CS_217 (2004-2005)

COMPUTER GRAPHICS I: IMAGE PROCESSING AND SYNTHESIS

(*Attempt 2 questions out of 3*)

Question 1

(a) How does the recursive flood fill algorithm work? You should mention boundary and interior defined objects, 4-connected and 8-connected pixels, and give pseudo-code for the algorithm for one of the cases. Briefly describe an iterative method for filling. Indicate which method would be better and why.

[7 marks]

(b) Using the image below, show what the results would be if we tried to display it on a bi-level device using *thresholding*. Calculate the error between the original and the bi-level images. What are the advantages and disadvantages of using such a method?

90	100	100	110	125
95	110	120	130	140

Demonstrate the results of using the *standard error-diffusion* method. Calculate the error between the original and the new image. What are the advantages and disadvantages of this method? What feature of the standard error-diffusion process retains error in the local area? Name another method that retains error in the local area, and describe how it achieves that. (In all cases assume a 0-255 grey-level image).

[10 marks]

(c) Explain, with an example, why ray tracing can be computationally expensive. (You should include some example calculations). How can bounding volumes lead to better computational times? (Again use your example to demonstrate by showing some calculations). Discuss a hierarchy of bounding volumes constructed manually and the automatic method of organising a scene using an *octree*. In your discussion, you may wish to mention, to what depth is an octree created, how the octree accelerates ray tracing, how it can be used to ray trace a scene, what benefits the octree offers and the complexity of the ray-intersection algorithm when an octree is employed.

[8 marks]

Question 2

(a) Given the following pattern dithering matrix:

3	7	5
6	1	2
9	4	8

and the following 6x3 grey-level image (with levels from 0 to 255):

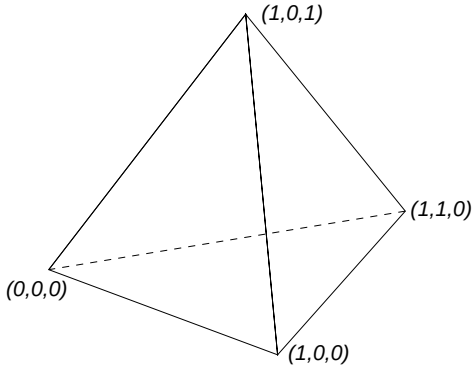
100	100	110	120	120	140
110	110	120	120	140	150
120	140	150	150	180	180

demonstrate all of the stages of the two processes of dithering and halftoning to obtain a bi-level image. Also create a bi-level image using the thresholding algorithm. Compare the total error resulting from using the thresholding algorithm with the dithering and halftoning algorithms.

You should include a description of each method as part of your answer, along with the advantages and disadvantages of each method.

[14 marks]

(b) Show the following tetrahedron can be represented using the methods of *explicit representation, pointers to a vertex list* and *pointers to an edge list*. What are the benefits and drawbacks for each method in terms of calculations and drawing operations? Which method is the most widely used and why?



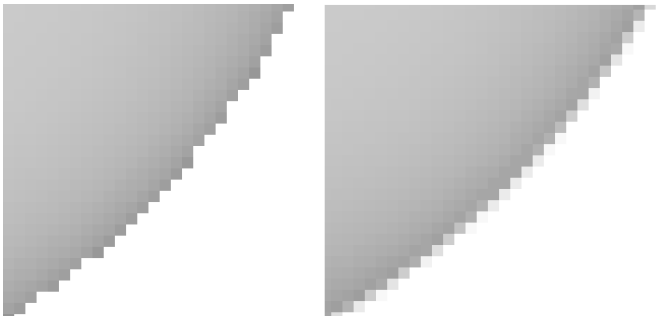
[5 marks]

(c) How is a histogram computed for an image and what does it represent? What effect does uniformly brightening or darkening an image have on the histogram? Describe the procedure for *histogram equalisation* and indicate the situations when it should be used and the effect it produces.

[6 marks]

Question 3

(a) What causes aliasing effects? A close-up of a ray-traced sphere is shown in the left part of the image, and has been shown ray-traced in the right part of the image using the anti-aliasing technique of *oversampling*. Describe the method of oversampling and indicate the benefits and drawbacks of the method.



Discuss *unweighted area sampling* and *adaptive oversampling*. Describe exactly how they work, and discuss the advantages and disadvantages of both methods.

[14 marks]

(b) State the two-dimensional line equation. From this equation derive the basic line incremental algorithm for the situation where the slope m lies in $[-1, 1]$ and use it to demonstrate the drawing of the line $(2, 4)$ to $(6, 6)$.

[4 marks]

(c) Write precise descriptions ($\frac{1}{2}$ to 1 page) about two of the following five topics:

Laser stereolithography;
Genetic programming for animation;
Event programming;
Linear interpolation;
Particle systems.

[7 marks]