

Two hours - online

EXAM PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

**UNIVERSITY OF MANCHESTER  
SCHOOL OF COMPUTER SCIENCE**

Computer Graphics and Image Processing

Date: Thursday 16th May 2019

Time: 09:45 - 11:45

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**This is an online examination. Please answer ALL 30 Questions  
The exam contains MULTIPLE CHOICE QUESTIONS**

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This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

## Q1-Q20 contain multiple choice questions and are, therefore, restricted

21. The polygon ABCD shown in Figure 1 contains a hole EFG. What process would you apply to enable ABCD to be correctly rendered by OpenGL? Describe the effect of applying this process to ABCD. In your answer refer to the vertices as A, B, C etc.

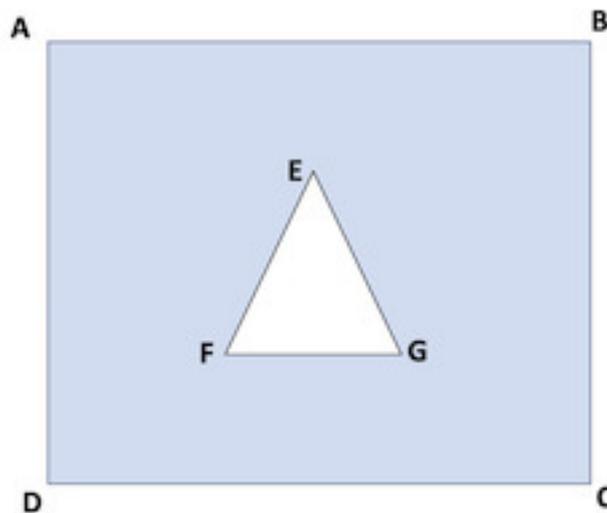


Figure 1

(3 marks)

22. Give three different examples of software or hardware limitations that mean computer graphics images are always approximations of conceptual models. (3 marks)

23. Figure 2 shows a world space with a conceptual camera positioned at point E, looking towards point C; the camera's axes are  $\hat{S}$ ,  $\hat{U}$ ,  $\hat{F}$ . Explain how to use this information to construct a viewing transformation Q which can be applied to objects. In your answer when you refer to transformations and their purposes, you need not specify the individual component values of any matrices.

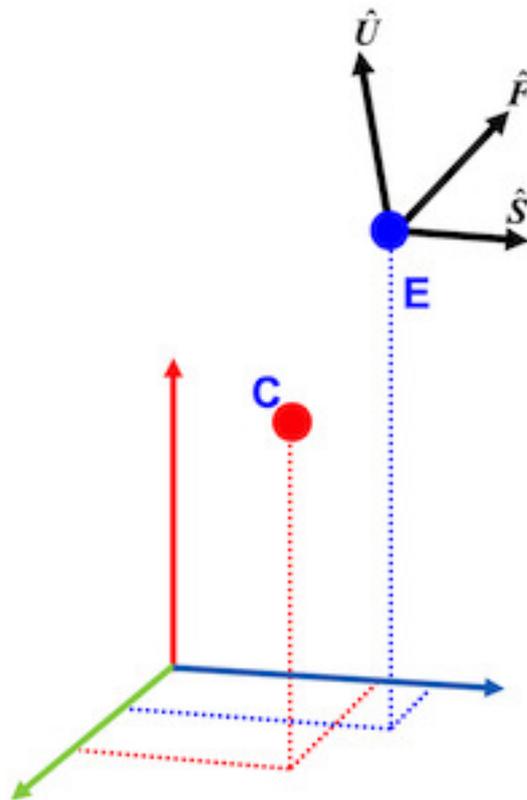


Figure 2

(4 marks)

24. Figure 3 shows a triangle T0 which is part of mesh comprising triangles T1 to T15. Explain how normal vector interpolation would be used to render T, and how the colours of the pixels a-h, between points P and Q, would be computed.

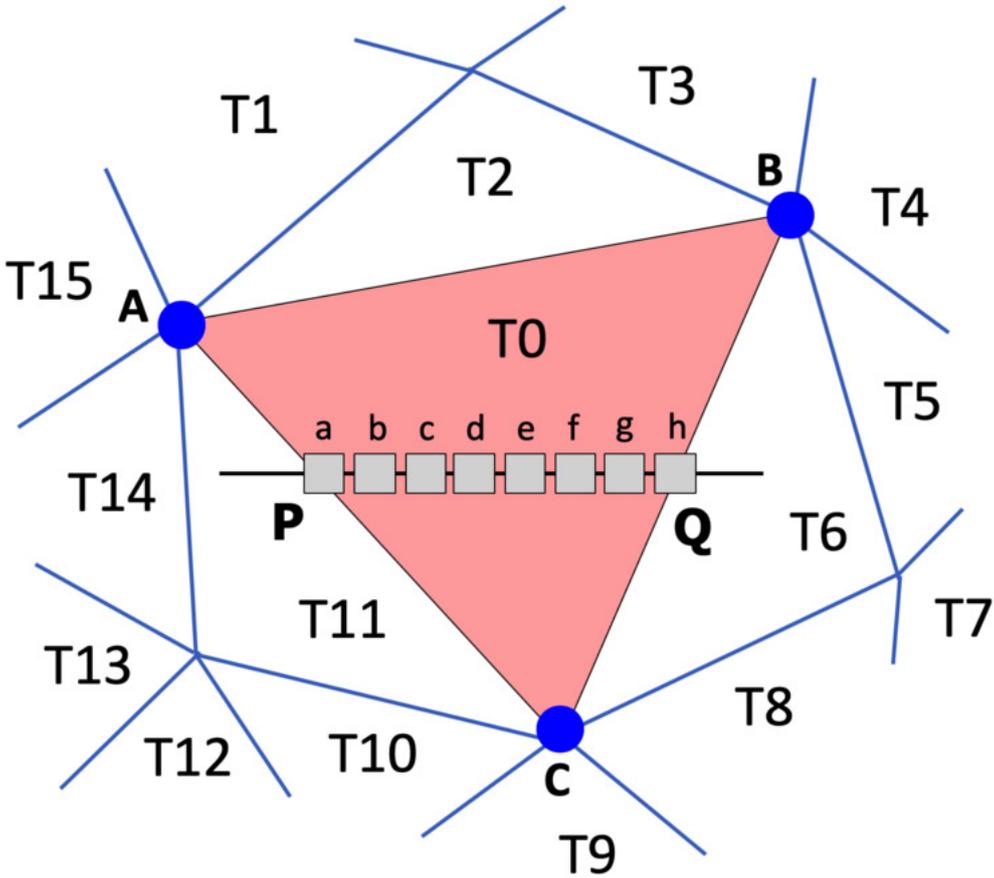


Figure 3

(4 marks)

25. Figure 4 shows a side view of a surface which is being illuminated by a light source at position P. Explain what the normalised vectors  $\hat{N}$ ,  $\hat{R}$  and  $\hat{V}$  represent. Explain how  $\hat{R}$  and  $\hat{V}$  are used to estimate specular reflection, and what other factors, together with their range of values, need to be included in the estimation.

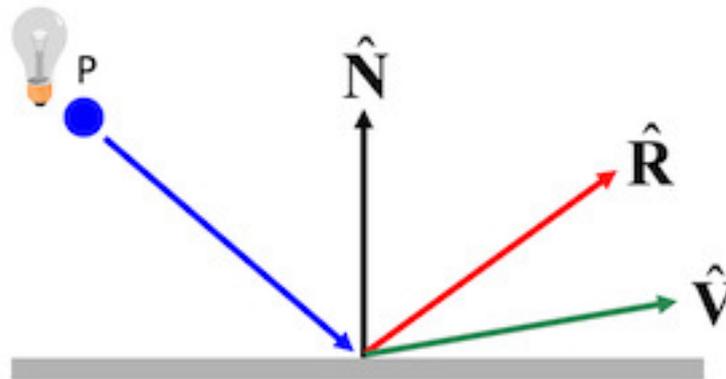


Figure 4

(6 marks)

26. Discuss the sources of uncertainty in the pixel values of a digital image captured using a digital camera. (2 marks)
27. A box filter, a weighted average filter or a median filter can be used to reduce noise. Define these filters. Comment on their performance. (4 marks)
28. Objects can be detected by a technique known as template matching. Describe template matching. How is the template created? What are the limitations of the technique? (6 marks)

29. In a bottling plant, bottles are filled with a liquid and the tops put on. The amount of liquid in each bottle must be measured to ensure that no bottle contains less than it should. You can assume that the image capture problem is solved and you are presented with an image of a bottle. Describe the image processing operations you would use to: find the outline of the bottle in the image, find the top of the liquid in the bottle and decide whether there was enough liquid in the bottle. Be clear about any assumptions you make about the image. (6 marks)
30. Dynamic thresholding is a technique used to separate a brighter object from a darker background in a monochrome image where there is an illumination gradient. “Dynamic” refers to the operation of computing a local threshold for each pixel (or small region) of the image. What are the consequences of doing this in regions that are entirely object or entirely background? If this poses a problem, how could it be solved? (2 marks)