# Indian Institute of Information Technology Allahabad

## Mid Sem/ C1 Question Paper

**Course Name:** Advanced Graphics & Animation (AGA) **Course Instructor/ Co-ordinator:** Prof Anupam

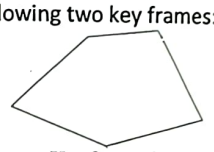
**Course Code:** TC-IT-AGA507 **Program Name(s):** MTech 2nd Sem/ BTech 6th **Exam Date:** 26-02-2024 (2:45 – 4:45 PM)

**Max.Marks: 25** **Time**: 2 hrs

**Note**: All questions are compulsory. All the subparts of a question are to be attempted together.

**1)** a) What is Cel animation and how does it work?
b) What is Tweening? Write the steps (showing formulas also) for equalizing keyframes in terms of number of edges. (1+2+2)
c) Perform computations (for equalizing number of edges) using following two key frames:

Keyframe 1



Keyframe 2

**2)** a) Calculate the dimensions of the following fractals (draw diagrams): (3+1+1)
i) Snowflakes (Koch curve)
ii) Cantor dust
iii) Box fractal
b) How much time is spent scanning across each row of pixels during screen refresh on a raster system with resolution of 1280 X 1024 and a refresh rate of 60 frames per second?
c) Why do we prefer using 'Triangle Strips' or 'Triangle Fans' for rendering 3D connected vertices over rendering each triangle individually?

**3)** a) Write two advantages of Parametric representation of Curves. (1)
b) The coordinates of four control points relative to a curve are given (1+2+1)
by p1(2, 2, 0), p2(2, 3, 0), p3(3, 3, 0), p4(3, 2, 0).
i) Write the equations of the Bezier curve.
ii) Find the curve for u = 0, ¼, ½, ¾, 1.
iii) Also plot the Bezier curve.

**4)** a) What is image morphing? What role does warping process play in morphing? (1+2+2)
b) What are two advantages of B-Spline curves over Bezier curves? What are Variation Diminishing and Convex Hull properties of B-Spline curves?
c) Draw the architecture of a raster-graphics system. Write the purpose of 'Display Processor' and 'Video Controller'.

**5)** a) Show that two successive reflections about any line in the XY plane that intersects the coordinate origin is equivalent to a rotation in the XY plane about the origin. (2+2+1)
b) What are the two steps to form a Canonical view volume from given general shape for the perspective view volume (draw related diagrams)?
c) Differentiate between the terms 'Fluorescence' and 'Phosphorescence' related with raster Scan CRT.

1a what is cel animation and how does it work?

Ans: Cel animation is a form of traditional 2D animation. 'Cel' is short for 'celluloid,' as the images were drawn on thin, transparent sheets of plastic material. This material was sometimes but not always celluloid. In traditional cel animation, each individual frame is drawn onto a cel in black ink. The cel is then flipped over, and color is applied to the opposite side. Backgrounds are created separately. When both are complete, the transparent cel is stacked in front of the background, then photographed to achieve a finished frame of animation. The same background may be used in conjunction with multiple cels; this is why backgrounds are often more detailed than the characters in front of them. This process is repeated at the frame rate desired for the final project.

1b what is tweening and write the steps ( showing formulas also) for equalizing keyframes in terms of number of edges

Tweening is the process of creating the inbetweens, which are the images that go between keyframes. Also known as 'inbetweeing,' the result in a smooth transition between two keyframes that depict different points in an action. Tweening is necessary to convey a sense of fluid movement with still images. Inbetweens are typically considered less imperative than keyframes.

Equalizing the Edge Count

- Let parameters $L_k$ and $L_{k+1}$ denote the number of line segments in two consecutive frames. Define

$$L_{max} = \max (L_k, L_{k+1})$$
$$L_{min} = \min (L_k, L_{k+1})$$

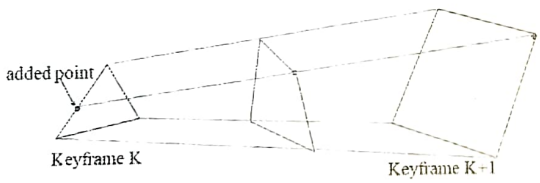
and

$$N_e = L_{max} \bmod L_{min}$$
$$N_s = \text{int}(L_{max} / L_{min})$$

Then the equalization is accomplished by-

i. dividing $N_e$ edges of $\text{keyframe}_{min}$ into $N_s+1$ sections
ii. dividing the remaining edges of $\text{keyframe}_{min}$ into $N_s$ sections

1c



$L_k = 3$
$L_{k+1} = 4$
$L_{max} = 4$
$L_{min} = 3$
$N_e = 1$
$N_s = 1$
As per above rule, Divide 1 ($N_e$) edges in 2 ($N_s$ +1) sections.

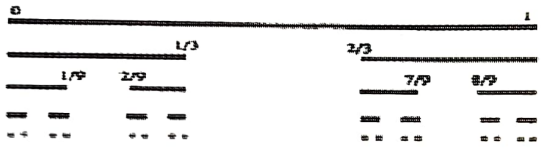
2a Calculate the dimensions of the following fractals:

Snowflakes (Koch curve)
Cantor Dust
Box fractal

Solution:

$$D = \log(4)/\log(3)$$
$$D = \log(2)/\log(3)$$
$$D = \log(5)/\log(3)$$

1. Cantor Dust:




*N=2, S=3, D=log2/log3 =0.6309*

2. Box Fractal:

*N=5, S=3, D=log5/log3=1.4649*

3. Koch Curve


*N=4, S=3, D=log4/log3=1.2618*

References:

http://www.cs.cornell.edu/courses/cs212/1998sp/handouts/Fractals/similar.html

2b How much time is spent scanning across each row of pixels during screen refresh on a raster system with resolution of 1280 X 1024 and a refresh rate of 60 frames per second?

Solution:

Resolution = 1280 X 1024

That means the system contains 1024 scan lines and each scan line contains 128 pixels.

Refresh rate = 60 frame/sec.

1 frame takes = 1/60 sec = 0.01666sec

1 frame buffer consist of 1024 scan lines (It means then 1024 scan lines takes 0.01666 sec)

1 scan line takes = 0.01666/1024 = 10.6 micro sec.

For Detail: https://www.safalta.com/doubts/graphic-designing/630e369708fa837437715cbd

2c Why do we prefer using 'Triangle Strips' or 'Triangle Fans' for rendering 3D connected vertices over rendering each triangle individually?

Solution.

The primary reason to use triangle strips is to reduce the amount of data needed to create a series of triangles. The number of vertices stored in memory is reduced from 3N to N+2, where N is the number of triangles to be drawn. This allows for less use of disk space, as well as making them faster to load into RAM.

3 a Write two advantages of parametric representation of curves

solution : (any two will be considered)

More degrees of freedom

Directly transformable

Dimension independent

No infinite slope problems

Separates dependent and independent variables

Inherently bounded

Easy to express in vector and matrix form

parametric_curves.ppt (utexas.edu)

3 b The coordinates of four control points relative to a curve are given by p1(2, 2, 0), p2(2, 3, 0), p3(3, 3, 0), p4(3, 2, 0).

a. Write the equations of bezier curve.

b. Also find the curve for u = 0, ¼, ½, ¾, 1.
c. Also plot the bezier curve.

Solution:

Control Points = 4

n = 4 - 1 = 3

P0 = (2,2,0) , P1 = (2,3,0) , P2 = (3,3,0) , P3 = (3,2,0)

Eq of bezier curve:

$$P(t) = (1-t)^3 * P0 + 3(1-t)^2 * t * P1 + 3(1-t) * t^2 * P2 + t^3 * P3$$

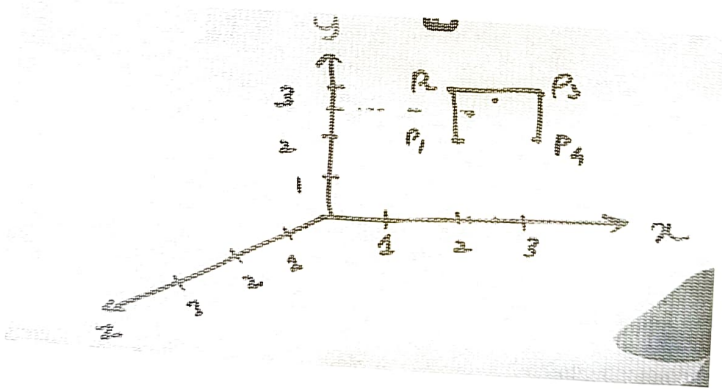
$$x(u) = 2*(1-u)^3 + 6u(1-u)^2 + 9u^2(1-u) + 3u^3$$

$$y(u) = 2*(1-u)^3 + 9u(1-u)^2 + 9u^2(1-u) + 2u^3$$

$$z(u) = 0$$

Putting the value of u in the above equation:

| u | x | y | z |
|---|---|---|---|
| 0 | 2 | 2 | 0 |
| 0.25 | 2.156 | 2.56 | 0 |
| 0.5 | 2.5 | 2.75 | 0 |
| 0.75 | 2.84 | 2.56 | 0 |
| 1 | 3 | 2 | 0 |



Reference:

https://youtube.com/watch?v=7zi1lafiFpo

4a What is image morphing? what role does image warping play in morphing?

{The image warping process means that it is a process of distorting an image using various transformations like scaling, rotation, translation, and more.

Image morphing is a special form of image warping which is a simple and smooth transition between two or more images. In simple words, its like a transformation of one image to another.}

Image Morphing is referred to as the animated transformation of one digital image to the other. 2D images are warped and faded to create illusion of metamorphosis.

In Warping the features of one image are moved or slided into the same positions as features of the other image.

## Warping: Physical Analogy

- Imagine an image printed on a sheet of rubber.
- Could change image by moving thin rigid rods glued to the rubber sheet.
- We would place these rods along contours of important features, such as eyes, nose, mouth, face outlines, etc.
- Imagine also that the rods can change length, as well as position.

b what are the advantages of b-spline curves over Bezier curves? What are the convex hull property and variation diminishing property of b-spline curves?

B-Spline overcomes following two disadvantages of Bezier curves:

1. Their non-localness: while a control point mainly influence the shape of the curves close to it, it also affects the entire curve to some extent.

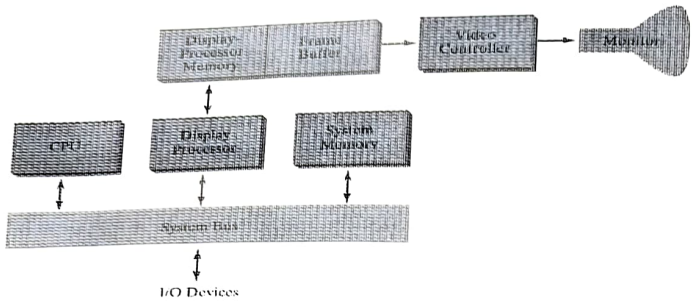
2. The fact that the degree of the curve is related to the number of control points. Thus either high order polynomials have to be used or multiple low-degree curve segments have to be used.

*Convex hull property*: The convex hull property for B-splines applies locally, so that a span lies within the convex hull of the control points that affect it. This provides a tighter convex hull property than that of a Bézier curve, as can be seen in Fig. 1.11. The $i$ -th span of the cubic B-spline curve in Fig. 1.11 lies within the convex hull formed by control points $\mathbf{p}_{i-1}$ , $\mathbf{p}_i$ , $\mathbf{p}_{i+1}$ , $\mathbf{p}_{i+2}$ . In other words, a B-spline curve must lie within the union of all such convex hulls formed by $k$ successive control points [130].

*Variation diminishing property:*

- 2-D: The number of intersections of a straight line with a planar B-spline curve is no greater than the number of intersections of the line with the control polygon. A line intersecting the convex hull of a planar B-spline curve may intersect the curve transversally, be tangent to the curve, or not intersect the curve at all. It may not, however, intersect the curve more times than it intersects the control polygon.
- 3-D: The same relation holds true for a plane with a 3-D space B-spline curve.

c Draw the architecture of a raster-graphics system with a display processor. Give a brief about the component.




For Detail: [Hearn, Baker & Carithers 2013] book - pg no. 22

Purpose of Display Processor:

Its purpose is to free the CPU from the graphics chores.

It digitizes a picture definition given in an application program into a set of pixel intensity values for storage in the frame buffer.

Other functions include generating various line styles (dashed, dotted or solid), displaying color areas and performing manipulations on displayed objects.

Purpose of Video Controller:

It performs the basic refreshing operation.
It accesses the frame buffer directly to refresh the screen.
It can retrieve multiple pixel values from the frame buffer on each pass.
The multiple pixel intensities are then stored in a separate register and used to control the CRT beam intensity for a group of adjacent pixels.
Double buffering is often used in real-time animations.

5a Show that two successive reflections about any line in the xy plane that intersects the coordinate origin is equivalent to a rotation in the xy plane about the origin.

Solution:

We need to show two successive reflections about any line in the XY plane that intersect the coordinate origin is equivalent to a rotation in the XY plane about the origin.

If a line intersects the XY plane, then the line is perpendicular to the XY plane.

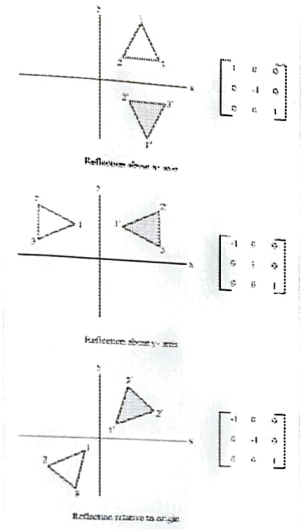
Axis of reflection

A line in plane

A line perpendicular to the XY plane

The mirror image is obtained by rotating the object 180 degrees about the reflection axis.

If successive reflections about a single axis yield the identity matrix then the object returns to its original position. A reflection About one axis followed by a reflection about the other axis is equivalent to the rotation of 180 degrees.

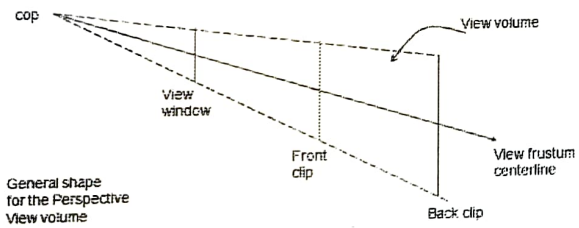


For Detail : https://www.chegg.com/homework-help/questions-and-answers/2-assuming-certain-full-colour-24-bit-per-pixel-rgb-raster-system-512-512-frame-buffer-man-q118452397

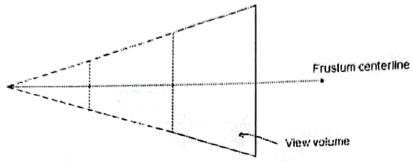
[Hearn, Baker & Carithers 2013] book

5b what are the two steps to form a canonical view volume from given general shape of the perspective view volume ( draw related diagrams)?

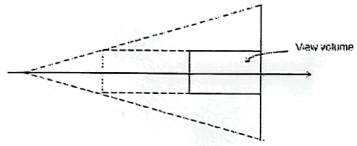
Producing a Canonical view volume for a perspective projection



Step 1: shear the view volume so that centerline of the frustum is perpendicular to the view plane and passes through the center of the view window.




Step2: scale view volume inversely proportional to the distance from the view window, so that shape of view volume becomes rectangular parallelepiped.




{

1. Translate and Center the View Volume:

[Explanation: Move the center of the perspective view volume (specified by the camera position) to the origin (0, 0, 0) in world coordinates.This is achieved through a translation transformation. The new view volume is now centered around the origin.]

2. Scale the View Volume to Canonical Dimensions:

Rescale the translated view volume to fit within a canonical shape This rescaling is accomplished using a scaling transformation.

}

5c Differentiate between the terms 'Fluorescence' and 'Phosphorescence' related with raster Scan CRT.

Solution.

Phosphor's Fluorescence is the light emitted as electrons (unstable) lose their excess energy while the phosphor is being struck by electrons.

Phosphorescence is the light given off by the return of the relatively more stable excited electrons to their unexcited state once the electron beam excitation is removed.

For Details: Microsoft PowerPoint - Display_Devs.pptx (iitm.ac.in)