CS-255 Computer Graphics

May/June 2017

Part A Compulsory Multiple-Choice Examination

Answer all questions [20 marks total] on the Multiple-Choice Answer Sheet

Specific Instructions

- Mark the “Answer Sheet” A01 for “Question” and your “Student ID No” in the appropriate boxes.
- There are 20 multiple choice questions each with five possible options (labelled A, B, C, D, E).
- Indicate your selected answer from the options by blocking out the appropriate box on the answer sheet provided. You must follow the marking instructions printed on the answer sheet.
- There is only one correct answer to each question, and all questions carry equal weighting.
- A correct answer will score 1 mark, an incorrect answer will score 0 marks. If you block out more than one answer, you will score 0, even if one of your answers is correct.
- You are advised to spend about 30 minutes on this part.
- Attach the Answer Sheet to your answer book with the treasury tag before you leave the examination.

The Multiple Choice Question part is omitted. Samples are given in lectures.

The resit exam for August 2017 will only contain a compulsory section.

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Part B Compulsory Section

Answer all questions [50 marks total] in the answer book

1. *Generally, describe the process of ray-object intersections. Specifically, derive the ray-sphere intersection equation.* *[**8 marks**]*

   Equation of ray from or through each pixel is solved with the equation of each object (in the naïve case) to find the closest intersection. [4] Derive the ray/sphere equation [4]

2. *How does an automatic hierarchical acceleration structure such as a kd-tree or an octree operate? How does it accelerate ray-tracing?* *[**6 marks**]*

   If a ray hits a bounding volume, it needs to be tested with the objects inside. If it doesn't hit, the objects inside are removed from the intersection process. Octree: A root node covers the geometry. Recursive step: It is divided into 8, and the geometry is split between the children as appropriate. Empty children play no further part. Full children with more than a threshold of objects are further subdivided in the recursive step. During ray queries, the ray is tested against the closest bound, and follows the tree in a depth first manner. [6 marks distributed throughout]

3. *Discuss Maximum Intensity Projection or Antialiasing techniques. Your answer should be about 1 page long.* *[**8 marks**]*

   MIP – rays are traced through volume data finding the maximum along the way. [2] This maximum is used to create an intensity from black to white. [2] The result is an X-ray looking 3D image [2]. Doctors are familiar with X-rays, so are comfortable with this approach. [2] Other points students could make surround depth perception and computation speed and marks can be distributed appropriately.

   Antialiasing – occurs in areas of high frequency when sampled less than the Nyquist rate [2]. Can be solved in several ways. Students can go for a broad list (supersampling, weighted area sampling, adaptive supersampling, geometric accurate methods), or could pick one topic and write in depth about it. They could also indicate sampling patterns – jitter, Poisson disk etc. [8 marks in total distributed throughout]

4. *Give the equation for the Lambertian / Diffuse reflection term in the Simple Reflection Model. Discuss its implementation for colour and identify the vectors involved.*

   *[**6 marks**]*

   Lambertian reflectors spread light equally in all directions according to reflectance coefficient Kd. Normal N, Light Vector L, angle between them N.L assuming unit vectors. Therefore the light intensity is:

   Intensity=Kd Id N.L

   where Id also is the intensity of the light. Each of these is a 3D vector (red, green blue). [6 marks total distributed throughout]

5. *This is a grey-level image containing pixel values between 0 and 255.*

130	*140*	*150*
120	*130*	*140*

a. *Demonstrate standard error-diffusion on the image.* *[**6 marks**]*

b. *How does standard error-diffusion process retain error in the local area?* *[**2 marks**]*

c. *What is the Floyd-Steinberg method?* *[**4 marks**]*

a. 130->White pixel, error -125 passed to next one. 140-125=15->Black, error=15, 150+15=165->W, error=-90, 140-90=50->B, error=50. 130+50=180->W, error=-75. 120-75=45->B error=45

W	***B***	***W***
B	***W***	***B***

b. At the end of the row the error is passed down to the adjacent pixel thus keeping it locally. Results in a zig-zag through the image.

c. Passes error to the 4 undrawn pixels in proportions where nearest neighbours are weighted more highly than the corner neighbours.

6. *State the normalisation equation used during the normalisation of an image (e.g. applied to intermediate values after cross correlation).*

The following 3x3 array of intermediate values is a result of a cross correlation. Apply the normalisation equation to the array to normalise it back to an image in the range 0 to 255.

135	*-165*	*400*
-75	*-325*	*15*
-90	*205*	*100*

*[**10 marks**]*

P=255*(I-min)/(max-min) [2]
max=400, min=-325 [2]
Apply the equation to get the result [6]

*	*	*	*	*
*	*161.8*	*56.3*	*255*	*
*	*87.9*	*0*	*119.6*	*
*	*82.7*	*186.4*	*149.5*	*
*	*	*	*	*