COMP 37111

Two hours - online

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UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Advanced Computer Graphics

Date: Friday 25th January 2019

Time: 09:45 - 11:45

This is an online examination. Please answer all Questions

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This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

Answer all questions

1. Explain, using two different examples, what is meant by the term 'self-similarity' (3 marks)

2. Your task is to create a 3D model of the scene shown in Figure 1. Specify a suitable technique for modelling each of the following elements in the scene, and describe how that technique would be used to closely match the appearance of the element:

   - The disused railway platform and shelter
   - The plants and trees
   - The mountains

Figure 1

(6 marks)

3. CPUs and GPUs get faster each year. Memory gets cheaper. So why is it important to be concerned about the number of polygons used for making 3D models where real-time manipulation is required? (2 marks)

4. Figure 2(a) shows a mesh, and Figures 2(b) and 2(c) show two possible simplifications of it. Explain which is the preferable simplification, and why. In your answer you can refer to the meshes as M, S1 and S2, and the points as P1, P2, etc.

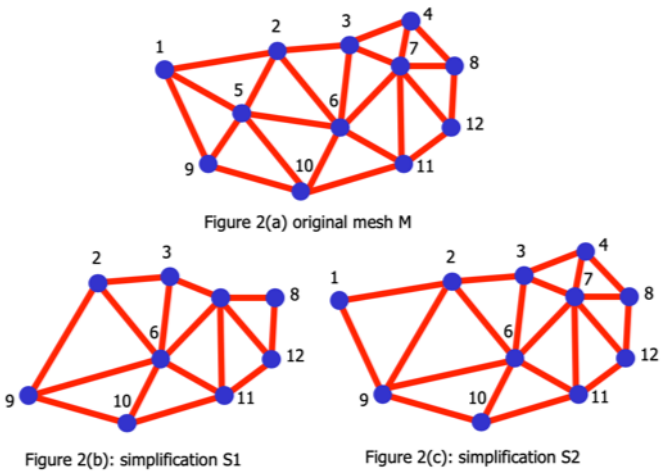

Figure 2

(2 marks)

5. When laser scanning an object, in what circumstances are scans from multiple viewpoints necessary? (1 mark)

6. When laser scanning an object from multiple viewpoints, describe an approach for combining the meshes obtained.

(4 marks)

7. Describe the effects of lens distortion on techniques to extract geometry from images, and how these effects can be minimised. (3 marks)

8. When extracting the geometry of a real-world scene using a video sequence, explain the role of feature detection, and describe why it is desirable to automate this. (3 marks)

9. What is the equation shown in Figure 3 known as in the context of computer graphics? Briefly explain its purpose. You need not define each individual variable, rather give an overall description of its role.

$$L_o(\mathbf{x}, \boldsymbol{\omega}, \lambda, t) = L_e(\mathbf{x}, \boldsymbol{\omega}, \lambda, t) + \int_{\Omega} \underbrace{f_r(\mathbf{x}, \boldsymbol{\omega}', \boldsymbol{\omega}, \lambda, t)}_{\text{A}} L_i(\mathbf{x}, \boldsymbol{\omega}', \lambda, t)(-\boldsymbol{\omega}' \cdot \mathbf{n})\delta\boldsymbol{\omega}'$$

Figure 3

(2 marks)

10. In Figure 3, what is the component labelled A called? What role does this component play? (2 marks)

11. With reference to Figure 4, describe the process of classical Whitted Ray Tracing. Your answer should mention the role of primary rays, secondary rays, and shadow feelers, and should describe how the process deals with shiny surfaces, refraction and transparency.

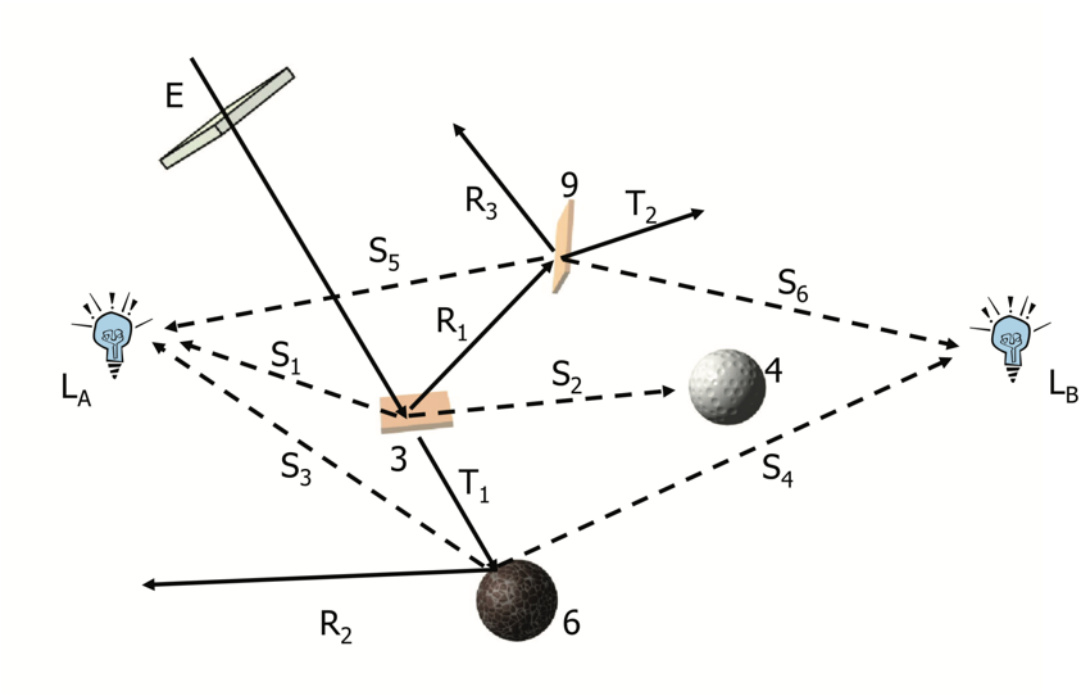

Figure 3

(6 marks)

12. A colleague claims that "Whitted Ray Tracing is a form of global illumination". In what sense is this statement true? In what sense is it not? (2 marks)

13. A mysterious insect approximately 1cm long has been discovered trapped in the middle of a block of transparent natural resin measuring roughly 10cm x 10cm x 10cm. The block cannot be damaged, and so is scanned whole using a magnetic resonance imaging machine that scans at a resolution of 0.01mm. Using a basic voxel data structure, describe a process of Direct Volume Rendering, explaining how the value for a point in space returned by the MRI device can be classified into the different materials within the block (i.e. resin, bone, muscle etc)? (4 marks)

14. The dataset produced by the scan in the previous question turns out to be too big for the hardware used for rendering images. Describe an alternative data structure into which the basic voxel data could be pre-processed to reduce its size, and describe the implications of your structure in terms of time complexity. (4 marks)

END OF EXAMINATION