Exam 1
CS 53000 - Introduction to Scientific Visualization

October 13, 2011

Name: _____

PUID: _____

Rules:

1. Closed book
2. One page of notes (front and back) to be submitted with your answers
3. No calculators or phones
4. **70 minutes to complete**

General advice:

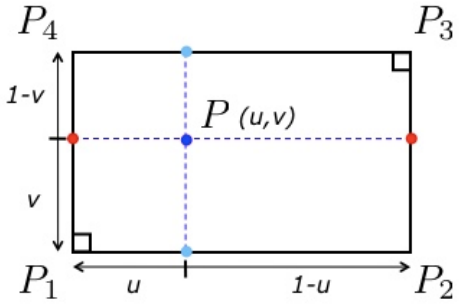
- The term “describe" does not mean complete sentences and paragraphs or essays. If it is easier you may use simple bullets and meaningful phrases to answer such questions.
- If you split answers across pages (or on the backs of pages) make a clear note on the page where the question is posed to indicate you have done so. Clearly note the question number (and part) on the separate page.
- There are a total of 5 questions for 70 points. Point values are roughly correlated with the amount of time you should spend on each question.

Question 1. [15 pts]

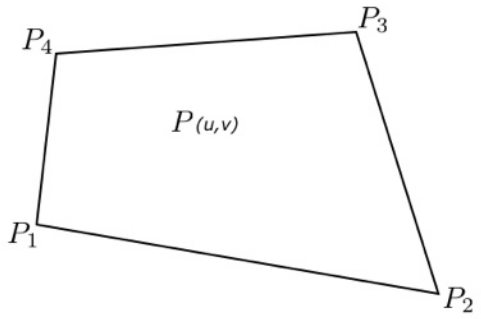
Data Representation and Processing.

a) Define the terms ‘interpolation’ and ‘approximation’. Explain the difference between these two forms of data reconstruction. Why are they both useful for visualization? Be specific.

b) Consider the rectangle cell depicted below. What type interpolation would you apply to compute the value associated with a point P located inside the cell? Assuming that each point P_i is associated with a value v_i, derive the mathematical expression of that interpolation at the point P using the notations of the figure. Explain.



c) Now consider the more general case of a quadrilateral cell, such as the one shown below. Explain how the interpolation discussed in the previous section can be generalized to this case. What type of equation must be solved?

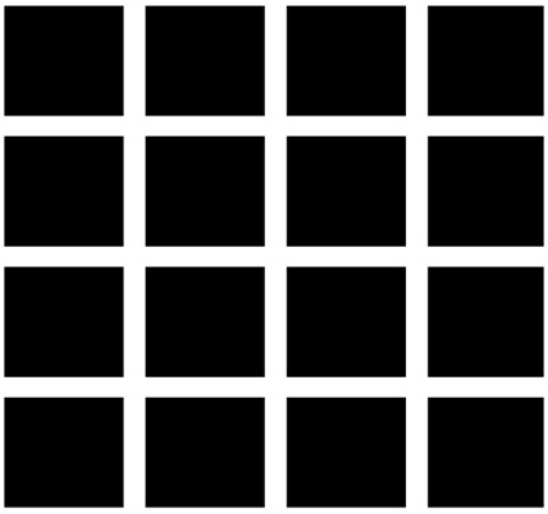


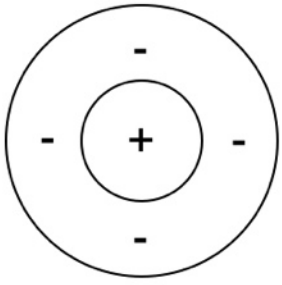
Question 2. [12 pts]

Human Vision and Illusions

a) The illusion in the image below is called the "*mach band*" illusion, because homogeneous gray bands appear to have a variation in brightness from left to right. (i) Which perceptual phenomenon is demonstrated by this illusion? (ii) What process and what anatomy in the retina could be used to explain this phenomenon?

b) Describe the illusion below (left). Explain its relationship to the notion of center-surround receptive field (right).

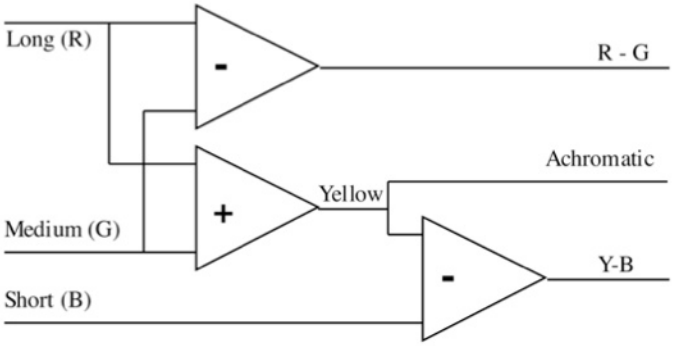




Question 3. [14 pts]

Color Perception and Color Visualization

a) What major theory of color perception does the following diagram represent? Explain the anatomical basis of this theory. Be specific.



b) What do the initials HSV stand for? What is the path (curve) in HSV color space of a rainbow color scale in which the brightness increases from left to right? Draw a figure showing this. What is the term used to designate a color scale in which two attributes are changing simultaneously?

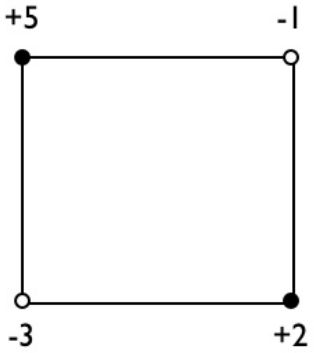
Question 4. [15 pts]

Isosurfacing

a) Summarize (in one sentence) the basic idea behind the marching cubes method.

b) This method applies a piecewise linear model to describe the isosurface geometry. Explain what this means. Why is this simple model acceptable despite the nonlinear nature of the trilinear interpolating function defined in each voxel? Be very specific.

c) The following case is ambiguous for the computation of a 0-isoline. Draw the two configurations that are theoretically possible for this isoline. How can this ambiguity be resolved? Explain. Apply this solution for the given scalar values associated with each vertex, using the expression derived in question 1b).



Question 5. [14 pts]

Volume Rendering

a) Explain the basic principle of direct volume rendering. What physical process is being approximated by the volume rendering integral? Provide the mathematical expression of that integral and explain the meaning of the different terms involved. (If you do not remember the expression, explain in words what it corresponds to.)

b) Given two samples on a ray with the following transfer function mappings (R: red, G: green, B: blue, A: alpha):
$(R, G, B)^1=(25, 100, 50)$ $A=0.1$, (front)
$(R, G, B)^2=(0, 50, 100)$ $A=0.5$, (back)
What is the result (R, G, B, A) of back-to-front compositing of these samples assuming a black (0,0,0) background? Explain.