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Suggested solutions to Examination, Computer Graphics MN1, 951219

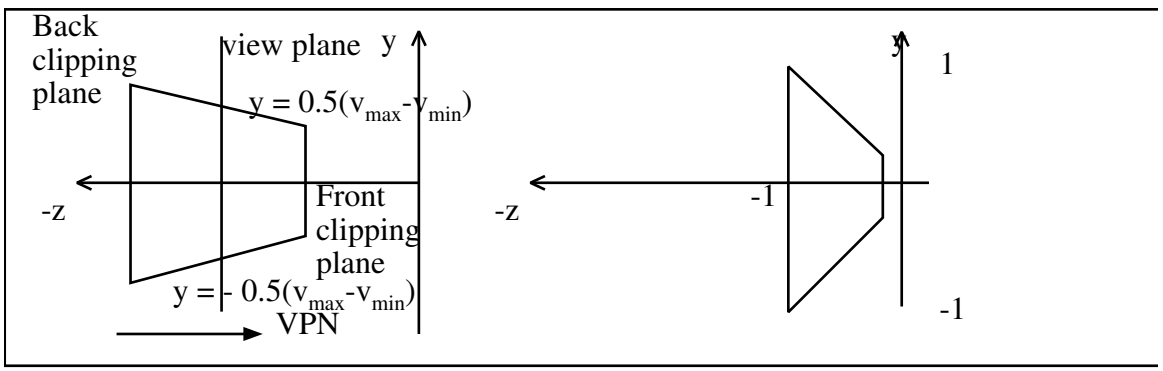
1. Resolution: # of distinguishable lines per unit length
   Addressability: # of dots per unit length that can be created
   Refresh rate: # of times per second the image can be redrawn
   Bandwidth: # of times the electron bream can be turned on or off per second

Bandwidth and refresh rate apply only to screens (mainly CRT's), resolution and addressability apply to hardcopy devices and screens.

2. a) Translation, scaling, and rotation
   b) In homogeneous coordinates, a third (in 2D, a fourth in 3D) coordinate is added to a point. Homogeneous coordinates are used in order to make it possible to express translation as a multiplication and consequently make it possible to concatenate transformations by multiplying transformation matrices.
   c) The first transformation last in the expression, i.e. a scaling (S) followed by a rotation (R): RSV (V is the vector). If row vectors are used the order becomes VSR.

3. The origin of the VRC is the VRP. The view plane normal (VPN) defines the *n* axis in the VRC. The VUP defines a second axis: the v-axis which determines the "tilt" of the camera. The third axis, *u*, is defined such that *u*, *v*, and *n* form a right-handed coordinate system. The PRP is the the centre of projection - the eye, as it were. We are looking towards the VRP. The VRP, VPN, and VUP are defined in WC, PRP in VRC.

4. We need to define a window (u_{min},u_{max},v_{min},v_{max}) in the view plane and front and back clipping planes in the view volume (the left-hand figure before scaling, the right-hand figure after scaling to the canonical, standardised view volume):



The initial clip test becomes simple tests: -z <= x,y <= z and -1 <= z <= z_{min} is inside

5. Coordinate system — Transformation

Modelling coordinates	-> modelling transformation ->
World Coordinates	-> view orientation matrix ->
View Reference Coordinates	-> view mapping matrix ->
Normalised Projection Coordinates	-> window-to-viewport transformation ->
2D device coordinates.	

6. Scan conversion is the "translation" of primitives from a description in mathematical terms (such as a line from P_1 to P_2 or a circle with radius r centred at P_3) to pixels to display.
Scan conversion is necessary because most graphics devices use raster techniques while graphics primitives are defined in mathematical terms.
The **midpoint line algorithm** uses *integer* arithmetic and *incremental* updating of a decision variable d which is the value of the midpoint between the two pixels we are to choose between. If the slope is between 0 and 1 and $dy = y_1-y_0$ and $dx = x_1-x_0$ the line is described by $F(x,y) = dy*x - dx*y + B *dx = 0$ (B is the line's intercept with the y axis). Given a selected point (x_p,y_p), d then becomes $F(x_p+1,y_p+1/2)$ and if the value of this is >0 we choose the NE (x_p+1,y_p+1) pixel, otherwise we choose E (x_p+1,y_p). A new value of d is then calculated incrementally from the old one.
point order: is important if the line goes through M (the midpoint). Symmetrical lines will result if E is selected when lines are generated from left to right and SW is selected when lines are generated from right to left.
clipping: starting at the edge of a clip region works if the decision variable is initialised correctly, i.e. to the value it would have had, had the complete line been drawn. This is necessary to ensure that the drawn portion of the line gets the same slope as the line.

7. Xt Intrinsics and Motif are widget sets, i.e. they define a number of user interface building blocks such as widgets, callback procedures, actions, resources. Motif is built on top of Xt.

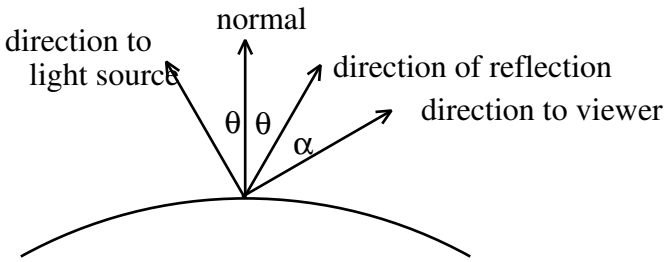
8. hue - dominant wavelength
saturation - excitation purity
brightness - luminance

9. Assuming that RGB is used and that at most 8 bits are used per colour:
512x512: 2^{24} (16777216)
1024x1024: 2^8 (256)
1280x1024: 2^6 (64) (or perhaps in reality 2^4 (16))

10. a) log(4) / log(3) ~ 1.2619
b) log(8) / log(4) 1.5
c) log(6) / log(6/sqrt(2)) ~ 1.2398

11. a) Image precision (z-buffer) and Object precision (Painter's algorithm).
    b) z-buffer: initialise z-buffer to background value
        for each polygon
          for each pixel in its projection
            if (pixel closer than current pixel in z buffer)
              write pixel.
    Painter's algorithm: sort polygons according to the farthest z value
        scan convert each polygon in ascending order (back-to-front)

12. $I = I_a k_a + f_{att} I_p (k_d \cos\theta + k_s \cos^n\alpha)$.
    I is the resulting pixel intensity.
    I_a is the ambient light
    k_a is the ambient light reflection coefficient of the material
    f_{att} is the attenuation of the light source (a function of the distance from the light)
    I_p is the intensity of a point light
    k_d is the diffuse-reflection coefficient of the material.
    k_s is the specular reflection coefficient of the material
    n in $\cos^n\alpha$ is the specular-reflection coefficient (1->infinity. infinity for perf. reflector)
    θ is the angle between the normal of the object and the direction to the point light
    α is the angle between the direction of reflection of the light and the viewpoint



13. This has to do with the fact that Phong shading interpolates normals rather than intensity. If n in the $\cos^n\alpha$ term of the illumination model is large and α varies between the vertices, Gouraud shading spreads the highlight over all of the polygon while Phong more accurately calculates the normals.

14. 1/ JPEG images are not bulkier than others - on the contrary JPEG images often become smaller because lossy compression is used.
    2/ More bits are used for intensity than for colour for precisely the opposite reason than the one given in the text.