = f^*X_{nose}/Z_{nose}$ $\quad$ $x_2 = f^*X_{forehead}/Z_{forehead} = f^*((X_{nose}+\Delta X)/(Z_{nose}+ \Delta Z))$

Using another focal length does not reduce the problem as the distance Δx is linearly related to f . Changing the lens with another f would just zoom the whole image but keep the relative distances.

Changing object distance Z, however, would have a significant influence. With large Z, the depth difference ΔZ becomes negligible w.r.t. to the observed distance Δx in the image, whereas for small Z, the ΔZ would significantly change this relative distance Δx between nose and forehead.

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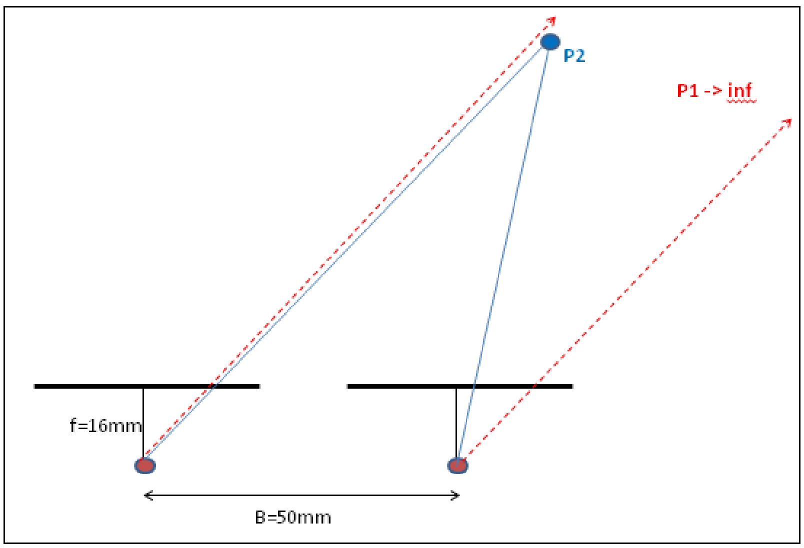
3. Simple Disparity [2 total]

Assume two cameras in the standard stereo geometry arrangement …..

a) Let us assume that the image planes are considered "virtual planes" between the scene and the optical centers. Using =fB/d, with B=50mm, f=16mm, and d=disparity expressed in µm (10^{-6}m = 10^{-3}mm, we can calculate:

Z_1 = infinity (no disparity), and
Z_2 = (16mm*50mm)/((81-28)*17 µm) = $0.8879*10^3$mm=888mm.

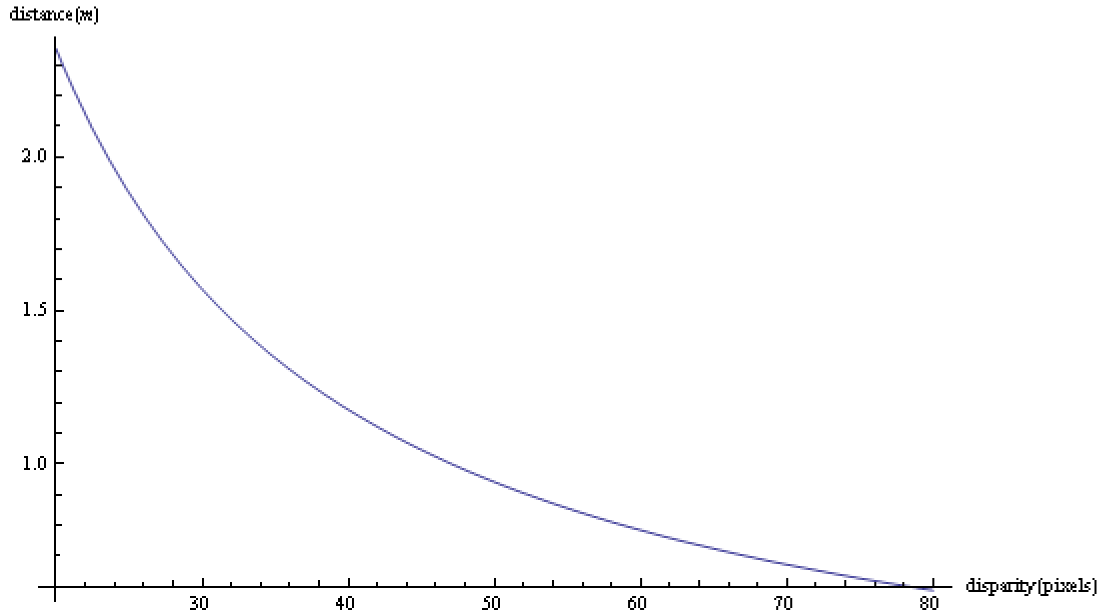


Assuming that the coordinate of the center of the image is aligned with the focal point, one can calculate X1 as infinity, and using some geometrical considerations X2=26mm. Y1 and Y2 have the same world coordinates.

Since Z1 is at infinity, the Euclidean distance between the world points calculates to infinity as well.

(Please note that given the standard camera geometry of the image plane behind the optical center and mirrored geometry, the left and right point coordinates will not result in intersecting lines for triangulation, simply exchanging P1 and P2 coordinates will help).

b) Z = fb/delta x: This is a nonlinear relationship with Z decreasing monotonically with increasing disparity. Plotting the disparity from 20 to 80 versus the relative depth shows this nonlinear relationship as a monotonically decreasing curve.



Practical Assignment: Feature Detection (Grading Practical Part: Total 9+11=20)

Will be discussed in class.

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4. Harris Corner Detection (Grading: 4+2+3=9)

Criteria:
"Completed" Experiment (setup of Matlab solutions for image smoothing and for corner detection, obtain results). **4**
Success: Reasonable results? **2**
Does report cover everything from theory, implementation, discussion of results / Quality of report: Style, clarity, organization, discussion. **3**

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5. Manually Assisted Image Stitching **(Grading: 4+2+3+2=11)**

Criteria:
"Completed" Experiment (setup of Matlab solution for landmark selection, calculation of translations, and image stitching, obtain results). **4**
Success: Reasonable results? **2**
Does report cover everything from theory, implementation, discussion of results / Quality of report: Style, clarity, organization, discussion. **3**
Additional evaluation of landmarks by using calculated corners? **2**

Bonus (rotated images) will be recorded separately