CS 280 FINAL EXAM, 1230-330pm, May 12, 1995

Make sure you have both pages of this exam. Each question is worth 20 points. Good luck.

1. Prove that any two distinct lines on the projective plane P^2 intersect.

2. Consider a camera translating along its optical axis towards a fronto parallel plane. How would you use the optical flow to predict time to collision?

3. Consider a binocular viewing geometry where both the eyes are pointing towards a point P on the perpendicular bisector of the line joining the two eyes. In this situation point P is imaged with zero disparity. Consider the plane formed by P and the pinholes of the two eyes. Prove that the set of all points on this plane with zero disparity is a circle (the so-called *Vieth-Muller* circle).

4. Outline an algorithm for recovering slant and tilt for a textured surface, based on the assumption that the texture is *isotropic*. The algorithm is given measurements of image moments as input.

5. Prove that for any two mutually visible points x and y in space, the radiance leaving point x in the direction of point y is the same as the radiance impinging on point y from the direction of point x.

6. Horn's formulation of shape from shading is based on the image irradiance equation $E(x, y) = R(\mathbf{n}(x, y))$. Locally the problem appears to be underconstrained–one equation, two unknowns. Outline one of the approaches that has been used to find a solution.

7. This exercise is aimed at testing your understanding of the geometry of occluding contours arising from the perspective projection of a smooth curved surface.

   (a) Give an example to show that the ray Q from the viewer to a point P on the contour generator need not be orthogonal to the contour generator.

   (b) Prove that the ray Q is *conjugate* to the contour generator.

8. Construct an example of each of the following:

   - A scene that shows a violation of the left–to–right ordering constraint for stereo correspondence.
   - An object which can be represented as a generalized cylinder in more than one way.
   - An object that has only one aspect.
   - A line drawing of a curved object where the line label changes along the edge.

9. It was not until 1960 or so that scientists were able to isolate the pigments in cones and show that there were three distinct types with different spectral response curves. How then was a three color theory of human vision developed and established in the nineteenth century?

10. For the following object recognition techniques:

    (a) The alignment method due to Huttenlocher and Ullman.

    (b) The approach based on recovering SHGC descriptions due to Zerroug and Nevatia.

    indicate a class of objects for which

    - technique a. works but b. does not.
    - technique b. works but a. does not.
    - neither is likely to work.

11. How many independent parameters are needed to characterize

    (a) An arbitrary affine transformation of R^3.

    (b) An arbitrary projective transformation of P^3.

    (c) The pose of a 3D object with respect to a camera.

    (d) A fixating binocular system (such as the human visual system) that obeys Listing's law.

    (e) A 2D moment matrix.