COMP37111

Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Advanced Computer Graphics

Date: Monday 25th January 2016

Time: 09:45 - 11:45

Please answer ONE Question from Section A
and ONE Question from Secton B

Use a SEPARATE answer book for each SECTION.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

Section A

1. a) You are required to create separate 3D models of the objects shown in Figure 1. Details of each object (left to right) are as follows:

   - the wine glass is symmetrical about its vertical axis
   - the courgette (or zucchini) has a complex shape whose cross-section changes throughout its length
   - the plant has detailed leaf structure with ripening chillies at the extremities of some branches.

   Your laser scanner is broken, so you must use other approaches. Suggest suitable methods for modelling the geometry of each of the objects. (3 marks per object)

Figure 1.

b) Your laser scanner has now been repaired, and your next task is to use it to create a 3D model of the bird shown in Figure 2.

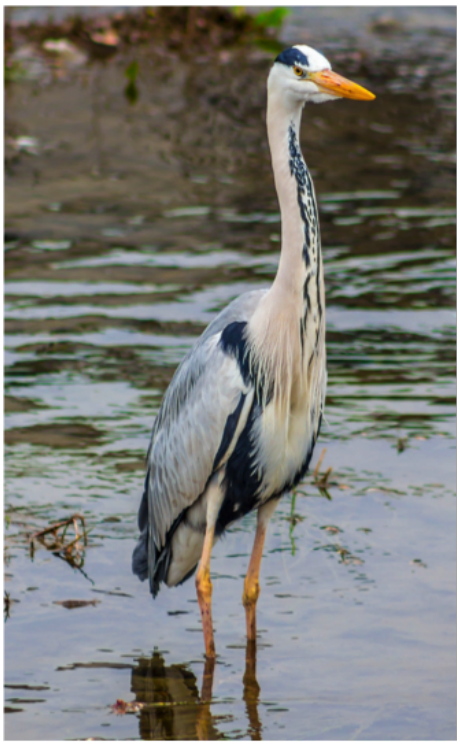

Figure 2.

The bird will stay motionless as you operate your laser scanner, but the water in which it stands will not. Explain how you would create an accurate 3D model of the bird using your scanner, and in your answer address the following points:

i) how you would employ a series of separate scans (2 marks)

ii) how you would combine separate scans into a single model (3 marks)

iii) how you would deal with missing data due to self-occlusion (4 marks)

iv) how you would isolate the bird model from any capture of the water (2 marks)

2. a) Illustrating your answer with an example of your own choice, explain the principles of extracting the 3D geometry of an object from a video sequence. In your answer, explain the role of the following:

   i) types of distortion and their elimination (3 marks)
   ii) intrinsic camera parameters (3 marks)
   iii) extrinsic camera parameters (3 marks)
   iv) feature detection (2 marks)
   v) feature tracking (2 marks)

   b) Assuming that the geometry you have extracted will be expressed using triangle meshes, explain under what circumstances it is desirable to reduce the number of triangles, and describe an algorithm for doing so. (4 marks)

   c) Figure 3 shows a still from a video sequence taken in the Kilburn building. The chair, plants and moose head are synthetic computer graphics objects created using OpenGL. Explain how they have been composited into the video, such that they realistically appear to be part of the original scene. (3 marks)

Figure 3.

Section B

3. a) In classical Whitted Ray Tracing, why is it common to start rays at the eye point rather than at a light source? (2 marks)

b) The diagram in Figure 4 represents a top-down view of a scene being Ray Traced. Copy the diagram into your answer book, add a suitable eye-point and view-plane, and use it to illustrate the process of Ray Tracing (the position, size, orientation etc of the objects in your copy need only be approximate). Assume that the sphere/-circle is a polished metal, the triangle/prism is colourless glass, the square/cube is made of a glossy red plastic; and the line/plane is a perfect mirror. By adding rays and other annotations as appropriate, use the diagram to explain the following:

i) role of primary rays (2 marks)

ii) the purpose of shadow feeler rays (2 marks)

iii) the role of secondary rays, and how they interact with each of the different objects in the scene. (8 marks)

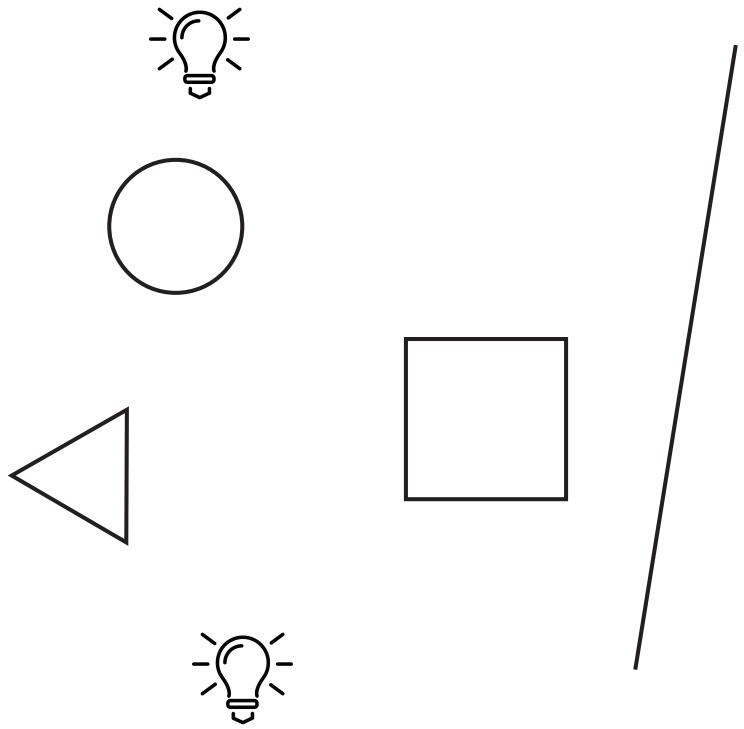

Figure 4.

c) With the aid of suitable diagrams, describe two distinct spatial enumeration structures that could be used to accelerate the process of ray tracing. For each, explain how which aspect of ray tracing it accelerates, and comment on its space and time complexity. (6 marks)

4. a) Figure 5 represents a top-down view of a 3D scene consisting of triangular prisms, cuboids and spheres. For each of the spatial enumeration techniques listed below, copy an approximation of the diagram into your answer book and use it to illustrate each of the following spatial enumeration techniques

   i) gridcell
   ii) octree
   iii) hierarchical bounded volume
   iv) binary space partitioning

   Describe each technique and comment on its efficiency in this particular case. (4 marks each)

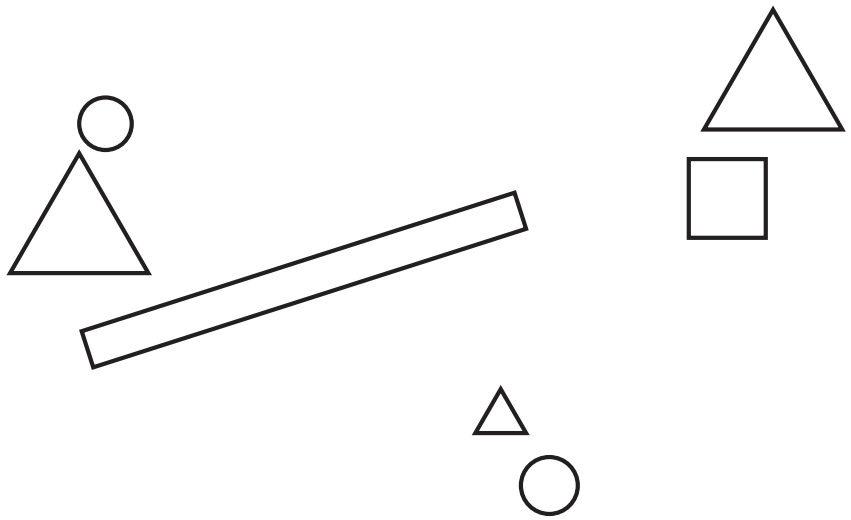

Figure 5.

   b) The scene could be said to exhibit 'spatial coherence'. What does this mean, and what are its implications with respect to spatial enumeration? Is there an equivalent 'temporal coherence' and what are the implications of your answer for real-time spatial enumeration? (4 marks)

END OF EXAMINATION