A0 6458

THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Calculators may be used in this examination but must not be used to store text. Calculators with the ability to store text should have their memories deleted prior to the start of the examination.

THE UNIVERSITY OF BIRMINGHAM

Degree of BSc with Honours
Artificial Intelligence and Computer Science. Second Examination
Computer Science/Software Engineering. Second Examination
Computer Science/Software Engineering with Business Studies. Second Examination

Degree of MSc in Computer Science

06 02504

Graphics 1

Thursday 24th May 2001 0930 - 1130

[Answer Question ONE and TWO other Questions]

Turn over

THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Any calculator

[Answer Question ONE and TWO other Questions]

1. (a) Let

$$A = \begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix} \qquad B = \begin{bmatrix} 4 & 0 \\ 5 & -2 \end{bmatrix} \qquad C = \begin{bmatrix} 9 & 0 \end{bmatrix} \qquad D = \begin{bmatrix} 1 \\ 3 \end{bmatrix}$$

Provide the answers, together with justifications, to the following questions:

(i) Is the matrix X below the result of multiplication of A*B or B*A?

$$X = \begin{bmatrix} 4 & 8 \\ -3 & 4 \end{bmatrix}$$

(ii) Which of the operations is undefined: A*D or D*A?

(iii) What is the result of multiplication C*D?

[6%]

(b) The viewing coordinate system is specified by the View Reference Point (VRP) and three vectors:

- $\bar{\mathbf{N}}$, from VRP to a target point, T, on the object
- $\bar{\mathbf{U}}$, the "up" vector
- $\bar{\mathbf{V}}$, the "handedness" vector

Given VRP = (10, 14, -20) and T = (0, 4, 0), calculate the $\bar{\mathbf{V}}$ vector

[8%]

Question 1 is continued over the page

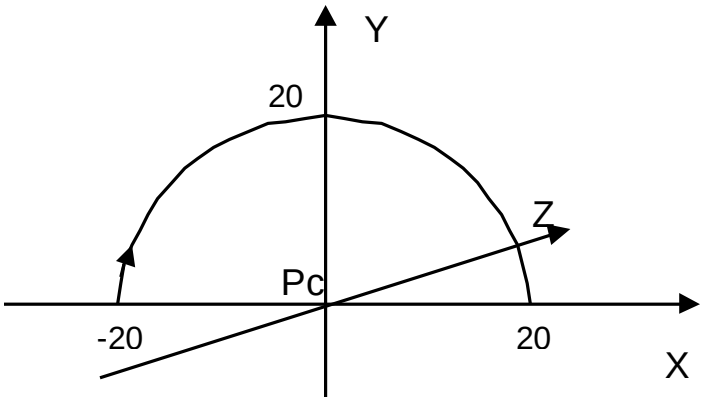
THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Any calculator

Question 1 continued

(c) You are to prepare the design for an animation sequence. The object is defined by a set of vertices in a matrix P. The target point Pc is at the centre of the world coordinate system at (0,0,0).

The animation is to be along a circular path, with the centre at (0,0,0) and a radius of 20 units. At the start of the animation sequence, the View Reference Point (VRP) is positioned at (-20, 0, 0). The VRP then moves along a circular path centred at (0,0,0). It passes through (0,20,0) and its position in the last frame is (20,0,0). This is illustrated in the figure below. The target point Pc remains unchanged throughout the animation.



There are to be 13 key frames, from frame 0 to 12, computed every $\varphi = 15$ degrees ($\sin \varphi = 0.26$, $\cos \varphi = 0.97$).

Specify all the transformation matrices necessary for computing the perspective projection for the first key frame (i.e. frame 0) and all the necessary matrix and vector operations.

[14%]

(d) Write an outline of the algorithm for computing ALL the key frames. Make it as efficient as possible. Specify any further necessary matrices and all the necessary matrix operations, but DO NOT CARRY OUT matrix and vector calculations.

[12%]

THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Any calculator

2. (a) Briefly explain the following terms:
   (i) the gradient of a line
   (ii) anti-aliasing
   (iii) a tangent
   (iv) a spline

[6%]

(b) Using the DDA algorithm compute the positions of the first 3 pixels in the line segment defined by the endpoints A = (4, 4) and B = (10, 12), [6%]

(c) Using vector operators, find a vector perpendicular to the line passing through the points (2, 4) and (12, -1). [4%]

(d) The following fragment of pseudo-code specifies a part of Bresenham's algorithm for generating a line segment for lines with positive slope, where $|m| \leq 1$. Modify this code so that it correctly generates line segments with negative slope, where $|m| \leq 1$. [8%]

- input line endpoints, (x_0,y_0) and (x_n, y_n)
- calculate $\Delta x = x_n - x_0$ and $\Delta y = y_n - y_0$
- set pixel at position (x_0,y_0)
- calculate parameter $p_0 = 2\Delta y - \Delta x$
- set i to 0
- repeat the following steps until (x_n, y_n) is reached
  - if $p_i < 0$
    set the next pixel at position $(x_i + 1, y_i)$
    calculate new $p_{i+1} = p_i + 2\Delta y$
  - if $p_i = 0$
    set the next pixel at position $(x_i + 1, y_i + 1)$
    calculate new $p_{i+1} = p_i + 2(\Delta y - \Delta x)$
  - increment i

(e) Use the modified algorithm to compute the positions of the first 4 pixels in the line segment defined by the endpoints A = (2, 6) and B = (10, 2).

[6%]

THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Any calculator

3. (a) Sketch the following:
   (i) Left-handed coordinate system seen from the positive end of the X axis
   (ii) Left-handed coordinate system seen from the positive end of the Y axis
   (iii) Left-handed coordinate system seen from the negative end of the Y axis
   (iv) Right-handed coordinate system seen from the negative end of the X axis

   [12%]

   (b) On each of the sketches above, indicate the direction of the positive angle of rotation about the respective axis (e.g. axis X in (i)).

   [4%]

   (c) A 2-dimensional triangle is defined by the (homogeneous) vertices

   V1 = [2 1 1]
   V2 = [5 3 1]
   V3 = [3 4 1]

   Define and carry out the following 2-dimensional transformations for the triangle:

   (i) Rotation about the centre of the XY coordinate system by -90^o
   (ii) Rotation about the point P = (2, 1) by $+90^o$

   You must make use of transformation matrices. Specify the numerical values in each matrix that you use. The results of calculations must be numerical. Show every step of calculations.

   [14%]

THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Any calculator

4. (a) Provide a brief description of the following terms:
   (i) Frame Buffer
   (ii) Vertical flyback
   (iii) Bit planes
   (iv) BitBLT

   [6%]

   (b) Define the following colours using the RGB model:
   (i) fully saturated red
   (ii) 50% saturated red
   (iii) 20% saturated grey

   [6%]

   (c) Outline the key features of the CIE XYZ colour model. [4%]

   (d) A grey level image that has been scanned appears too dark. Sketch approximately the shape of the mapping functions for RGB which would improve the image contrast. [5%]

   (e) During an image acquisition the red camera sensor was faulty and the resulting colour image contains only half of the red component. Sketch approximately the shape of the mapping functions for RGB which would compensate for this fault.

   [5%]

   (f) Sketch a diagram showing the relationships between the following components of the BufferedImage in Java:
   - BufferedImage
   - ColorModel
   - Raster
   - DataBuffer
   - SampleModel

   [4%]