B. E.

Fifth Semester Examination, May-2008

COMPUTER GRAPHICS

Note : Attempt any five questions.

Q. 1. (a) What are the differences between Raster-scan CRT and vector scan CRT?

Ans. Raster Scan CRT :

A Raster scan or raster scanning is the pattern of image detection and reconstruction in television, and is the pattern of image storage and transmission used in most computer bitmap image systems. The word raster comes from the Latin word for a rake, as the pattern left by a rake resembles the parallel lines of scanning raster.

In a raster scan, an image is cut up into a sequence of (usually horizontal) strips known as "scan lines". Each scan line can be transmitted in the form an analog signal as it is read from the detector, as in television systems or can be further divided into discrete pixels for processing in a computer system. When the image is displayed, each scan line is turned back to a line across the television screen or computer monitor. After each scan line, the position of the scan line is advanced, typically downward across the image in a process known as vertical scanning and a next scan line is detected, transmitted, stored, retrieved, or displayed. This ordering of pixels by rows is known as raster order, or raster scan order.

Vector Scan :

The cathode ray tube (CRT) is a vacuum tube containing an electron gun (a source of electrons) and a fluorescent screen, with internal or external means to accelerate and deflect the electron beam, used to form images in the form of light emitted from the fluorescent screen. The image may represent electrical waveforms (oscilloscope), pictures (television, computer monitor), radar targets and others.

The single electron beam can be processed in such a way as to display moving pictures in natural colors.

The CRT uses an evacuated glass envelope which is large, deep, heavy, and relatively fragile. Display technologies without these disadvantages, such as flat plasma screens, liquid crystal displays, DLP, OLED displays have replaced CRTs in many applications and are becoming increasingly common as costs decline

The cathode rays are now known to be a beam of electrons emitted from a heated cathode inside a vacuum tube and accelerated by a potential difference between this cathode and an anode. The screen is covered with a phosphorescent coating (often transition metals or rare earth elements), which emits visible light when excited by high-energy electrons. The beam is defected either by a magnetic or an electric field to move the bright dot to the required position on the screen.

In television sets and computer monitors the entire front area of the tube is scanned systematically in a fixed pattern called a raster. An image is produced by modulating the intensity of the electron beam with a received video signal (or another signal derived from it). In all CRT TV receivers except some very early models, the beam is deflected by magnetic deflection, a varying magmatic field generated by coils (the magnetic yoke), driven by electronic circuits, around the neck of the tube.

Q. 1. (b) Draw and explain the basic structure of direct view storage Tube (DVST). Also discuss its working.

Ans. DVST :

Storage Tube :

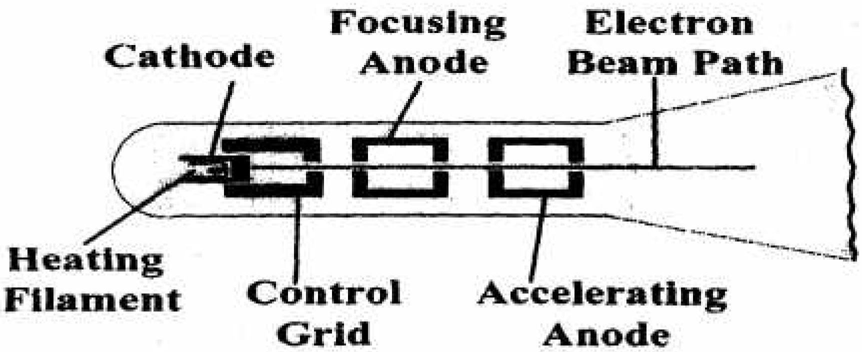
– It is a CRT with a long

Persistence phosphor :

* Provides flicker-free display
* No refreshing necessary

A slow moving electron beam draws a line on the screen

* Screen has a storage mesh in which the phosphor is embedded
* Image is stored as a distribution of charges on the inside surface of the screen
* Limited interactive support



* Modifying any part of the image require redrawing the entire modified image
* Change in the image requires to generate a new charge distribution in the DSVT
* Slow process of drawing
* Erasing takes about 0.5 seconds all lines and characters must be erased.
* No animation possible with DVST

Q. 2. (a) How DDA differs from Bresenhsm`s line drawing algorithm?

Q. 2. (b) Explain the transformations used in magnification and education with respect to origin. Find the new coordinates of the triangle A (0.0), B (1,1) and C(5,2) after it has been reduced to half its size.

Ans. DDA : Input line endpoints, (x0,y0,) and (xn, yn)

* set pixel at position (x0, y0)

- calculate slope m
- Case $|m| \leq 1$: repeat the following steps until (xn, yn) is reached:
- yi + 1 = yi + Dy/DX
- xi + 1 = xi + 1.   set pixel at position (ni + 1, Round (y i + 1)
- Case $|m| > 1$: repeat the following steps until (xn, yn) is reached:
- xi + 1= xi + Dx/Dy
- yi + 1 = yi + 1.   set pixel at position (Round (xi + 1), yi + 1)

Bresebnham's line algorithm (slope ≤ 1)

- Input line endpoints, (x0,y0) and (xn,yn)
- Calculate Dx = xn - x0 and Dy = yn - y0
- Calculate parameter p0 = 2 Dy - Dx
- Set pixel at position (x0, y0,)
- Repeat the following steps until (xn, yn) is reached:
- If pi < 0
- Set the next pixel at position (xi + 1, yi)
- Calculate new pi + 1 = pi + 2 (Dy-Dx)

DDA versus Breasenham's Algorithm-DDA works with floating point arithmetic

- Rounding to integers necessary
- Bresenham's algorithm uses integer arithmetic
- Constants need to be computed only once
- Bresenham's algorithm generally faster than DDA

Q. 3. (a) What is windowing? Explain its importance? What is multiple windowing?

Q. 3. (b) Explain Cohen-sutherlend line clipping algorithm.

Ans. Cohen Sutherland Line clipping Algorithm :

The Cohen-Sutherland line clipping algorithm quickly detect and edispenses with two common and trivial cases. To clip a line, we need to consider only its endpoints. If both endpoints of a line lie inside the window the entire line lies inside the window. It is trivially accepted and needs no clipping. On the other hand, if both endpoints of a line lie entirely to one side of the window, the line must lie entirely outside of the window. It is trivially rejected and needs to be neither clipped nor displayed. The Cohen-Sutherland algorithm uses a divide-and-conquer strategy. The line segment's endpoints are tested to see if the line can be trivially accepted or rejected. If the line cannot be trivially accepted or rejected, an intersection of the line with a window edge is determined and the trivial reject/accept test is repeated. This process is continued until the line is accepted.

To perform the trivial acceptance and rejection tests, we extend the edges of the window to divide the plane of the window into the nine regions. Each end point of the line segment is then assigned the code of the region in which it lies.

1. Give a line segment with endpoint $P_1 = (x_1, y_1)$ and $P_2 = (x_2, y_2)$
2. Compute the 4-bit codes for each endpoint.

   If both codes are 0000, (bitwise OR of the codes yields 0000) line lies completely inside the window: pass the endpoints to the draw routine.

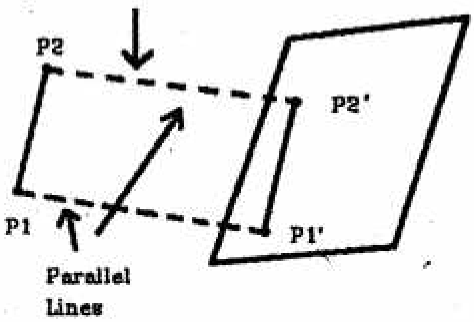
   If both codes have a 1 in the same bit position (bitwise AND of the codes is not 0000), the line lies outside the window. It can be trivially rejected.
3. If a line cannot be trivially accepted or rejected, at least one of the two endpoints must lie outside the window and the line segment crosses a window edge. This line must be **clipped** at the window edge before being passed to he drawing routine.
4. Examine one of the endpoints, say $P_1 = (x_1, y_1)$ Read p_1's 4-bit code in ord_r: Left-to-Right, Bottom-to-Top.
5. When a set bit (1) is found, compute the intersection I of the corresponding window edge with the line from P_1 to P_2 . Replace P_1 with I and repeat the algorithm.

Q. 4. (a) The pyramid defined by the coordinates A (0,0,0,), B (1,0,0) C (0,1,0) and D (0,0,1) is rotated 90 about the line L that has direction vector V = i+j+k and passing through the origin. Find the co-ordinates of the rotated figure.

Q. 4. (b) Explain the difference between parallel and perspective projection.

Ans. Parallel Projection :

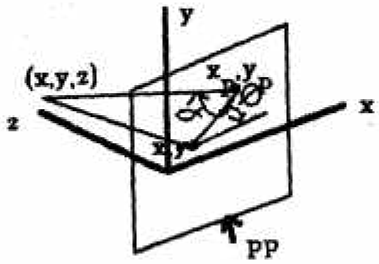
Projection rays (projectors) emanate roam a Center of Projection (COP) and intersect projection Plane (PP). The COP for parallel projectors is at infinity. The length of a line on the projection plane is the same as the "true Length'.



There are two different types of parallel Projections:

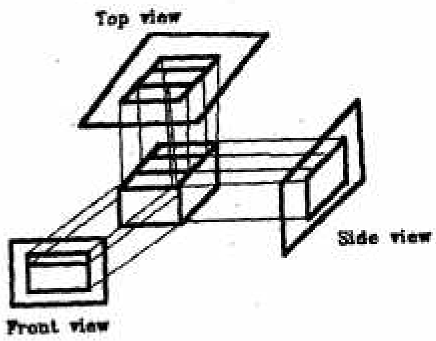
If the direction of projection is perpendicular to the projection plane then it is an orthographic projection. If the direction of projection is not perpendicular to the projection plane then it is an oblique projection.

Look at the parallel projection of a point (x,y,z). (Node the left handed coordinate system). The projection plane is at z = 0, x, y are the orthographic projection values and xp, yp are the oblique projection values (at angle a with the projection plane)



Look at orthographic projection: it is simple, just discard the z coordinates. Engineering drawings frequently use front, side, top orthographic views of an object.

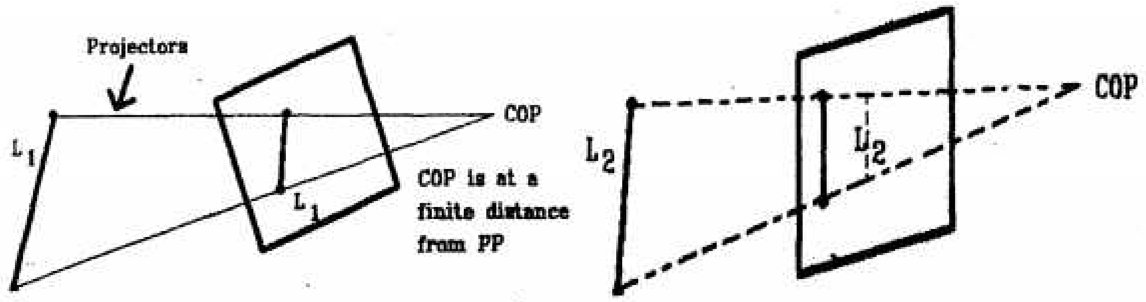
Here are three orthographic views of an object.



Orthographic projections that show more than 1 side of an object are called axonometric orthographic projections. The most common axonometric projection is an isometric projection where the projection plane intersects each coordinate axis in the model coordinate system at an equal distance.

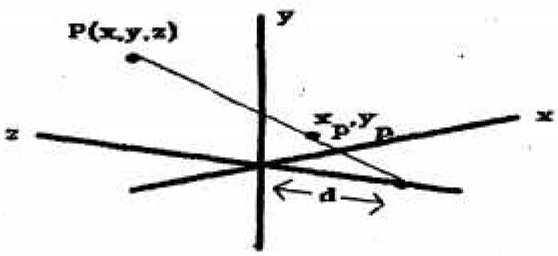
Perspective Projection :

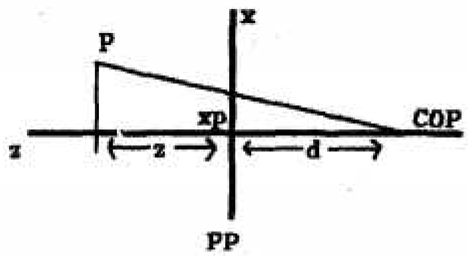
The perspective viewing projection has a Center of Projection ("eye") at finite distance from the projection plane (PP).



So the distance of a line from the projection plane determines its size on the projection plane, i.e. the father the line is from the projection plane, the smaller its image on the projection plane. It the two images above, the projections of L1 = L2 but the actual length of L 1 <> L2. Perspective projection is more realistic since distant objects appear smaller.

Computing the Perspective Projection :





- Look at above diagram from y axis

Now $x / (z + d) = xp/d$

$xp = x[p / (z+d)]$

$xp = x/ (z / d + 1)$

Do same for y (look down the x axis) and get

$y p = y / (z / d + 1)$

$zp = 0$

Note that we can increase the respective effect by decreasing d (moving closer). We can represent this in matrix from by using homogeneous coordinates as follows:

[xh yh zh w] = [x y z 1] |1 0 0 0|

|0 1 0 0|

|0 0 0 1/d|

|0 0 0 1|

where:

$xh = x$

$yh = y$

$zh = 0$

$w = (z/d) + 1$

And Points on the projection place are [xp yp zp 1] = [xh/w yh/w zh/w 1]

This leads to the same xp, yp as before.

A problem with a perspective transformation is that it does not preserve straight lines or planes, i.e., straight lines are not transformed into straight lines and planes are no longer planar after the transformation.

Look at example of a 3D line in object space from:

P1 (x1 = 2.0, y1 = 5.0, z1 = 6.0) to P2 (x2 = 8.0, y2 = 7.0, z2 = 12.0)

In parametric form this line is represented as:

$x (t) = 2 + 6 x t$

$y (t) = 5 + 2 x t$

$z (t) = 6 + 6 x t$

Q. 5. (a) Explain depth buffer method for hidden surface detection.]

Ans. Depth Buffer Method :

z-buffer method :

* A commonly used image-space approach to hidden-surface removal
* It is also referred as Depth-Buffer method

* Use the intensity color of the nearest 3D point for each pixel

Z buffer algorithm

for all positions (x,y) in the view screen

frame (x,y) =|_background

depth (x,y)=max_distance

end

for each polygon in the mesh

for each point (xy) in the polygon-fill algorithm

compute, z, the distance of corresponding 3D-point from COP

if depth (x,y) > z // a closer point

depth (x,y) = z

frame (x,y=|(p) //shading

endif

endfor

endfor

Determining Z-Depth :

If we have the plane equation:

$$AX + By + Cz + D = 0 \text{ Normal Vector: } N=(A,B,C)$$

Insert Known x,y into plane eqn.. and solve for z:

$$z = (-ax - by - d)/c$$

Then at (x1 + Dx, y1)

$$z' = z1 - aDx/c \quad a/c \text{ is constant for the plane } Dx = 1$$

So incrementing:

$$zi+1 = zi - a/c \text{ across scan line}$$

$$zj+1 = zi\,j - b/c \text{ between scanlines}$$

Q. 5. (b) Explain painter's algorithm.

Ans. Painter's Algorithm :

The **painter's algorithm,** also known as a **Priority fill,** is one of the simplest solutions to the visibility problem in 3D computer graphics. When projecting a 3D scene onto a 2D plane, it is necessary at some point to decide which polygons are visible, and which are hidden.

The name "painter's algorithm" refers to a simple-minded painter who paints the distant parts of a scene at first and then covers them by those pars which are nearer. The painters algorithm sorts all the polygons in a scene by their depth and then paints them in this order, furthest to closest. It will paint over the parts that are normally not visible - thus solving the visibility problem - at the cost of having painted redundant areas of distant objects.

In basic implementations, the painter's algorithm can be inefficient. If forces the system to render each point on every polygon in the visible set, even if that polygon is occluded in the finished scene. This means that, for detailed scenes, the painter's algorithm can overly tax the computer hardware.

A reverse painter's algorithm is sometimes used, in which objects nearest to the viewer are painted first -- with the rule that point must never be applied to parts of the image that are already painted. In a computer graphic system, this can be very efficient, since it is not necessary to calculate the colors (using lighting, texturing and such) for parts of the more distant scan that are hidden by nearby objects. However, the reverse algorithm suffers from any of the same problems as the standard version.

These and other flaws with the algorithm led to the development of Z-buffer techniques, which can be viewed as a development of the painter's algorithm, by resolving depth confliction on a pixel-by-pixel basis, reducing the need for a depth-based rendering order. Even in such systems, a variant of the painter's algorithm is sometimes employed. As Z-buffer implementations generally rely on fixed-precision depth-buffer registers implemented in hardware, there is scope for visibility problems due to rounding error. These are overlaps or gap sat joins between polygon. To avoid this, some graphics engineering implementations "overrender", drawing the affected edges of both polygons in the order given by painter's algorithm. This means that some pixels are actually drawn twice (as in the full painters algorithm) but this happens on only small parts of the image and has a negligible performance effect.

Q. 6. (a) Discuss advantages of using B-Splines curves over Bezier curves for modelling curves.

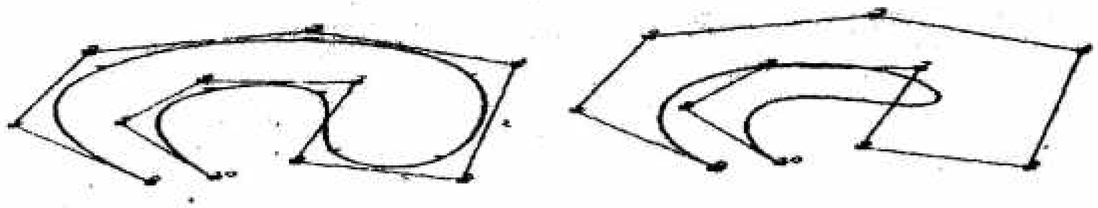
Ans. B-spline curves share many important properties with Bezier curves, because the former is generalization of the later. Moreover, B-spline curves have more desired properties than Bezier curves. The list below shows some of the most important properties of B-spline curves.

In the following we shall assume a B-spline curve C (u) of degree p is defined by n + 1 control points and a knot vector U = { u, u1 ...., um } with the first p + 1 and last P + 1 knots "clamped" (i.e., uo = u1 = ... = up and $U_{m-p} = U_{m-p+1} = \dots u_m$).

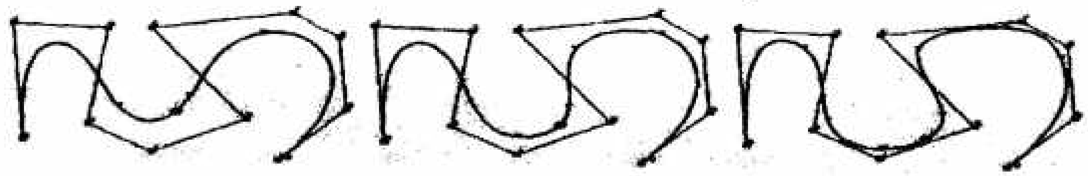
1. B-spline curve C (u) is a piecewise curve with each component a curve of degree p.

As mentioned in previous page, C (u) can be viewed as the union of curve segments defined on each knot span. In the figure below, where n = 10, mk = 14 p = 3, the first four knots and last four knots are clamped and the 7 internal knots are uniformly space. There are eight knot spans, each of which corresponds to a curve segment. In the left figure below, these knot points are shown as triangles.

This nice property allows us to design complex shapes with lower degree polynomials. For example, the right figure below shows a Bezier curve with the same set of control points. It still cannot follow the control polyline nicely even though its degree is 10!



In general, the lower the degree, the closer a B-spline curves follow its control polyline. The following figures all use the same control polyline and knots are clamps and uniformly spaced. The first figure has degree 7, the middle one has degree 5 and the right figure has degree 3. Therefore, as the degree decreases, the generated B-spline curve moves closer to its control polyline.



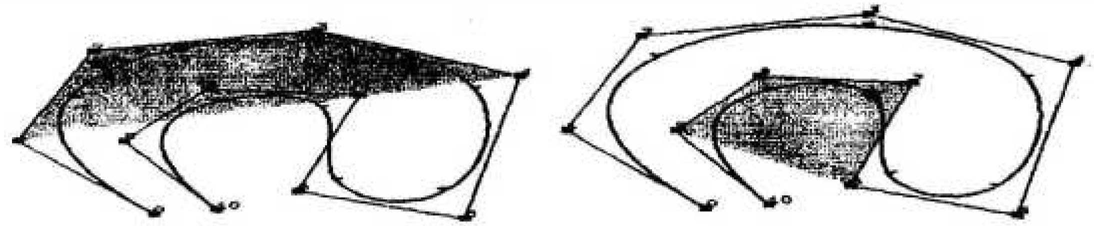
2. **Equality m = n + p +| 1 must be satisfied.**

Since each control point needs a basic function and the number of basic functions satisfies m = n + p + 1.

3. **Clamped B-spline curve c (u) passes through the two end control points po and pn.**

Note that basis function $N_{o,p}(u)$ is the coefficient of control point P_o and is non-zero on $[u_o, u_{p+1})$. Since $u_o = u_1 = \ldots\ldots u_p = 0$ for a clamped B-spline curve, $N_{o,o}(u), N_{1,0}(u), \ldots\ldots\ldots, N_{p-1,0}(u)$ are zero and only $N_{p,o}(u)$ is non-zero recall from the triangular computation scheme).. Consequently, if u = 0, then $N_{o,p}(0)$ is 1 and C (0) = po. A similar discussion can show C (1) = Pn

4. **Strong Convex Hull property: A B-spline curve is contained in the convex hull of its control polyline. More specifically, if u is in knot span $[u_i, u_{i+1})$, then C (u) is in the convex hull of control points** P_{i-p}, $P_{i-p+1}, \ldots\ldots$, P_i. If u is in knot span $[u_i, u_{i+1})$, there are only P + 1 basis functions $\left(\text{i.e.}, Ni.p(u), \ldots\ldots, N_{ip+1,p(u)}, N_{i-P+1}(u), N_{i-p,p}(u))\text{non} -\right)$ Zero on this knot span. Since $N_{k,p}(u)$ is the coefficient of control point Pk, only p+1 control points P_i, P_{i-1}, Pi 2, ..., Pi-p have non-zero coefficients. Since on this knot span the basis functions are non-zero and sum to i, their "weighted" average, C (u), must lie in the convex hull defined by points $P_i, P_{i-1}, P_{i-2}, \ldots\ldots, P_{i-p}$. The meaning of "strong" is that while C (u) still lies in the convex hull defined by all control points, it lies in a much smaller one.



The above two B-spline curves have 11 control points (i.e., n = 10), degree 3(i.e., p = 3) and 15 knots (m = 14) with first four and last four knots clamped. Therefore, the number of knot spans is equal to the number curve segments. The knot vector is

U_0	U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_{10}	U_{11}	U_{12}	U_{13}	U_{14}
0	0	0	0	0.12	0.25	0.27	0.5	0.62	0.75	0.87	1	1	1	1

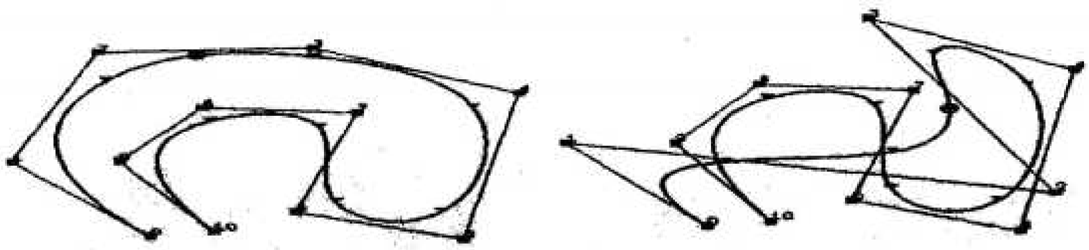
The left figure has u in knot span $[U_4, U_5) = [0.12, 0.25)$ and the corresponding point (i.e. C (u)) in the second curve segment. Therefore, there are P+1 = 4 basis function non-zero on this knot span (i.e., $N_{4,3}(u), N_{3,3}(u), N_{2,3}(u)$) and the corresponding control points are P_4, P_3, P_2 and P1. The shaded area is the convex hull defined by these four points. It is clear that C (u) lies in this convex hull.

The B-spline curve in the right figure is defined the same way. However, u is in $[u_9, u_{10}) = \{0.75, 0.87)$ and the non-zero basis functions are $N_{9,3}$ (u), N7.3 (u) and N6.3 (u). The corresponding control points are P_9, P_8, P_7 and P_6.

Consequently, as u moves from 0 to 1 and crosses a knot, a basis functions becomes zero and a new non-zero basic function becomes effective. As a result, one control point whose coefficient becomes zero will leave the definition of the current convex hull and is replaced with a new control point whose coefficient becomes non-zero.

5. Local Modification Scheme: changing the position of control point Pi only affects. The curve C(u) on interval [ui, ui+p+1).

This follows from another important property of B-spline basis functions. Recall that Ni.p (u) is non-zero on interval [ui, ui+p+1). If u is in the indicated interval, Nip (u) pi has no effect in computing C 9u) since Ni,p (u) is zero. On the otherhand, if u is in the indicated interval, Ni.p (u) non-zero. If pi changes its position, Ni,p (u) pi is changed and consequently C () changed.

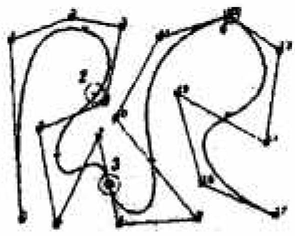


The above B-spline curves are defined with the same parameters as in the previous convex hull example. We intent to move control point P2. The coefficient of this control point is N2,3 (u) and the interval on which this coefficient is non-zero is [U2, u2+3+1) = [u2, u6} = [0,0.37}. Since u2= u3 = 0, only three segment that correspond to [u3, u4) (the domain of the first curve segment), [u4, u5) (the domain of the second curve segment) and [u5, u6) (the domain of the third curve segment) will be affected. The right figure shows the result of moving P2 to the lower right corner. As you can see, only the first, second and third curve

segments change their shapes and all remaining curve segments stay in their original place without any change.

This local modification scheme is very important to curve design, because we can modify a curve locally without changing the shape in a global way. This will be elaborated on the moving control point page. Moreover if fine-tuning curve shape is required, one can insert more knots (and therefore more control points) so that the affected area could be restricted to a very narrow region. We shall talk about knot insertion later.

6. C(u) is C^{p-k} continuous at a knot of multiplicity k If u is not a knot, C(u) is in the middle of a curve segment of degree p and is therefore infinitely differentiable. If u is a knot in the non-zero domain on N_{i-p} (u) since the latter is only C^{p-k} continues, os does C (u).



The above B-spline curve has 18 control points (i.e., n = 17), degree 4, and the following clamped knot vector

to u4	u4	u6 and u1	u8	u9 to u11	u12	u13 to u16	u17	u18 to u22
0	0.125	0.25	0.375	0.5	0.625	0.75	0.875	1

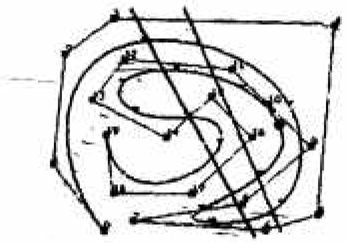
Thus, u6 is a double knot, u9 is a triple knot and. U_{13} is a quadruple knot. Consequently, C (u) is of C_4 continuous at any point that is not a knot, C_3 continuous at all simple knots, C^2 continuous at u6, C^1 continuous at u13.

All points on the curve that correspond to knots are marked with little triangles. Those corresponding to multiple knots are further marked with circles and their multiplicities. It is very difficult to visualized the difference between C^4, C^3 and even C^2 continuity. For the C^1 case, the corresponding point lies on a leg, while the C^1 case, the corresponding point lies on a leg, while the C^0 case forces the cure to pass through a control point. We shall return to this issue later when discussing modifying knots.

/

7. Variation Diminishing property :

The variation diminishing property also holds for B-spline curves. If the curve is in a plane (wasp.., space), this means no straight line (wasp., plane) intersects a B-spline curve more times than it intersects the curve's control polyine.



In the above figure, the blue line intersects both the control polyline and the B-spline curve 6 times, while the yellow line also intersects the control polyline and the B-spline curve 5 times. However, the orange line intersects the control polyline 6 times and the curve 4 times.

8. Bezier Curves Are Special Cases of B-spline Curves :

If n = p (i.e., the degree of a B-spline curve is equal to n, the number of control points minus 1), and there are 2(p + 1) = 2 (n + 1) knots with p + 1 of them clamped at each end, this B-spline curve reduces to a Bezier curve.

9. *Affine Invariance :*

The affine invariance property also holds for B-spline curves. If an affine transformation is applied to a B-spline curve, the result can be constructed from the affine images of its control points. This is a nice property. When we want to apply a geometric or even affine transformation to a B-spline curve, this property states that we can apply the transformation to control points, which is quite easy, and once the transformed control points are obtained the transformed B-spline curve is the one defined by these new points. Therefore, we do not have to transform the curve.

The Advantage of Using B-spline Curves :

B-spline curves require more information (i.e., the degree of the curve and a knot vector) and a more complex theory than Bezier curves. But, it has more advantages to offset this shortcoming. First, a B-spline curve can be a Bezier curve. Second, -spline curves satisfy all important properties that bezier curves have. Third, B-spline curve is separated from the number of control points. More control flexibility than bezoar curves can do. For example, the degree of a B-spline curve is separated from the number of control points. More precisely, we can use lower degree curves and still maintain a large number of control points. We can change the position of a control point without globally changing the shape of the whole curve (local modification Property). Since B-spline curves satisfy the strong convex hull property, they have a finer shape control. Moreover, there are other techniques for designing and editing the shape of a curve such as changing knots. However, keep in mind that B-spline curves are still polynomial curves and polynomial curves cannot represent many useful simple curves such as circles and eclipses. Thus, a generlization of B-spline, NURBS, is required.

Q. 6 (b) What are advantages of non-uniform rational B-splines.

Ans. Advantages of Non Uniform B Spline :

∅ **Very powerful**

§ Can make not only polynomial curves, but also circles ellipses, etc.

∅ Easily extended to surfaces

$$P(u,v) = \sum_{i=0}^{n}\sum_{j=0}^{m} B_{i,d}(u)B_{j,d}(v)p_{i,j}$$

∅ When we move to cox-de Boor, it is no longer mandatory that the knots be evenly spaced!

§ If we move knots closer together, we increase the influence of some control points

§ Forcing duplicate knots can cause points to interpolate

§ Most common example:

* Knots = {0, 0, 0, 0, 1, 1, 1, 1}

* This is equivalent to a Bezier curve

∅ n=3, knots = (0, 0, 0, 0, 1, 1, 1, 1)

§ Bezier curve

∅ Arbitary n,

§ knots = (0, 0, 0, 0, 1, 2,......, n-3, n-2, n-2, n-2, n-2,)

§ Example: (0, 0, 0, 0, 1, 2, 3, 3, 3, 3)

* n = 5, 6 control points......

§ These are called "open splines"

* They interpolate the end points

An illumination model (equation) expresses the components of light reflected from or transmitted (refracted) through a surface. There are three basic light components: ambient, diffuse, and spectral. We will develop local illumination models that contain some or all of these components. The models are local in that they do not consider light from objects in the scene. Only light sources generate light. Light reflected from other objects does has no effect on other objects. Ray tracing and radiosity models provide these global lighting effects.

Only a crude approximation to ambient light will be used to represent light from environment and its effect on the light reflected from an object. Light can be diffusely or specularly reflected and diffusely or specularly refrected.

The illumination equation must be evaluated in view space since perpective mapping destroys the geometry of surface normals, view vectors, light source vectors.

/

Ambient Reflected Light

* Ambient light component - - non-directional light source that is the product of multiple reflections from the surrounding environment
* Assume the intensity /a of ambient light is constant for all objects
* The ambient-reflection coefficient ka, which ranges from 0 to 1, determines the amount of ambient ligh reflected by the object's surface
* The ambient-reflection coefficient is a material propery
* The ambient illumination equation is

/ = ka/s

Where / is the intensity of reflected light from a surface with ambient-reflection coefficient ka in ε environment with ambient intensity /a

Diffuse light :

Diffuse light is reflected (or transmitted) from a point with equal intensity in all directions. Diffuse reflected light is typical for dull, matte surfaces such a paper or a flat wall paint. Diffusely refrancted light typical for frosted glass.

Diffuse reflection is modeled by the Lambert's laws, which basically states that brightness depends on on the angle θ between the light source direction Land the surface normal N.

Lambert's first law :

The illuminance on a surface illuminated by light falling on it perpendicularly from a point source proportional to the inverse square of the distance between the surface and the source.

Lambert's second law :

If the rays meet the surface at an angle, then the illuminance is proportional to the cosing of the angle wi thenormal.

Lambert's third law :

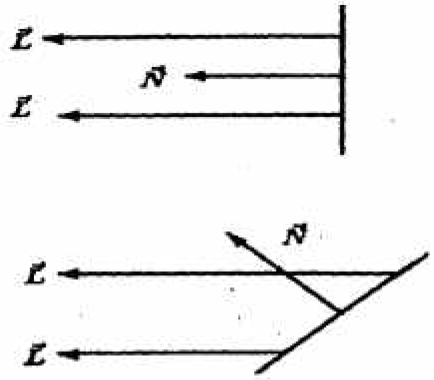
The luminous intensity of light decreases exponentially with distance as it travels through an absorbing medium.

The light beam covers an ara whose size is inversely propertional to the cosine of θ and the amount of relected light seen by the viewer is independent of the viewer's position and proportional to cos θ.

Figure : A diagram illustrating Lambert's

Laws.

/



Diffuse illuminationmodel.

What all this means isthat the diffuse illumination equation we'll use is

$$I = k_d I_p x \cos\theta,$$

where

1.

θ is the angle between the surface normal N and the light ector L;

2.

/p is the intensity of a point light source; and

3.

Kd is the diffuser election coefficient or diffuse reflectively of the surface which varies between 0 and 1 and depends on the surface material.

Assuming that N and Lare unit length vectors, we can write the cosine as a simple,dot product and the diffuse illumination equation as

$$I = k_d I_p (\overline{N}.\overline{L}).$$

This equation mist be evaluated in view coordinates since a perspective transformation will modify θ and the ir.:.er product. Often, we pretend the point light source is sufficiently far away so that θ $\overline{L}$ can be considered contact for all points on the surface. Thus, the the duress illumination equation only to be evaluated once for the entire surface, provided of course the surface is flat so that $\overline{N}$ does not change either.

Intensity attenuation.

We should also take into account the distance of objects from the light source. This will allow us to distinguish two identical, parallel surface at different distance. The intensity from the more distance surface must be attenuated (lessened). The energy from a point lights source obeys an inverse square law, that is our basic diffuse illumination model should be modified to

$$I = \frac{k_d I_p(\overline{N}.\overline{L})}{d^2},$$

where d is the distance from the point light source to the surface. In practice, a more general model usually gives better results. For example, Foley and Van Dam [1] suggest using

$$\max\left(\frac{1}{c1 + o2d + c3d^2}, 1\right)$$

as an attenuation factor for some choice of ```tuning" parameters c1, c2, and c3; So now our diffuse model is

$$I = \frac{k_d I_p(\overline{N}.\overline{L})}{\min(c1 + c2d + c3d^2, 1)}$$

A more simple model, such as,

$$I = \frac{k_d I_p(\overline{N}.\overline{L})}{c1 + c2d}$$

is also often used.

Specular Light

The specular component of reflection (or refracted) light accounts for highlights caused by light reflecting (or refracting) primarily in one direction. Specular reflection is mirror-like; it gives to shiny sports on surfaces. The amount of specular ly reflected light seen by a vewer depends on the angle θ between $\overline{L}$ and $\overline{N}$ and the angle ϕ between the viewer $\overline{V}$ and the reflected ray $\overline{R}$. Specularly reflected light, unlike iffusely reflected light, in view dependent. In drawing the specular component we often refer to the ``specular bump "which shows that most light is reflected in a particular direction. Bui-Thogng phone developed a popular approximation to the specular component of light. Phong's model is

$$I = W(\theta) I_p \cos^n(\phi),$$

$W(\theta)$

Where is the fraction striking the surface that is specularly reflected, and n is the phong specular-reflection exponent. $W(\theta)$ is often set to a constant, call it ks, and refer to it as the specular-reflection coefficient or specular reflectivity. between 1 and several The phong exponent n varies from 1 to several hundred.

A setting n=1 gives broad gentle fall off to the highlight, while large settings of n give focused highlight.

Q. 8. Write short notes on the following :

(a) Application of computer graphics.

(b) Types of projection.

Ans. Applications of Computer graphics :

1. **Digital Art :**

Digital art most commonly refers to art created on a computer in digital from. Digital art can be purely computer-generated, such as fractals, and algorithmic art or taken from anther source, such as a scanned photograph, or an image drawn using etor graphics software using a mouse or graphics table. Though technically the term may be applied to art done using other media or processes and merely scanned in, it is usually reserved for art that has been non-trivally modified by a computing process (such as a computer program, microcontroller or any electronic system capable of interpreting an input to create an output); digitized text data and raw audio and video recordings are not usually considered digital art in themselves, but can be part of a larger project. In an expanded sense, "digital art" is a term applied to contermorary art that uses the methods of mass production or media.

2. **Special effects :**

The illusions used in the film, television, theater, or entertainment industries to simulate the imagined events in a story are traditionally called special effects (a.k.a. SFX, SPFX< or simply FX). In modern films, special effects are usually used to alter previously-filmed elements by adding, removing or enhancing objects within the scene. The use of special effects is more common in big-budge films, but affordable animation and compositing software enables even amateur filmmakers to create professional-looking effects. Special effects are traditionally divided into the categories of **Optical effects** and **mechanical effects.** In recent years, a greater distinction between special effects and visual effects has been recognized, with "visual effects" referring to post-production and optical effects, and "special effects" referring to on-set mechanical effects. Optical effects (also called visual or photographic effects), are techniques in which images or film frames are created and manipulated for film anode. Optical effects are produced photographically, either "in-camera" using multiple exposure, matters or the Schufftan proess, or in post-production processes using an optical printer or video editing software. An optical effect might be used to place actors or sets alginate different background, or make an animal appear to talk. Mechanically effects (also called practical or physical effects), are usually accomplished during the live-action shooting. This includes the use of mechanized props, scenery and scale models, and pyrotechnics. Making a car appear to drive by itself, or blowing up a building are examples of mechanical effects. Mechanical effects are often incorporated into set design and makeup. For example, a set may be built with break-away doors or walls, or prostheitic makeup can be used to make an actor look like a monster.

3. Visual effects :

Visual effects (or 'VFX') is the term gien in which images or [film] frames are created and manipulated for film and video. Visual effects usually involve the integration of live-action footage with computer generated imagery or other elements (such as pyrotechnics or model work) in order to create environment or scenarios which look realist, but would be dangerous, costly, or simply impossible to capture on file. They have become increasingly common in big-budget films, and have also recently become accessible to the amateur filmmaker with the introduction of affordabel animation and compositing software.

4. Video game :

A video game is a game that involves interaction with a user interface to garnierite visual feedback on a video device. The word video in video game traditionally referred to a raster display device. However, with the popular use of the term "video game", it now imples any type of display device. the electornic systems used to play video games ae known as platforms; examples of these are personal computers and video game consoles. These platforms are broad in range, from large computer to small handheld devices. Specialized video games such as arcade games, while previously common, gave gradually declinede in use. The input device normally used to manipulate video games is called a game controller, which varies across platforms. For instnace, a dedicat3ed console controller might consist of only a button and a joystick, or featurre a dozen buttons and one or more joysticks. Early personal computer based games hstorically relied on the availability of a keyboard for gameplay, or more commonly, required the user to purchase a separate joystick with at least one button to play. Many modern computer games allow the player to use a keyboard and mouse simultaneously. Beyond the commopn element of visual feedback, video games have have utilized other systems to privide interaction and information to the player. Chief examples of these sound reproduction devices, such as speakers and head-phones, and an array of haptic peripherals, such as vibration or force feedback.

Ans. (b) Types of Projection : Multiview Orthographic

* **Used for :**
* engineering drawings of machines, machine parts
* working architectural drawings
* **Pros :**
* accurate measurement possible
* all views ae at same scale
* **Cons :**
* does not provide "realistic" view or sense of 3D form
* **Usually need multiple views to get feeling for object.**

Axonometric Projections

* Same method as multiview orthographic projections, except projecton plane not parallel to any of the coordinate planes. Parallel lines are equally foreshorened.
* Isometric : Angles between all three principla axes are equal (120o). The same scale ratio applies along each asis.
* Dimetric : Angles between two of the principal axes are equal. Two scale ratio are needed.
* Trimetric : Angles different between the three principal axes. Three scale ratios required.

Isometric Projection

* **Used for :**
* catalogue illustrations
* patent office records
* furniture design
* structural design
* **Pros :**
* don't need multiple views
* illustrates 3D nature of object
* measurements can be made to scale along principal axes.
* **Cons :**
* lack of foreshortening creates distorted appearance.
* more useful for rectangular than curved shapes.

Oblique Projections

*** Projectors are at an oblique angle to the projection plane.**

*** pros :**

* presents the exact shape of one face of an object (can take accurate measurements) : better for ellipticla shapes than axonometric projections, better for"mechanical" viewing
* lack of perspective forshortening makes comparison of sizes easier
* displays some of the object's three-dimensional appearance
* **Cons :**
* objects can look distorted if careful choice not made about position of dprojection plane (e.g., circles become ellipses)

* lack of foreshortening (not realistic looking)

Perspective Projections

* **Used for :**
* advertising
* presentation drawings for architecture, industrial design, engineering fine art
* **Pros :**
* gives a realistic view and feeling for three dimensional form of object
* **Cons :**
* does not preserve shape of object or scale (except where object intersects projection plane)
* **Different from a parallel projetion because**
* parallel lines not parallel to the projection plane converge
* size of the object is diminished with distance
* foreshortening is not uniform.