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NAD

Solution notes for Computer Graphics & Image Processing 2002

(a) (i) about 500dpi for greyscale or full colour displays; about 3000 dpi for black and white (bilevel) displays.
The human eye has a limited spatial resolution which means it can distinguish two dots about $\frac{1}{500}$ of an inch apart from a distance of 12"
The higher number for bi-level displays is owing to the fact that such displays use halftoning to achieve greyscale.

(ii) depends on the maximum contrast of the display. About 2^{10} levels for CRT. About 2^{14} levels for movie film. The eye can only distinguish intensity levels if there is at least a 2% difference.

(iii) three because the eye has a three dimensional colour system.

(iv) about 100Hz because the human eye can detect flicker up to this frequency in some situations (50Hz is too low)

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(b) normal z-buffer is faster than A-buffer which is generally faster than supersampled (8x8) z-buffer. However the latter is faster than A-buffer when the polygons get small because it is at this level that the A-buffer loses its speed advantage (A-buffer is much faster for pixels entirely inside the polygon).

Image quality for A-buffer and 8x8 z-buffer will be about the same and much better than normal z-buffer.

For 50-pixel polygons, A-buffer is best as it gives nice quality at a reasonable speed.

For 2-pixel polygons, there is little to choose between A-buffer and supersampled z-buffer although A-buffer's optimizations will probably still win out over the more simplistic z-buffer. Memory allocation issues and data structure management issues could counteract A-buffer's advantages to mean that supersampled z-buffer is slightly faster.

At high resolution, normal z-buffer could be best because the human eye will not be able to appreciate the extra subtle detail provide by the other two, much slower methods.

(c) rotate by θ about $P = (x_p, y_p)$

① translate P to the origin $\begin{bmatrix} 1 & 0 & -x_p \\ 0 & 1 & -y_p \\ 0 & 0 & 1 \end{bmatrix}$

② rotate by θ about origin $\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

③ translate origin to P $\begin{bmatrix} 1 & 0 & x_p \\ 0 & 1 & y_p \\ 0 & 0 & 1 \end{bmatrix}$

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(d) rotate by θ about an axis passing through $P = (x_p, y_p, z_p)$ and pointing in direction $V = (x_r, y_r, z_r)$

1. translate P to the origin
2. rotate the axis onto the z-axis by:
   - 2a rotating the axis about the z-axis, into the yz-plane
   - 2b rotating the result about the x-axis, onto the z-axis
3. rotating by θ about the z-axis
4. 4a reverse 2b
   4b reverse 2a
5. reverse 1

1 $\begin{bmatrix} 1 & 0 & 0 & -x_p \\ 0 & 1 & 0 & -y_p \\ 0 & 0 & 1 & -z_p \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 2a $\begin{bmatrix} \cos\phi & \sin\phi & 0 & 0 \\ -\sin\phi & \cos\phi & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

2b $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\psi & \sin\psi & 0 \\ 0 & -\sin\psi & \cos\psi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 3 $\begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

4a = 2b with ψ replaced by $(-\psi)$
4b = 2a with ϕ replaced by $(-\phi)$
5 = 1 with all minus signs replaced by plus signs.

$$\phi = \tan^{-1}\left(\frac{x_r}{y_r}\right) \qquad \psi = \tan^{-1}\left(\frac{\sqrt{x_r^2 + y_r^2}}{z_r}\right)$$

Marking scheme & comments for Computer Graphics and Image Processing

(a) tests the "Background" part of the course
(c) tests the "2D computer graphics" part of the course as a precursor to (d)
(b) and (d) test the "3D computer graphics" part of the course

Marking scheme – preliminary

(a) (i) 2 (ii) 1 (iii) 1 (iv) 1 — 5

(b) order for speed — 1
explanation for order — 1
order for quality — 1
explanation for order — 1
50-pixel answer — 1
2-pixel answer — 1
high resolution — 1

(c) translate – rotate – translate — 1
correct matrices — 1

(d) translate at each end — 1
rotate onto an axis, rotate about that axis, and rotate back — 2
correct matrix forms — 2
correct values for ϕ and ψ — 1