CAP5416: Midterm Exam II

30th November 2001

1. [25 points] **Stereo:** The main purpose of this question is to see if you can conceptually lay out an end to end stereo system. To this end,

   (a) [10 points] With a finite fixation point (which means that the normal vectors to the two image planes are not parallel), clearly demonstrate the cases where the corresponding points in the two image planes of a line *which lies in a plane formed by the two normal vectors* (after transporting the normals to the projection centers) are i) in the same order, ii) in reverse order, iii) in no specific order.

   (b) [5 points] Write down the equations of each of the two lines (formed by perspective projection of the real line in space) in the respective left and right coordinate systems.

   (c) [3 points] What is the relationship between the two lines and the famous epipolar lines that we encounter in the stereo problem? If the original line in space is treated as a finite line segment, does your answer change?

   (d) [5 points] If all the points in the above line segment lie at a distance beyond the fixation point, what is the disparity of the points on the line segment?

   (e) [2 points] What kind of a 3D reconstruction of this line segment can be achieved if we have no knowledge of intrinsic and extrinsic parameters?

2. [30 points] **Motion:** Assume that a point P on a rigid object is undergoing a real 3D motion which is represented as $V(t)$ where it should be understood that $V(t)$ is a 3D vector corresponding to the x, y, and z directions. We are tracking the motion of the points on this object using an *adaptive focus* camera. Assume that the focal length of the camera changes with time according to a function $f(t)$ which may be unknown.

   (a) [10 points] Using the above representation for the motion and the adaptive focal length, write down the motion field in the image plane of a point moving in space.

(b) [5 points] Immediately specialize to the case of rigid body motion where the motion $V(t) = -T + \omega \times P$. Write down the motion field. Is there any coupling between that part of the motion field which depends only on the change in the focal length and the rotation parameters? Discuss.

(c) [10 points] Specialize to the case where the adaptive focus $f(t) = \alpha Z(t)$ where α is a fixed parameter and $Z(t)$ is the instantaneous depth of the point P. Write down the general equation for the motion field for a 3D motion vector $V(t)$.

(d) [5 points] Write down the motion field for (c) when specialized to the case of rigid body translation and rotation ($V(t) = -T + \omega \times R$). Is there any interaction between the depth Z and the rotation parameters? Discuss.

3. [15 points] **Optical flow:** Analogous to the homework question, formulate optical flow when it is assumed to be a quadratically varying vector field. How many free parameters have to be estimated? What is the minimum value of N for an $N \times N$ patch used to estimate the vector field.