Instructions

The class average on the midterm was approximately 10.5/15 (70 percent). Rather than scaling the grade, I am giving you the opportunity to raise your grade by redoing some of the questions that overall were not handled as well as I had hoped.

• You may choose at most three of the following questions.

3 – 5, 8, 11 – 14.

• If you submit more than three, I will not grade any them.

• Your grade on these questions will override your grade on these questions on your original exam.

NOTE: This implies that if you originally submitted a correct answer and you now submit an incorrect one, you will lose that point and your grade could go down.

• Please resubmit to me a hard copy in class on Tuesday (or slide them under my office door, if you cannot attend class and I’m not in my office when you drop by). I will hand back the original exams and post solutions at the end of class Tuesday.

• I would like you to figure out the solutions on your own. Do not discuss the answers with each other.

Questions

1. Panum’s fusional area increases with eccentricity. Illustrate this claim by drawing Panum’s fusional area in (X, Z) space and in disparity space (xl, xr).

2. Neural mechanisms for controlling accommodation and vergence are known to be closely coupled. This coupling makes sense because it helps to focus the eyes on the scene point that one is ‘looking at’.

   Why does this coupling create a problem for 3D movies?

3. The vestibulo-ocular reflex (VOR) needs to account for the depth of the object one is looking at. Why?

   Hint: The vestibular system measures head translation and rotation.

4. How can VOR account for the depth of the object one is looking at? In particular, what information is available to VOR about object depth?

   Hint: Give two sources of information.

5. Suppose an observer is moving through space e.g. walking, riding a bicycle, driving, etc. Let (xT, yT) be the instantaneous heading direction.

   Suppose also that the observer is making a smooth pursuit eye movement to visually track some object in the scene. What, if anything, can one say about the image velocity (vx, vy) at the image position (xT, yT)?

6. Give values for the slant and tilt angle of at least two points near the boundary of a sphere. It is sufficient to draw a sphere and identify the slant and tilt at two such points.

   Hint: Slant depends on the magnitude of the depth gradient and tilt depends on the direction of the depth gradient.

7. Many animals such as birds, snakes, fish and deer have white bellies. Explain why this decreases the visibility of the animal (i.e. good camouflage) when the animal is viewed from the side, and under natural lighting.

   Hint: this question is taken directly from the Exercises.
8. Consider a surface such as a hanging drapery whose depth is

\[ Z(X, Y) = Z_0 + a \sin(k_0 X). \]

Assume the shading model \( I(X, Y) = \mathbf{N} \cdot \mathbf{L} \) and assume that the light is parallel to the viewing direction, i.e. from behind the head, so \( \mathbf{L} = (0, 0, -1) \).

[There was a typo in the exam. I wrote \( \mathbf{L} = (0, 0, 1) \) which is inconsistent with the phrase 'from behind the head'.]

How does \( I(X, Y) \) depend on the frequency \( k_0 \) ?

Hint: Do not derive a detailed mathematical expression. You can get the answer just by geometric reasoning from a simple sketch.

9. Contrast sensitivity is defined as the inverse of contrast detection threshold. Give a sketch to show how contrast sensitivity in human vision varies with spatial frequency. Assume a high mean intensity level (daylight), and central vision (not peripheral).

10. What is a likely underlying neural mechanism for the variation that you drew in the previous question?

11. [There were some ambiguities with the wording of the original question. I have changed the wording here.]

Suppose you are looking at a brick wall, where the bricks are shaped like squares (not rectangles) and the viewing direction is parallel to the ground plane and oblique to the wall, i.e. not frontoparallel.

Sketch the likelihood function for surface orientation (slant and tilt) from the texture compression cue. By ‘compression’, I mean a change in aspect ratio i.e. disk becomes ellipse, square becomes something other than square.

Specifically, draw a 2D space (where axes are slant and tilt), and identify the peaks of the likelihood function defined on that 2D space.

*If you wish, you can represent slant and tilt in polar coordinates instead.*

12. Same scenario as previous question, but now sketch the likelihood function for surface orientation from the texture size cue.

The final three questions are about the following experiment, which measures how well a person can discriminate depths from binocular disparities. Subjects are asked to compare the depths of two disks, one (A) shown above the other (B). By “above”, I mean that A’s y coordinate is greater than B’s and A and B do not overlap. The person’s task in the experiment is to answer the question, “Is A farther than B?”. The answer is yes or no.

13. Draw the psychometric curve that plots the percentage of times the person answers yes, where the depth of A is varied and the depth of B is fixed. Label any important points on the curve.

[ADDED: You should assume that tested depth values of A include depths that are less than B and others that are greater than B.]

14. How would the result in Q13 change if image noise were added?

15. When people view natural scenes, depths in the upper half of the visual field are typically greater than depths in the lower half of the visual field. For example, the sky tends to be in the upper half and the ground tends to be in the lower half. Given this observation and supposing the visual system uses a Bayesian prior for depth which depends on location in the visual field, how would the psychometric curve in Q14 change? Briefly justify.