



MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu



LECTURE HANDOUTS

L-01

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: Product Cycle - Design Process

Introduction : (Maximum 5 sentences)

Product Cycle:

- The product begin with a need which is identified based on customers and market demands
- In order to establish the scope and definition of CAD/CAM in an engineering environment and identify existing and future related tools

Design Process:

- Is the formulation of a plan to help an engineer build a product with a specified performance goal.
- This process involves a number of steps, and parts of the process may need to be repeated many times before production of a final product can begin.

Prerequisite knowledge for Complete understanding and learning of Topic:

Introduction
Growth
Maturity
Decline

Detailed content of the Lecture:



Introduction stage: In this stage the product is new and the customer acceptance is low and hence the sales are low.

Growth stage: Knowledge of the product and its capabilities reaches to a growing number of customers.

Maturity stage: The product is widely acceptable and sales are now stable, and it grows with the same rate as the economy as a whole grows.

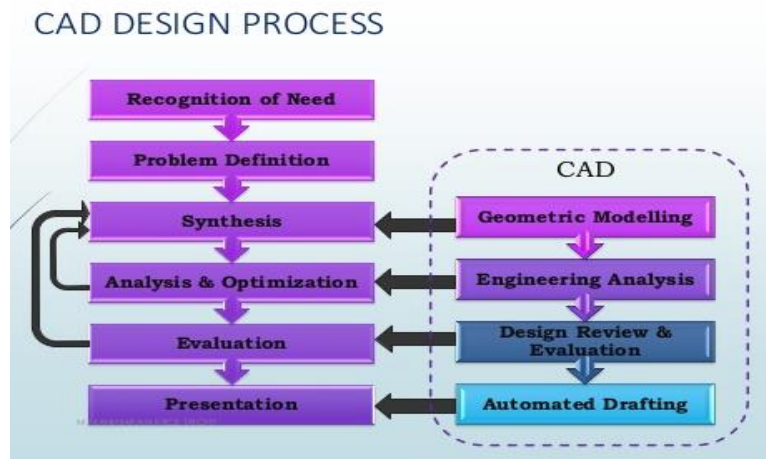
Decline stage: At some point of time the product enters the decline stage. Its sales start decreasing because of a new and a better product has entered the market to fulfill the same customer requirements.

Design Process:

The Various Design process are,

1. Shigley's Design Process
2. Ohsuga Model
3. Earle Model

Shigley's Design Process:



Recognition of need:

- The existing products or potential for new products in the market have to be identified.

Definition of Problems:

- It includes the specification of physical and functional characteristics, cost, quality, performance requirements etc.

Synthesis:

- The designer develops number of designs to meet the requirement of design.

Analysis and optimization:

- Each design from the synthesis stage is analyzed and the optimum one is selected.
- Based on the Analysis, improvements are made and redesigned.
- The process is repeated until the optimized within all constraints imposed by designer.

Evaluation:

- The previous stage is checked for all specifications mentioned in the "Design Brief"
- Prototype of the product is developed and experimentally checked for its performance, quality, reliability and aspects of product.

Presentation:

- After the product design passing through the evaluation stage, drawings, diagrams, Material Specification, assembly lists, bill of materials

Video Content / Details of website for further learning (if any):

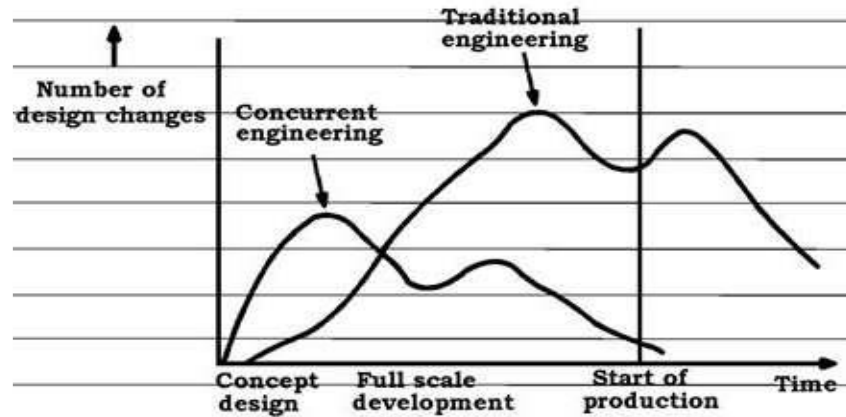
https://www.youtube.com/watch?v=_26E6QR_hmU

<https://www.youtube.com/watch?v=n8w1xOutFW4>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989
- Peter S Shirley A. K. Peters, Ltd. 63 South Avenue Natick, MA United States, ISBN:978-1-56881-469-8 Pages: 804

- Often the need for engineering changes is discovered during planning or manufacturing or assembly. In each phase/activities there is no interaction between them. The other name for sequential approach is 'over wall' approach.
- There is no interaction i.e. there is a communication barrier between each department.



Long lead time

If any modification to be made on the product by stream department, it has to be fed back and this often involves in additional expenditure and also results in unnecessary delay in Product cycle.

Limitations

Decisions are taken by individuals.

Product modifications/changes will be slow.

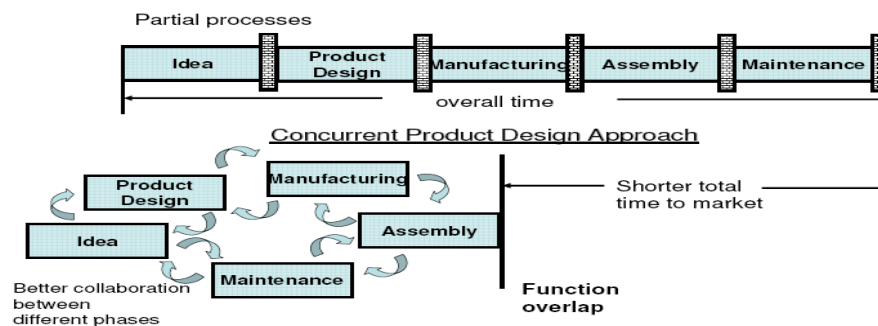
Each activity is carried out sequentially.

Because of the above reasons, time taken for product development is more

Concurrent Engineering

Global competition pressurizes the firms to produce products with high Performance, reliable, low cost with less lead time.

To achieve this, in the product planning stage itself a co-operate work between design and manufacturing and other related activities has to be made.



A typical team consists of experts from

- 1) Material Manufacturing process
- 2) Assembly
- 3) Maintenance
- 4) Marketing
- 5) Service personnel
- 6) End users and
- 7) Specialists in the product related field.

The product development is the responsibility of this multi-disciplinary team which follows the product from inception to complete production.

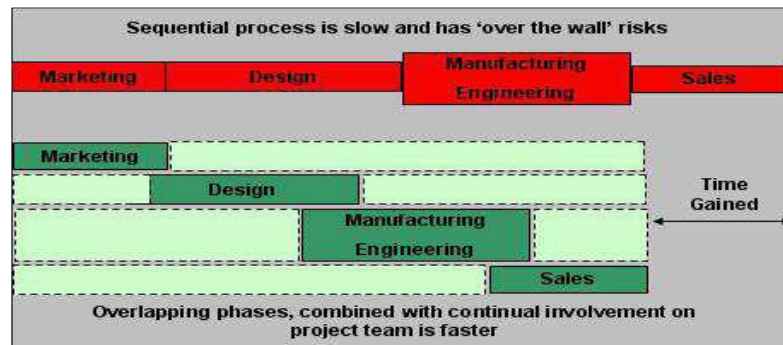
There are circumstances in which concurrent engineering is not necessarily the best approach, especially where there is very high uncertainty in the product development process.

Characteristics of Concurrent Engineering:

- Product responsibilities lie on team of multi-disciplinary group.
- Integration of design, process planning and production will be achieved.
- Product lead time will be less, because cross-functional activities are started simultaneously.
- Most of the modification charges are carried in the planning stage itself.
- Frequent review of design and development process, and Rapid prototyping

Advantages of Con-Current Engineering:

- The design decisions are taken by a team of multi-disciplinary experts.
- Changes and modifications on the product design will be faster.
- Shorter lead times because all the activities related to product Developments are carried out simultaneously.
- Higher quality.



Examples of Concurrent Engineering (CE)

- Hewlett Packard - Yokogawa HP - Cycle time decreased by 35 %, Manufacturing cost 42%, Inventory 64%, Field failure rates 60 %
- Neon Car in USA - Each team took 1 year - 4 months before launch team
- Scooty by TVS Motors Ltd. - Cross functional teams

Video Content / Details of website for further learning (if any):

- <https://www.youtube.com/watch?v=or4o0KgWqPE>
- <https://www.youtube.com/watch?v=VrpQ8m8GZZo>
- <https://www.youtube.com/watch?v=pxXy8OnJh2A>
- https://www.youtube.com/watch?v=I-90d_gRnQU

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989
- Prasad, B. 1995. "On Influencing Agents of CE," Concurrent Engineering: Research & Applications – An International Journal, 3(2):78-80.



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LECTURE HANDOUTS

L-03

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: Computer aided design – CAD system architecture

Introduction :

Computer systems to assist in the creation, modifications, analysis and optimization of a design.

Activities of the CAD process are mass properties, finite element analysis, dimensioning, tolerance, assembly modeling, generating shaded images, and documentation and drafting.

The CAD process and its tools utilize three disciplines: Geometric Modeling, Computer Graphics, and Design

CAD system architecture

In CAD, Computer architecture is a set of disciplines that explains the functionality, the organization and the introduction of computer systems; that is, it describes the capabilities of a computer and its programming method in a summary way, and how the internal organization of the system is designed and executed to meet the specified facilities.

Prerequisite knowledge for Complete understanding and learning of Topic:

Geometric Modeling,
Engineering analysis
Design review and evaluation
Automated drafting.

Detailed content of the Lecture:

The conventional design process has been accomplished on drawing boards with design being documented in the form of a detailed engineering drawing. This process is iterative in nature and is time consuming.

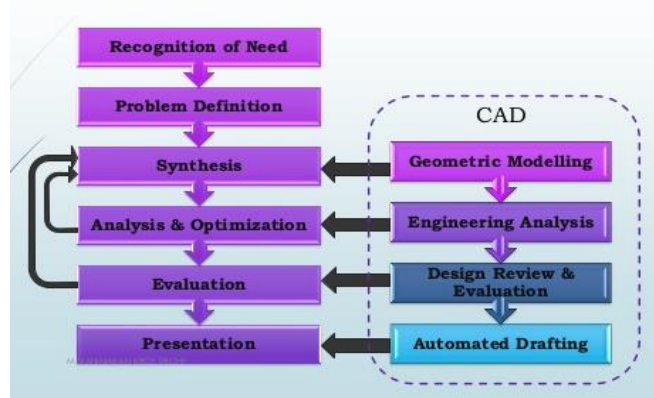
The computer can be beneficially be used in the design process.

Geometric Modeling

The geometric modeling is concerned with computer compatible mathematical description of geometry of an object.

Engineering analysis

The computer can be used to aid the analysis work such as stress-strain analysis, heat transfer analysis, etc. the analysis can be done by using specific program generated for it or by using general purpose software commercially available in the market.



Design review and evaluation

The accuracy of the design can be checked and rectified if required in the screen itself. Layering feature available in software are very useful for design review purpose. Similarly, using the layer procedure, every stage of production can be checked. Suppose a new mechanism is to be designed, the same mechanism can be simulated in the computer.

Another advantage of animating the complete assembly of product is that whether any component fouls the other components in its working.

Automated drafting

Automated drafting is the process of creating hard copies of design drawing.

The important features of drafting software's are automated dimensioning, scaling of the drawing and capable of generating sectional views.

CAD systems can increase productivity on drafting.

Benefits of CAD

Efficiency, effectiveness and creativity of the designer are drastically improved.

Faster, Consistent and more accurate.

Easy modification (copy) and improvement (Edit).

Repeating the design drawing is not needed when modifying.

Manipulation of various dimensions, attributes is easy.

Parametric and posses parent-child relationship.

Engineering applications of CAD

This list includes following applications of CAD but not limited to:

- Structural design of Aircraft

- Aircraft simulation

- Real time simulation

- Automobile industries

- Architectural design

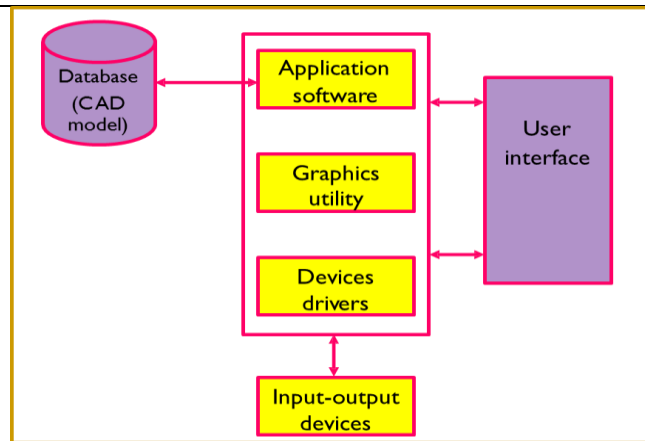
- Pipe routing and plan layout design

- Electronic industries

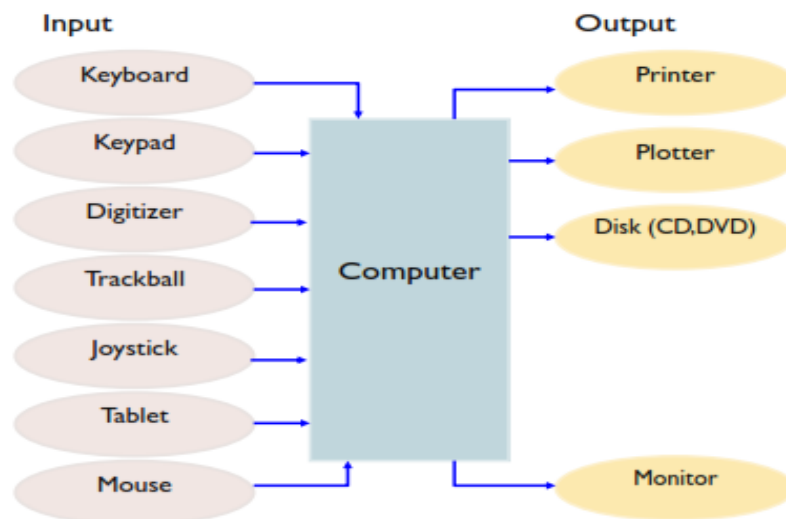
- Dynamic analysis of mechanical systems

- Kinematic analysis

Basic Structure of a CAD system



I/O devices of CAD system



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=ZDeLwFwnFKg>

<https://www.youtube.com/watch?v=xQpSyRgy4cA>

<https://www.youtube.com/watch?v=4TzMyXmzL8M>

<https://www.youtube.com/playlist?list=PL13FD5F00C21BBC0B>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989
- Tarbiat Modares University, Mechanical Engineering Department, Tehran, P.O.Box: 14115-116, Iran



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LECTURE HANDOUTS

L-04

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: Computer graphics

Introduction :

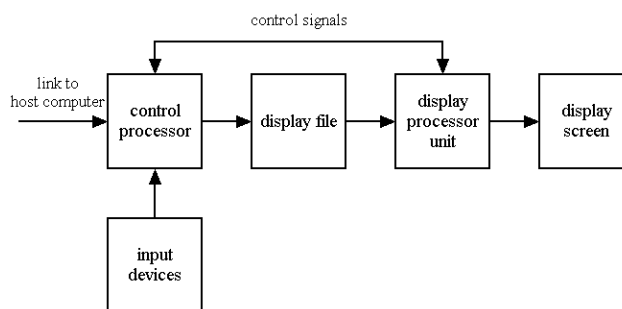
Computer Graphics involves creation, display, manipulation and storage of pictures and experimental data for proper visualization using a computer.

Color monitors are one example of such display device. There are other examples of output devices like LCD Panels, laser printers, color printers, plotters etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Control Process,
- Display File,
- Processor unit,
- Display screen

Detailed content of the Lecture:



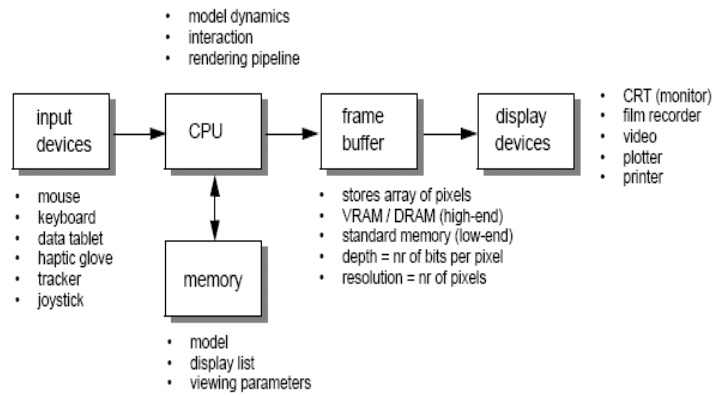
Graphics system comprises of a host computer which must have a support of a fast processor, a large memory and frame buffer along with a few other crucial components. Through these input devices it is possible to provide input to the computer and display device is an output device which shows the image.

Few examples of application areas of Computer Graphics:

The first and most important of them is the GUI as it is called. It has various components. A graphical interface is basically a piece of interface or a program which sits between the user and the graphics application program.

It helps the graphics system to interact with the user both in terms of input and output. Let us see few examples.

Typical components which are used in a Graphical User Interface are menus, icons, cursors, dialog boxes and scrollbars.



Grids are used in two dimensional graphics packages to align the objects along a set of specific coordinates or positions. It can be switched on and off and displayed on the screen. Sketching is an example which is used to draw lines, arcs, poly lines and various other objects.

It is easy to interact and handle with two dimensional objects but for interacting with the three dimensional objects three dimensional interface is needed to pick up one of the 3D objects from a two dimensional screen.

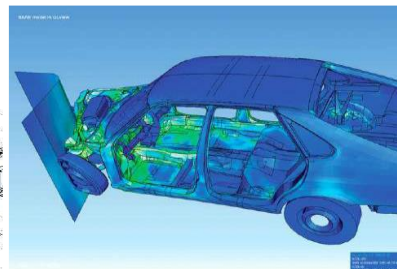
Other typical application areas of Computer Graphics

A typical example of CAD/CAM is a vast scope in many fields of engineering and technology.

VLSI: Very Large Scale Integration constructions in the area of architecture and civil engineering and circuits.



3D graphics of camshaft with piston



3D structure of car when crash testing

Characteristics of computer graphics:

Based on the control the user has over the image

Passive computer graphics - the user has no control

Interactive graphics - the user may interact with the graphics

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=NmMky9Pg8Yc>

<https://www.youtube.com/watch?v=m5YbqpL7BIY>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
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LECTURE HANDOUTS

L-05

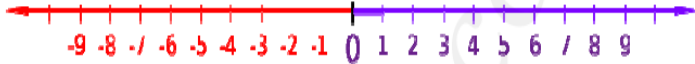
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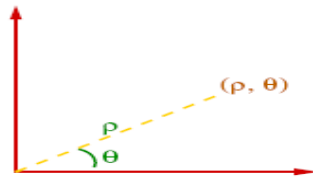
II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: Co-ordinate systems
Introduction : A coordinate system is one which uses one or more numbers, or coordinates, to uniquely determine the position of a point or other geometric element on a manifold such as Euclidean space.
Prerequisite knowledge for Complete understanding and learning of Topic: Number line Polar coordinate system Cylindrical Coordinate systems Spherical Coordinate systems Homogeneous Coordinate systems
Detailed content of the Lecture: Number line: The simplest example of a coordinate system is the identification of points on a line with real numbers using the number line. In this system, an arbitrary point O (the origin) is chosen on a given line. The coordinate of a point P is defined as the signed distance from O to P, where the signed distance is the distance taken as positive or negative depending on which side of the line P lies.  + Cartesian coordinate system [(x,y) and (x,y,z)]
Each point is given a unique coordinate and each real number is the coordinate of a unique point
Polar coordinate system (ρ,θ):

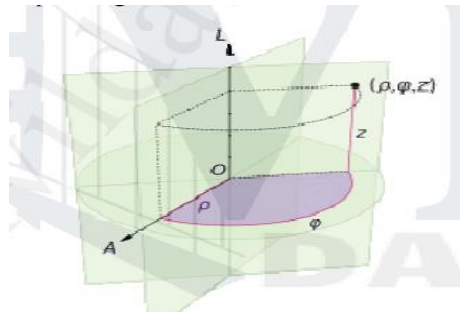


Polar Coordinates

For a given angle θ , there is a single line through the pole whose angle with the polar axis is θ (measured counter clockwise from the axis to the line).

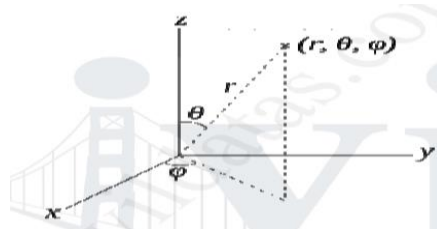
Then there is a unique point on this line whose signed distance from the origin is r for given number r .

Cylindrical Coordinate systems



A cylindrical coordinate system is a three-dimensional coordinate system that specifies point positions by the distance from a chosen reference axis, the direction from the axis relative to a chosen reference direction, and the distance from a chosen reference plane perpendicular to the axis.

Spherical Coordinate systems



A spherical coordinate system is a coordinate system for three-dimensional space where the position of a point is specified by three numbers.

The radial distance of that point from a fixed origin, its polar angle measured from a fixed zenith direction and the azimuth angle of its orthogonal projection on a reference through the origin and is orthogonal to the zenith, measured from direction on that plane.

Homogeneous coordinate system

Three dimensional representation of a two dimensional plane is called Homogeneous Co-ordinates. The respective system is called Homogeneous coordinate system.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=4yT6A0HCdwo>

https://www.youtube.com/watch?v=ilJRA8m_yNo

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
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LECTURE HANDOUTS

L-06

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: 2D and 3D transformations

Introduction :

2D transformations

Transformation means changing some graphics into something else by applying rules. We can have various types of transformations such as translation, scaling up or down, rotation, shearing, etc. When a transformation takes place on a 2D plane, it is called 2D transformation.

3D transformations

In Computer graphics, 3D Translation is a process of moving an object from one position to another in a three dimensional plane. Consider a point object O has to be moved from one position to another in a 3D plane. Tx defines the distance the Xold coordinate has to be moved.

Prerequisite knowledge for Complete understanding and learning of Topic:

2D transformations

- i. Translation
- ii. Scaling
- iii. Reflection with mirror
- iv. Rotation

3D transformations

- i. Translation
- ii. Scaling
- iii. Reflection with mirror
- iv. Rotation

Detailed content of the Lecture:

2D transformations- Translation

It is the movement of an object from one position to another position. Translation is done using translation vectors. There are three vectors in 3D instead of two.

These vectors are in x, y, and z directions. Translation in the x-direction is represented using Tx. The translation in y-direction is represented using Ty.

The translation in the z- direction is represented using Tz.

If P is a point having co-ordinates in three directions (x, y, z) is translated, then after translation its coordinates will be (x1 y1 z1) after translation. Tx Ty Tz are translation vectors in x, y, and z directions respectively.

$$x1=x+ Tx, \quad y1=y+Ty, \quad z1=z+ Tz$$

$$\left\{ \begin{array}{cccc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{array} \right\} \text{ or } \left\{ \begin{array}{cccc} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{array} \right\}$$

Scaling

Scaling is used to change the size of an object. The size can be increased or decreased. The scaling three factors are required S_x , S_y and S_z .

S_x =Scaling factor in x- direction

S_y =Scaling factor in y-direction

S_z =Scaling factor in z-direction

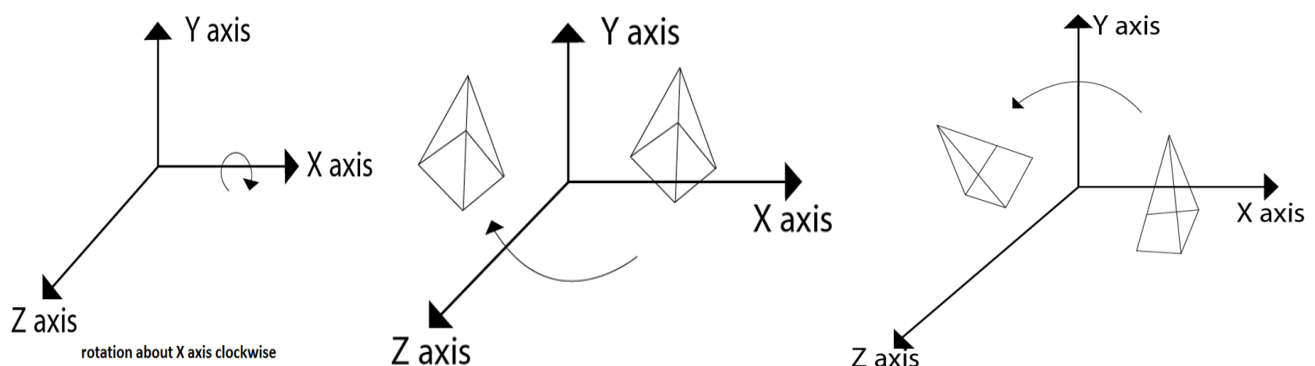
To change the size of an object, scaling transformation is used. In the scaling process, the dimensions of the object can be enlarged or reduced.

Matrix for Scaling

$$\left\{ \begin{array}{cccc} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{array} \right\}$$

Rotation

It is moving of an object about an angle. Movement can be anticlockwise or clockwise. 3D rotation is complex as compared to the 2D rotation. For 2D we describe the angle of rotation, but for a 3D angle of rotation and axis of rotation are required. The axis can be either x or y or z.



- i. Following figure show rotation of the object about the X axis
- ii. Following figure show rotation of the object about the Y axis
- iii. Following figure show rotation of the object about the Z axis

Mirroring/ Reflection

In modeling operations, one frequently used operation is mirroring an object. Mirroring is a convenient method used for copying an object while preserving its features.

Reflection is the mirror image of original object.

In reflection transformation, the size of the object does not change.

3D transformations

It is often necessary to display objects in 3-D on the graphics screen.

The Transformation Matrices developed for 2-dimensions can be extended to 3-D.

Translation

It is the movement of an object from one position to another position. Translation is done using translation vectors. There are three vectors in 3D instead of two.

These vectors are in x, y, and z directions. Translation in the x-direction is represented using T_x . The translation in the y-direction is represented using T_y .

The translation in the z-direction is represented using T_z .

If P is a point having co-ordinates in three directions (x, y, z) is translated, then after translation its coordinates will be (x1 y1 z1) after translation.

Matrix for translation

$$\left\{ \begin{array}{cccc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{array} \right\} \text{ or } \left\{ \begin{array}{cccc} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{array} \right\}$$

Scaling

Scaling is used to change the size of an object. The size can be increased or decreased. The scaling three factors are required S_x S_y and S_z .

Concatenation or Combined Transformation

The combined transformation matrix can be obtained by multiplying the respective transformation matrices.

The sequence of transformations can be combined into a single transformation using the concatenation process

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=iWxS2zpaRjk>

<https://www.youtube.com/watch?v=I8o4kK9QRL4>

<https://www.youtube.com/watch?v=DD70ZIDjL7g>

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- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
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LECTURE HANDOUTS

L-07

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED

Course Teacher DESIGN &

Unit MANUFACTURING :Mr.M.Sound

Topic of Lecture: ~~Homogeneous coordinates~~ ^{array} ~~coordinates~~

Introduction : I

Homogeneous coordinates are ubiquitous in computer graphics because they allow common vector operations such as translation, rotation, scaling and perspective projection to be represented as a matrix by which the vector is multiplied.

Prerequisite knowledge for Complete understanding and learning of Topic:

Homogeneous Coordinates used in Computer Graphics

Problem if Homogeneous Coordinates were not used in matrix transformations

Three basic functions (translate, scale and rotate)

Detailed content of the Lecture:

Homogeneous Coordinates

The rotation of a point, straight line or an entire image on the screen, about a point other than origin, is achieved by first moving the image until the point of rotation occupies the origin, then performing rotation, then finally moving the image to its original position.

The moving of an image from one place to another in a straight line is called a translation. A translation may be done by adding or subtracting to each point, the amount, by which picture is required to be shifted.

Translation of point by the change of coordinate cannot be combined with other transformation by using simple matrix application. Such a combination is essential if we wish to rotate an image about a point other than origin by translation, rotation again translation.

To combine these three transformations into a single transformation, homogeneous coordinates are used. In homogeneous coordinate system, two-dimensional coordinate positions (x, y) are represented by triple-coordinates.

Homogeneous coordinates are generally used in design and construction applications. Here we perform translations, rotations, scaling to fit the picture into proper position.

Following are matrix for two-dimensional transformation in homogeneous coordinate:

1. Translation $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ t_x & t_y & 1 \end{bmatrix}$ or $\begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$

2. Scaling $\begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$

3. Rotation (clockwise) $\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Advantages of using homogeneous coordinates:

- Simpler formulas. With homogeneous coordinates, all the transforms discussed become linear maps, and can be represented by a single matrix. ...
- Fewer special cases. ...
- Unification & extension of concepts

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=4CpKWoiYhvg>

https://www.youtube.com/watch?v=4e1rmDf_7bU

<https://www.youtube.com/watch?v=mq2S1SzAD1s>

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LECTURE HANDOUTS

L-08

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: Line drawing -Clipping

Introduction :

A drawing is created by an assembly of points, lines, arcs, circles. In computer graphics drawings are created in a similar manner.

A line in Computer graphics is a portion of straight line that extends indefinitely in opposite direction. It is defined by its two end points.

If any part of the geometry is not inside the window, it is made invisible by the CAD software through a process known as clipping.

Prerequisite knowledge for Complete understanding and learning of Topic:

Basics for the display of all types of Shapes

Visible portion of drawing lying within a window

Detailed content of the Lecture:

Line drawing

Each of these is called an entity. The drawing entities that a user may find in a typical CAD package include

Point, line, construction line, multi-line, polyline

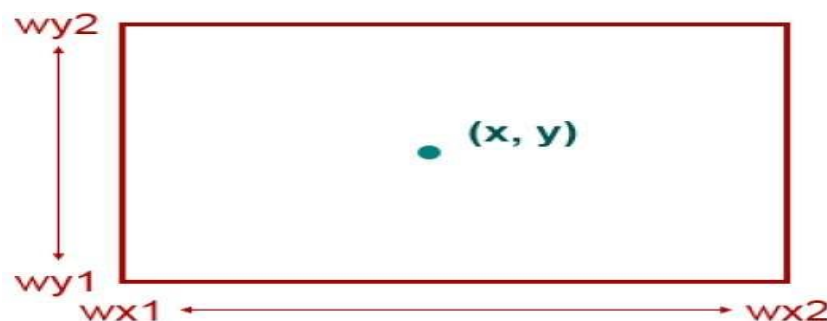
Circle, spline, arc, ellipse, polygon, rectangle

Point Plotting

The frame buffer display is an example of a point plotting device.

The smallest unit accepted by such displays is a single pixel.

To construct a useful picture on a point plotting device, a picture must be Built out of several hundreds of pixels.



Drawing Of Lines

Straight line segments are used a great deal in computer generated pictures.

The following criteria have been stipulated for line drawing displays :

Lines should appear straight

Lines should terminate accurately

Lines should have constant density

Line density should be independent of length and angle

Line should be drawn rapidly

DDA Algorithm

The digital differential analyzer generates lines from the differential equations.

DDA is scan conversion line-generating algorithm, based on the calculation of either Δy or Δx differences along the line path.

A line can be generated by increasing unit interval in one coordinate and determining the corresponding integer values of interval in other coordinate nearest to the line path.

The digital differential analyzer generates lines from the differential equations.

DDA is scan conversion line-generating algorithm, based on the calculation of either Δy or Δx differences along the line path.

Advantages

It is the simplest algorithm.

It is a faster method.

It eliminates the multiplication of necessary increments.

Disadvantages

Floating point arithmetic in DDA algorithm is time-consuming.

The algorithm is orientation dependent. Therefore, accuracy is poor.

Clipping

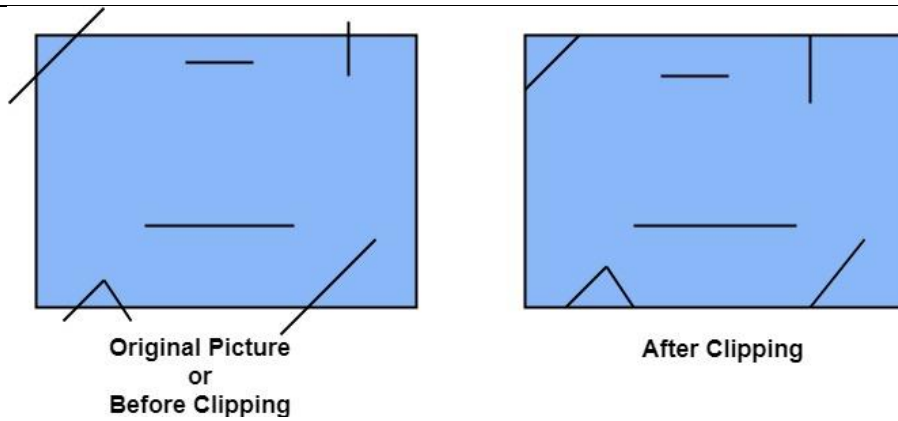
Clipping is the process of determining the visible portions of a drawing lying within a window.

Clipping, in the context of computer graphics, is a method to selectively enable or disable rendering operations within a defined region of interest.

In clipping each graphic element of the display is examined to determine whether or not it is completely inside the window, completely outside the window or crosses a window boundary.

Typical clipping algorithm: Cohen-Sutherland clipping algorithm.

If clipping is not done properly a CAD system will produce incorrect pictures due to an overflow of internal coordinate registers. This effect is known as wrap round.



Applications of Clipping:

- Extracting part of defined scene for viewing
- Identifying visible surfaces in 3D Views
- Anti-aliasing line segments or object boundaries
- Creating objects using solid modelling procedures
- Drawing and painting operations

Video Content / Details of website for further learning (if any):

- <https://www.youtube.com/watch?v=W5P8GlaEOSI>
- <https://www.youtube.com/watch?v=RGB-wlatStc>
- <https://www.youtube.com/watch?v=2RNU9E1BVT0>
- <https://www.youtube.com/watch?v=pGbEtoyb94I>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989



Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I

Topic of Lecture: Viewing Transformation

Introduction :

Viewing Transformations the process of mapping part of a world coordinate scene to device coordinates system is known as Viewing Transformations.

Prerequisite knowledge for Complete understanding and learning of Topic:

Part of world coordinate scene to device coordinates system

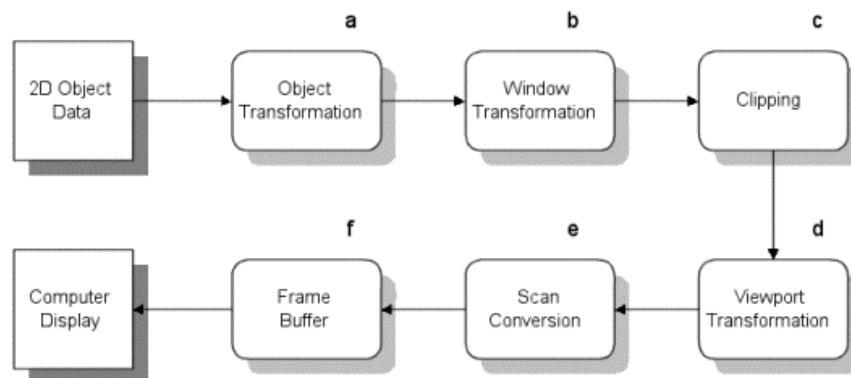
No rotation of the model

The user looks onto the model

The area on the screen window are to be displayed

Detailed content of the Lecture:

For the complex drawings of an object/element, World Coordinate system becomes very difficult to visualize. In such cases a window is required to visualize portions of the drawing on the display device.



Window

world coordinate area for display (what is viewed)

A window defines a rectangular area in world coordinates.

Normally an image is modelled in World Device Coordinates (WDC).

When the interest is a portion of it then the portion of interest which is a polygonal area can be specified in world coordinates, called the "window".

Viewport

Area on display device to which window is mapped (where it is displayed)

A viewport is defined in normalized coordinates, a rectangular area on the display device where the image of the data appears.

Viewing Transformations - mapping part of a world coordinate scene to device coordinates - i.e., Window to Viewport Mapping

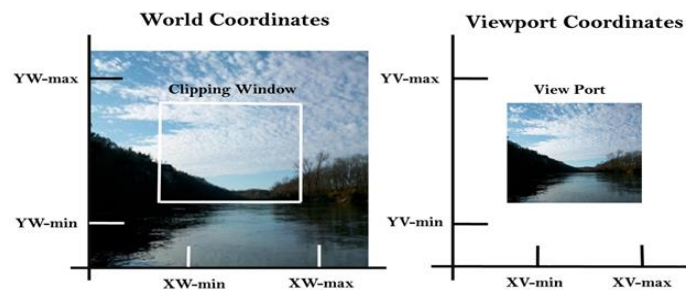


Fig: Window to viewport mapping

They can be used to translate, rotate, mirror, and scale entities.

These operations and their related input are based on the mathematical relations.

The angle of rotation could be positive or negative. A positive angle is an angle represented by a vector whose direction is in positive direction of the axis of rotation.

The mirror operation requires a mirroring axis. The existing entity is always mirrored onto the other side of the mirroring axis in reverse, that is, as if it were being viewed in a mirror.

The operation is usually used to adjust the size of displayed geometry within a view window.

If the geometry is too small, the operation can enlarge it to fill the view window.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=mafHOa7hWRU>

<https://www.youtube.com/watch?v=mi9Ino6PI-s>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
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LECTURE HANDOUTS

L-10

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : I I

Topic of Lecture: Representation of curves

Introduction : (Maximum 5 sentences)

In order to understand the significance of curves, we should look into the Types of model representations that are used in geometric modeling.

Curves play a very significant role in CAD modeling, especially, for generating a wireframe model, which is the simplest form for representing a Model.

Prerequisite knowledge for Complete understanding and learning of Topic:

Wireframe model

Surface Model

Solid model

Detailed content of the Lecture:

Explicit (non-parametric)

$$Y = f(X), Z = g(X)$$

Implicit (non-parametric)

$$f(X,Y,Z) = 0$$

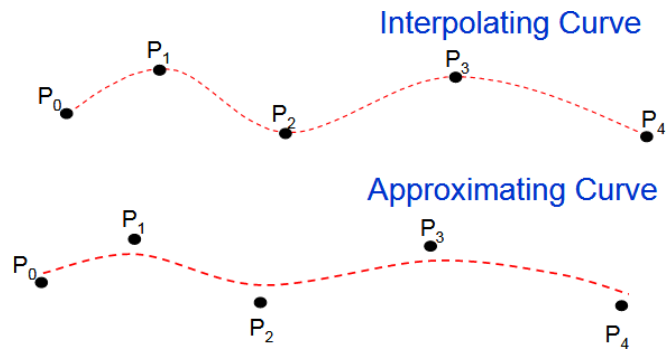
Parametric

$$X = X(t), Y = Y(t), Z = Z(t)$$

C 0 - Zero-order parametric continuity - the two curves sections must have the same coordinate position at the boundary point.

C 1 - First-order parametric continuity - tangent lines of the coordinate functions for two successive curve sections are equal at their joining point.

C 2 - second-order parametric continuity - both the first and second parametric derivatives of the two curve sections are the same at the intersection.



Example: A Circle of radius R

Implicit:

$$x^2 + y^2 + z^2 - R^2 = 0 \text{ \& } z=0$$

Parametric:

$$x(t) = R \cos(t)$$

$$y(t) = R \sin(t)$$

$$z(t) = 0$$

Using parametric equations allows curves that can double back and cross themselves, which are impossible to specify in a single equation in the $y = f(x)$ case.

Parametric equations are also easier to evaluate: changing u results in moving a fixed distance along the curve, while in the traditional equation form much work is needed to determine whether to step through x or y , and determining how large a step to take based on the slope.

Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=_26E6QR_hmU

<https://www.youtube.com/watch?v=n8w1xOutFW4>

<https://www.youtube.com/watch?v=brRkLazDbmA>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
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LECTURE HANDOUTS

L-11

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Hermite curve

Introduction :

Hermite curve is geometrically determined by defining positions and tangents of end points. Hermite curve is also known as cubic curve.

Hermite curve passes (interpolate) through the end points of the curve segment and possesses first order (slope) continuity

Prerequisite knowledge for Complete understanding and learning of Topic:

Hermite cubic, curve is an interpolating piecewise cubic polynomials.

Unlike the natural cubic splines, Hermite curve segments are adjusted locally because shape of each curve segment is dependent only upon its end point constraints.

Detailed content of the Lecture:

Hermite curve is geometrically determined by defining positions and tangents of end points.

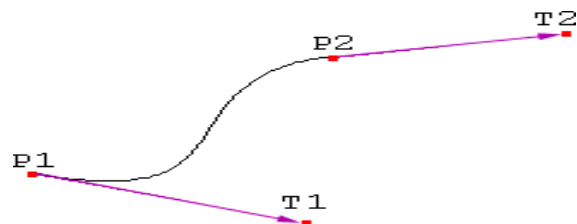
Hermite curve is also known as cubic curve.

Hermite curve passes (interpolate) through the end points of the curve segment and possesses first order (slope) continuity.

Hermite cubic, curve is an interpolating piecewise cubic polynomials.

Unlike the natural cubic splines, Hermite curve segments are adjusted locally because

$$P(S) = \sum_{i=0}^3 C_i S^i, \quad 0 \leq S \leq 1$$



shape of each



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LECTURE HANDOUTS

L-12

RA

II/IV

Course Name with Code 19RAC11 COMPUTER AIDED DESIGN & MANUFACTURING

Course Teacher :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Bezier curve- B-spline curves

Introduction :

A Bezier curve is defined by a set of data points. The curve may interpolate or extrapolate the data points.

Some CAD systems offer both options; others offer the interpolation version only. In both cases, the data points are used to control the shape of the resulting curves.

Bezier curves are another very popular curve type developed by P. Bezier of the French car firm Regie Renault.

Prerequisite knowledge for Complete understanding and learning of Topic:

A Bezier Curve is obtained by a defining polygon.

First and last points on the curve are coincident with the first and last points of the polygon.

Degree of polynomial is one less than the number of points

Tangent vectors at the ends of the curve have the same directions as the respective spans

Detailed content of the Lecture:

The shape of the Bezier curve is obtained or determined by the number of control points. Generally the Bezier curve approximates the data points and interpolates the end points. The position of the control points and vertices of Bezier characteristics polygon is used to define the Bezier curve.

4 · The Bezier curve follows the shape of characteristics polygon.

The Bezier curve is tangent to the first and last polygon segment of the characteristic polygon.

The shape of the Bezier curve is defined uniquely by the characteristic polygon

Bezier curves, unlike B-splines, must have precisely n control points, where n + 1 is the degree of the Bezier polynomial.

To create a longer curve, it is necessary to connect multiple Bezier curves

B - Spline curves give another effective method, besides that of Bezier curves.

It has the ability to interpolate or approximate a set of given data points. Moreover B - spline curves are the proper and powerful generalization of Bezier curves.

In addition to Bezier curves, the B -spline curve separates the degree of the resulting curve from the number of the given control points.

The flexibility in the degree of the resulting curve is achieved by choosing the blending function of B - spline curves with an additional degree of freedom that does not exist in Bernstein polynomials.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=ZDeLwFwnFKg>

<https://www.youtube.com/watch?v=xQpSyRgy4cA>

<https://www.youtube.com/watch?v=4TzMyXmzL8M>

<https://www.youtube.com/playlist?list=PL13FD5F00C21BBC0B>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989
- Tarbiat Modares University, Mechanical Engineering Department, Tehran, P.O.Box: 14115-116, Iran



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L-13

LECTURE HANDOUTS

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Rational curves-Techniques for surface modeling

Introduction : (Maximum 5 sentences)

Rational curve is defined by the algebraic ratio of two polynomials while a nomenclature curve is defined by one polynomial.

A parametric curve in homogeneous form is referred to as a rational curve.

The technique of representation of objects (or) components by surfaces is called surface modelling.

In this surface modelling, objects (solid objects) can be clearly interpreted by the user (viewer).

Prerequisite knowledge for Complete understanding and learning of Topic:

NURBS (non uniform rational B-splines)

Internal representation of all geometric entities

Representation of objects (or) components by surfaces B-splines and NURBS (Non-Uniform Rational B-Splines) are used for creating surfaces.

Detailed content of the Lecture:

Rational curves:

Rational Bezier curves, rational B-spline and -spline curves, rational ionic sections, rational cubics and rational surfaces have been formulated.

The most widely used rational curves are non uniform rational B-splines (NURBS).

The formulation of rational curves requires the introduction of homogeneous space and the homogeneous coordinates.

The homogeneous space is A - D space.

A rational B-spline curve defined by n + 1 control points P_i is given by,

$$P(S) = \sum_{i=0}^n P_i R_i k(S), \quad 0 \leq S \leq S_{\max}$$

$R_i, k(S)$ are the rational B - spline basis function are given by

$$R_i, k(S) = \frac{h_i N_i, k(u)}{\sum_{i=0}^n h_i N_i, k(S)}$$

The rational basis function $R_i, k(s)$ have nearly all the analysis and geometric characteristics of their non rational B - spline counter parts.

A rational B - spline is considered as unified representation that can define a variety of curves and surfaces.

Consider a circular cylinder (hole) represented by a B - spline, some data on the specific curve type may be lost unless it is carried along.

Non-uniform rational B-spline

NURBS (non uniform rational B-splines) are almost exclusively used by CAD/CAM systems as the internal representation of all geometric entities that these systems provide. NURBS provide a convenient design tool to create smooth curves and surfaces interactively.

These splines were developed by integrating the representations of B-splines with rational Bezier curves.

Advantages

Any curve or surface can be formulated using NURBS.

NURBS are considered a unified canonical representation that can define both synthetic (Bezier, B-splines) and analytic (circles and conics) curves and surfaces.

Their related algorithms are stable and accurate.

They reduce the memory consumption when storing shapes (compared to simpler methods).

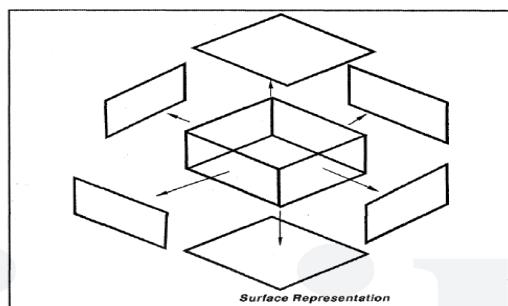
Techniques for surface modeling

The technique of representation of objects (or) components by surfaces is called surface modelling.

In this surface modelling, objects (solid objects) can be clearly interpreted by the user (viewer).

Moreover, mass property and inertia property calculation would be difficult.

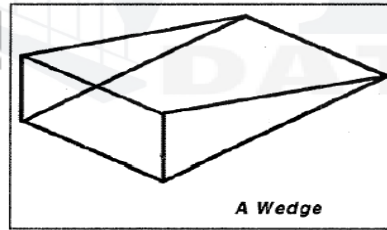
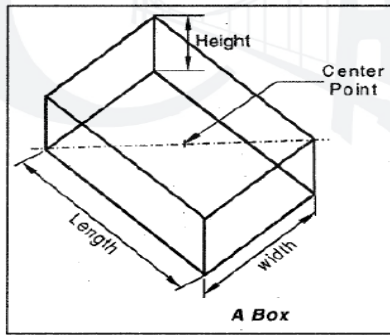
This surface modelling application is for modelling car-bodies, ships, aerospace structure, dies, etc.



- (a) Box (b) Pyramid wedge (c) Sphere (d) Dome
(e) Torus (D Mesh) (e) Cones

Box is a three-dimensional solid specified by length, center and corner.

Wedge: A 3D solid with a sloped face tapering along the x-Axis.



Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=CeOV_tVo970

<https://www.youtube.com/watch?v=az2s2WELn7o>

<https://www.youtube.com/watch?v=TN9waino0f8>

<https://www.youtube.com/watch?v=ONj8HDP4PYw>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
5. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.



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LECTURE HANDOUTS

L-14

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Surface patch

Introduction : (Maximum 5 sentences)

Patch Surfaces are defined as surfaces generated using 1 or more curves that make a closed connection.
3D Curves or existing edges of parts and surfaces can be used to create the Patch Surface.
The building blocks of the surfaces are known as patch.

Prerequisite knowledge for Complete understanding and learning of Topic:

Curves
Control Points
Parametric variables

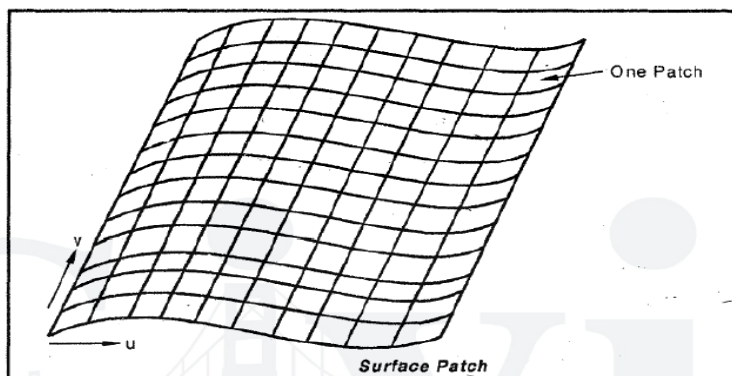
Detailed content of the Lecture:

The techniques available for surface modelling are:

- Surface patch
- Coons Patch
- Bicubic Patch
- Bezier surfaces
- B-spline surfaces.

Surface Patch

The building blocks of the surfaces are known as patch.
Generally u and v are the two variables used for representing a patch.
A patch is bi-parametric, values ranging between 0 and 1.
For creating Curved patches, one of the parametric variables is fixed.



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=H6QBcrM4uso>

<https://www.youtube.com/watch?v=HyyWv9PuP5E>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
5. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.



LECTURE HANDOUTS

L-15

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Coons and bicubic patches

Introduction : (Maximum 5 sentences)

A Coons patch, is a type of manifold parameterization used in computer graphics to smoothly join other surfaces together, and in computational mechanics applications, particularly in finite element method and boundary element method, to mesh problem domains into elements.

A set of four cubic curves with parameter s , and using these four curves to generate a set of four control points for any given value of s , and then using these control points to define a parametric curve with parameter t , we can generate a surface called a bicubic patch.

Prerequisite knowledge for Complete understanding and learning of Topic:

Interpolation of sets of points on a surface.

Referred to point and tangent

Detailed content of the Lecture:

Coons patch:

A coons patch is a result of interpolation done on intersecting mesh of curves, resulting in rectangular grid of patches.

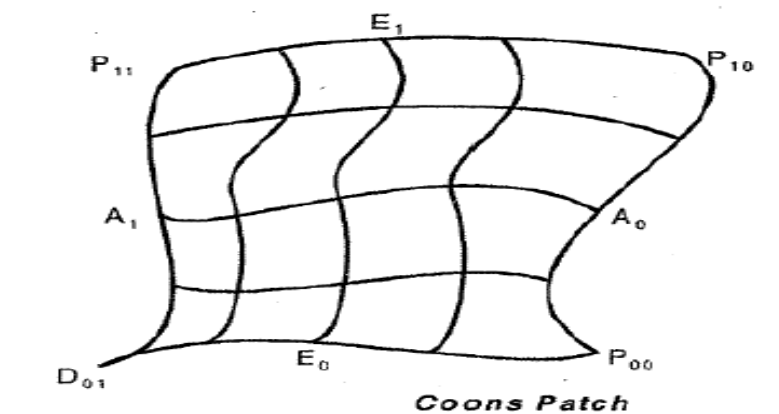
Coons patch is used to create a surface using Curves that form Closed boundaries.

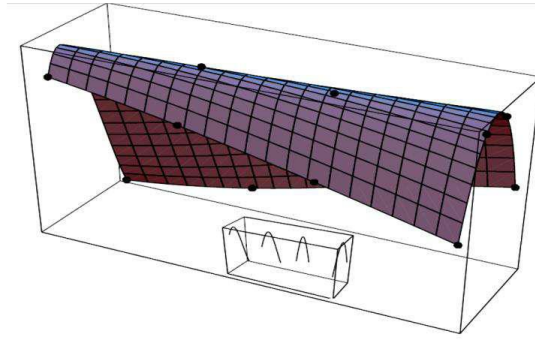
The Patches May be Triangular or Rectangular type.

The simplest of coons patch is the linearly lended coons patch.

Linear Coons surface is a generalization of lofted surfaces.

This patch is defined by 4 boundary curves and corner points of patch.





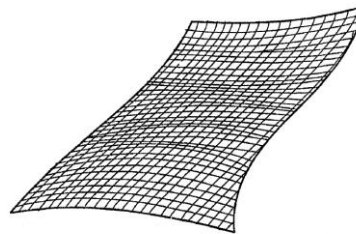
All four boundary curves are given, and none has to be a straight line.

Naturally, the boundary curves have to meet at the corner points, so these points are implicitly known.

BICUBIC SURFACE PATCH:

In order to define the surfaces using point and tangent, bicubic patch is referred. The General form of bicubic Patch is,

$$\vec{P}(ab) = \sum_{i=0}^3 \sum_{j=0}^3 \vec{K}_{ij} a^i b^j$$



Bi - Cubic Surface Patch.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=qziWoZIK8tI>

https://www.youtube.com/watch?v=poY_nGzEEWM

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1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
5. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.



LECTURE HANDOUTS

L-16

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Bezier and B-spline surfaces

Introduction : (Maximum 5 sentences)

Bézier surface is defined by a set of control points. Similar to interpolation in many respects, a key difference is that the surface does not, in general, pass through the central control points; rather, it is "stretched" toward them as though each were an attractive force. They are visually intuitive, and for many applications, mathematically convenient.

Extending the Idea of B-Spline curve, we obtain a Cartesian product B-splie surface.

Bezier Surface is generated from the basics of Bezier Curve.

Prerequisite knowledge for Complete understanding and learning of Topic:

Set of control points.

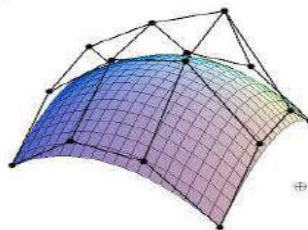
Basics of Bezier Curve.

Detailed content of the Lecture:

This is a synthetic Surface that approximates data points.

Bezier Surface is generated from the basics of Bezier Curve. It can permit twist in the Surface.

The Surface Does not Pass Through all the Control points.



A bezier surface is given by,

$$\vec{P}(a,b) = \sum_{i=0}^m \sum_{j=0}^n \vec{B}_{i,m}(a) \vec{B}_{j,n}(b) \vec{P}_{i,j}$$

$\vec{P}_{i,j} \rightarrow$ Vertices of Polygon

$\vec{B}_{i,m}$ and $\vec{B}_{j,n} \rightarrow$ Blending Functions.

In Bezier curves, it is possible to convert the straight surface to smooth surface between Patches.

The parametric cubic (PC) curve, Equation is useful, since it can be used when either four points, or two points and two tangent vectors, are known.

The PC curve can easily be extended to a bicubic surface patch by means of the Cartesian product.

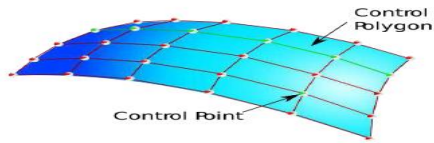
The conclusion is that curves that lie on this surface in the u or in the w directions are parametric cubics.

B-SPLINE SURFACE

It is a surface that can approximate or interpolate given input data.

It is another synthetic Surface which can be generated through interpolation or approximation type.

It is a general surface like a Bezier surface but with the advantage of permitting local control of the surface.



B-Spline surface

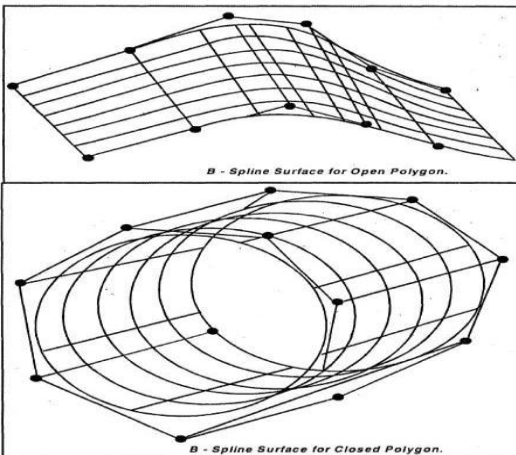
There is another case, where the control polygon is closed feature.

The general form for B-spline surface is:

$$\vec{P}(a, b) = \sum_{i=0}^m \sum_{j=0}^n N_{i,k}(a) N_{j,l}(b) \vec{P}_{i,j} \quad \text{where,}$$

$\vec{P}_{i,j} \rightarrow$ Vertices of Polygon

$N_{i,k}$ and $N_{j,l} \rightarrow$ Blending Functions



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=83Nsel2uv6k>

<https://www.youtube.com/watch?v=E5SngbIJ4fk>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
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LECTURE HANDOUTS

L-17

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Solid modeling Techniques

Introduction : (Maximum 5 sentences)

Solid models are the most preferred form of CAD models and represent unambiguous image of a component.

A solid model can be shaded and rendered in desired colors to give it a more realist appearance.

Representation of an object by a solid model is relatively a new concept.

Prerequisite knowledge for Complete understanding and learning of Topic:

basic elements or shapes

Set of rules (Boolean operations) to create the object.

importance for manufacturing

Detailed content of the Lecture:

Solid Model:

Solid models are the most preferred form of CAD models and represent unambiguous image of a component.

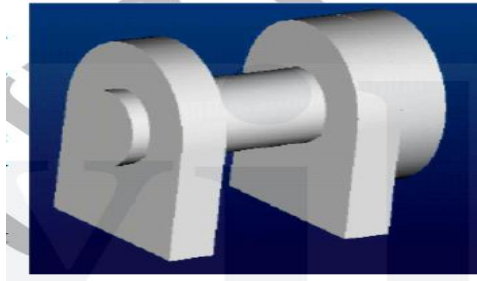
Solid models represent objects in a very realistic and unambiguous form; however, they require a large amount of storage memory and high-end computer hardware.

A solid model can be shaded and rendered in desired colors to give it a more realist appearance.

Representation of an object by a solid model is relatively a new concept.

There were only a couple of solids modeling CAD programs available in late 1980s, and they required mainframe computers to run on.

However, in 1990s, due to the low cost and high speed, PCs have become the most popular solid modeling software platform, prompting almost all the CAD vendors to introduce their 3-D solid modeling software that will run on a PC.



Solid models are mathematical models of objects in the real world that satisfy specific properties, listed below.

1. Bounded: The boundary must limit and contain the interior of the solid.
2. Homogeneously Three-Dimensional: No dangling edges or faces be Present so that the boundary is always in contact with the interior of the solid.

Solid Model Creation Scheme

There are six common representations in solid modeling.

i. Spatial Enumeration: In this simplest form of 3D volumetric raster model, a section of 3D space is described by a matrix of evenly spaced cubic volume elements called voxels.

ii. Cell Decomposition: This is a hierarchical adaptation of spatial enumeration. 3D space is sub-divided into cells. Cells could be of different sizes. These simple cells are glued together to describe a solid object.

iii. Boundary Representation: The solid is represented by its boundary which consists of a set of faces, a set of edges and a set of vertices as well as their topological relations.

iv. Sweep Methods: In this technique a planar shape is moved along a curve. Translational sweep can be used to create prismatic objects and rotational sweep could be used for axisymmetric components.

v. Primitive Instancing: This modeling scheme provides a set of possible object shapes which are described by a set of parameters. Instances of object shape can be created by varying these parameters.

vi. Constructive Solid Geometry (CSG): Primitive instances are combined using Boolean set operations to create complex objects.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=aYRIRPdRO0c>

<https://www.youtube.com/watch?v=kECACbOriIg>

<https://www.youtube.com/watch?v=N1Vzv6AZYB0>

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LECTURE HANDOUTS

L-18

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: CSG and B-rep

Introduction : (Maximum 5 sentences)

CSG:

This scheme is based on the principle that two primitives can be combined to produce a new solid model.

This method is also known as 'Building Block' method.

B-Rep:

In this method, front view, top view, bottom view, side view of an object is sketched and connected by means of lines to create a relationship.

Prerequisite knowledge for Complete understanding and learning of Topic:

basic elements or shapes

Set of rules (Boolean operations) to create the object.

importance for manufacturing

B-rep scheme is closely related to the traditional drafting method.

Detailed content of the Lecture:

CONSTRUCTIVE SOLID GEOMETRY (CSG)

This scheme is based on the principle that two primitives can be combined to produce a new solid model.

Introduced: Ian Braid (Cambridge University, ~74). This method is also known as 'Building Block' method.

The scheme uses the Union, Intersection, and Subtraction techniques to create three-dimensional models, which are based on the Boolean operation.

In a CSG model, physical objects are created by combining basic elementary shapes known as primitives like blocks, cylinders, cones, pyramids and spheres.

The steps involved in generating a solid model are:

1. Select the primitives from a library
2. Go through the scaling, dimension modification, and any other transformations.
3. Combine the primitives to create the desired solid model.

Since CSG method uses solid primitives, internal details of the object are automatically contained in the model.

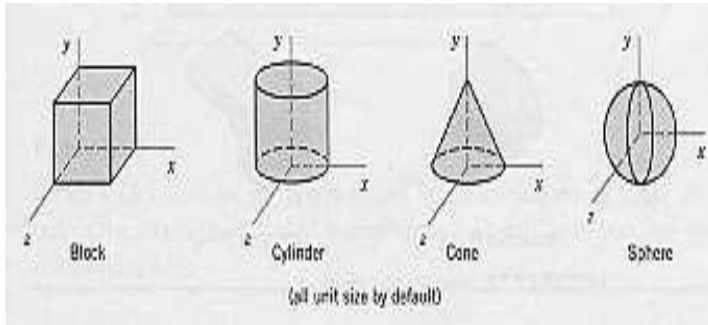
The model can be sectioned to reveal internal details and can be used for calculating mass, volume, moment of inertia, etc.

New solid models can be created from the primitives or other solid models by the following Boolean operations like union (\cup), difference ($-$) and intersection (\cap).

Union (\cup): Two solids are joined and the common volume of one of the primitives is neglected in the resulting solid.

Subtraction or Difference ($-$): One solid is subtracted from the other and the resultant solid retains only the uncut portion of the solid.

Intersection (\cap): When two solids are combined, the resultant solid represents the common volume of the two solids.



BOUNDARY REPRESENTATION (B-REP) SCHEME

In this method, front view, top view, bottom view, side view of an object is sketched and connected by means of lines to create a relationship.

The B-rep is built on the idea that a physical object is enclosed by a set of faces, which themselves belong to closed and orientable surfaces.

The data base for boundary model has topology and geometry.

The boundary of an object includes faces, vertices and edges.

A solid model is created by combining faces and contains vertices, edges, loops, and bodies.

In B-rep, a model is made up of the following primitives:

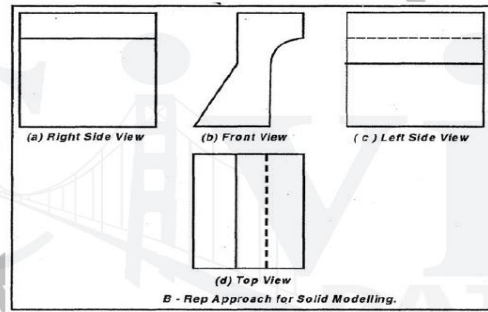
Vertex: A point in space

Edge: A finite, no-intersecting space curve bounded by two vertices that are not necessarily distinct.

Face: A finite connected, non-self-intersecting, region of a closed oriented surface, bounded by one or more loops.

Loop: An ordered alternating sequence of vertices and edges. A loop defines a non-self-intersecting closed space curve, which may be a boundary of a face.

Body: Entity that has faces, edges and vertices. A minimum body is a point.



The major operations carried out in B - rep system are:

Extrusion, Revolution
 Chamfer, Tweaking
 Blending, Swaging

Advantages of B-rep

This method is very powerful for creating complex shapes solid models.
 B-rep model can be easily converted into wire frame model system.
 B-rep system stores an explicit definition of the model boundaries.
 B-rep system is very much compatible with other systems.

Limitations of B-rep

This requires more storage space.
 This concept cannot be applied for tool path generation.
 Sweeping can create a solid model.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=aYRIRPdRO0c>
<https://www.youtube.com/watch?v=kECACbOriIg>
<https://www.youtube.com/watch?v=N1Vzv6AZYB0>

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LECTURE HANDOUTS

L

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Visual Realism Hidden - Line removal algorithms

Introduction : (Maximum 5 sentences)

Visual Realism is a method for interpreting picture data fed into a computer and for creating pictures from difficult multidimensional data sets.

Visualization can be classified as :

- Visualization in geometric modeling
- Visualization in scientific computing.

Hidden line and surface removal methods remove the uncertainty of the displays of 3D models and is accepted the first step towards visual realism.

Shaded images can only be created for surface and solid models.

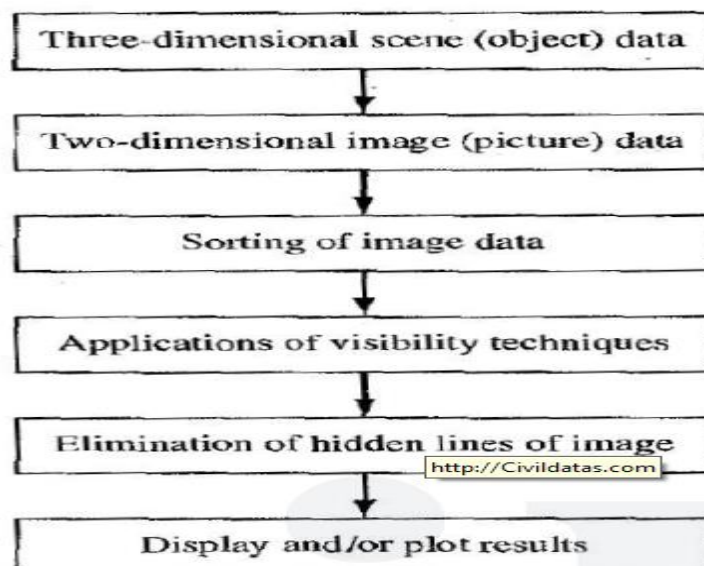
Prerequisite knowledge for Complete understanding and learning of Topic:

- To know about the 3D Objects
- To know about the Colouring
- To know about the Animation

Detailed content of the Lecture:

For a given 3D scene, a given viewing point, and a given direction, eliminate from a 2D projection of the scene all parts of edges and faces which the observer cannot see.

For orthographic projections, the location of the viewing point is not needed.



The Priority Algorithm

This algorithm is also known as the depth or Z algorithm.

The algorithm is based on sorting all the faces (polygons) in the scene according to the largest z coordinate value of each. This step is sometimes known as assignment of priorities.

If a face intersects more than one face, other visibility tests besides the z depth are needed to resolve any ambiguities.

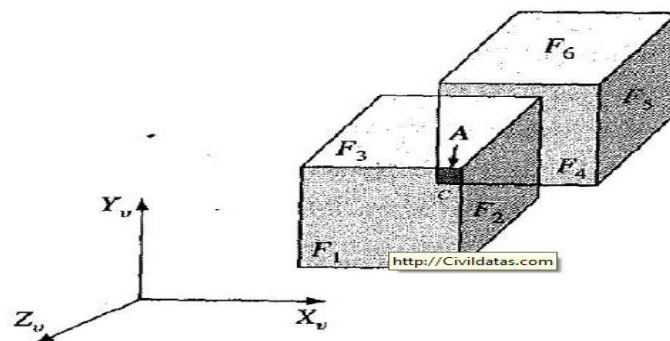
This step constitutes determination of coverings.

Example

Consider a scene of two boxes as shown in Figure. It shows the scene in the standard VCS where the viewing eye is located at infinite distance -on the positive Z_v direction. The following steps provide guidance for implementing the algorithm:

Step 1: Utilize the proper orthographic projection to obtain the desired view (whose hidden lines are to be removed) of the scene.

This result in a set of vertices with coordinates of (X_v, Y_v, Z_v) .



(a) Scene of two boxes

Step 2:

Utilize the surface test to remove back faces to improve the efficiency of the priority algorithm.

Step 3: Assign priorities to the faces in the face list.

Step 4: Reorder the face and priority lists so that the highest priority is on top of the list. In this case, the face and priority lists are $[F1, F2, F3, F4, F5, F6]$ and $[1, 1, 1, 2, 2, 2]$, respectively.

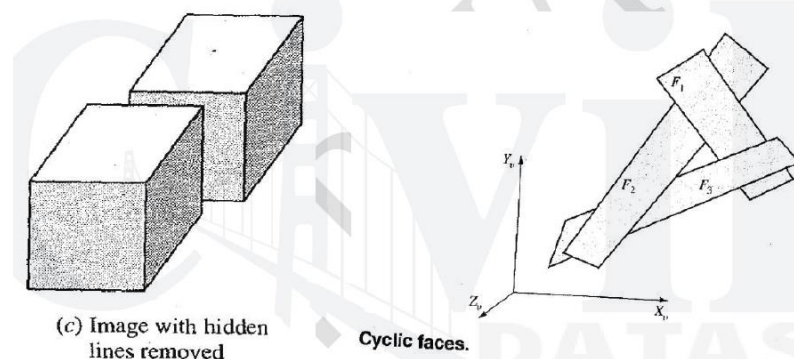
Step 5: In the case of a raster display hidden line removal is done by the hardware.

Step 6: In the case of a vector display the hidden line removal must be done by the software by determining coverings.

An edge list can be created which maintains a list of all line segments that will have to be drawn as visible.

Visibility techniques such as the containment test and edge intersection are useful in this case.

In Some scenes, ambiguities may result after applying priority test. The figure shows a case in which the order of faces is cyclic.



(c) Image with hidden lines removed

Cyclic faces.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=GxSCRLF37z4>

<https://www.youtube.com/watch?v=W6d1jsJrck>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
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LECTURE HANDOUTS

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RA

VI / III

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarajan

Unit : III

Topic of Lecture: Image Space method

Introduction :

Image space method is implemented in the screen coordinate system in which the objects are viewed. In an image-space algorithm, visibility is decided point by point at each pixel Position on the view plane. Most hidden line/surface algorithms use image-space methods.

Prerequisite knowledge for Complete understanding and learning of Topic:

To know about the 2D images
To know about the line drawings

Detailed content of the Lecture:

In a 3D objects and viewing specification, we wish to determine which lines or surfaces of the objects are visible, so that we can display only the visible lines or surfaces.

This process is known as hidden surfaces or hidden line elimination, or visible surface determination.

The hidden line or hidden surface algorithm determines the lines, edges, surfaces or volumes that are visible or invisible to an observer located at a specific point in space.

These algorithms are broadly classified according to whether they deal with object definitions directly or with their projected images.

These two approaches are called object-space methods or object precision methods and image-space methods, respectively.

When we view a picture containing non-transparent objects and surfaces, then we cannot see those objects from views which are behind from objects closer to eye.

We must remove these hidden surfaces to get a realistic screen image.

The identification and removal of these surfaces is called Hidden-surface problem.

There are two approaches for removing hidden surface problems -

Object-Space method and Image-space method.

Object-space method: - Object-space method is implemented in the physical coordinate system in which objects are described.

It compares objects and parts of objects to each other within the scene definition to determine which surfaces, as a whole, we should label as visible. Object-space methods are generally used in line-display algorithms.

Image space method is implemented in the screen coordinate system in which the objects are viewed.

In an image-space algorithm, visibility is decided point by point at each pixel Position on the view plane.

Most hidden line/surface algorithms use image-space methods.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=dqsVQ31ZfuE>

<https://www.youtube.com/watch?v=wUovjubxmPo>

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LECTURE HANDOUTS

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VI / III

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Course Teacher Design : Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Object Space method

Introduction :

Object-space method: - Object-space method is implemented in the physical coordinate system in which objects are described.

It compares objects and parts of objects to each other within the scene definition to determine which surfaces, as a whole, we should label as visible. Object-space methods are generally used in line-display algorithms.

Prerequisite knowledge for Complete understanding and learning of Topic:

- To know about the 2D images
- To know about the line drawings

Detailed content of the Lecture:

Space object algorithms have the advantage of retaining the relevant data and because of this ability the interaction of algorithm with the object becomes easier.

The calculation done for the colour is done only once. Object space algorithms also allow shadow generation to increase the depth of the 3 dimensional objects on the screen.

The incorporation of these algorithms is done in software and it is difficult to implement them in hardware.

What's the difference between Image Space and Object Space

- Image space algorithms are much more efficient than object space algorithms
- Object space algorithms are much more functional than image space algorithms
- Colour calculation in object space algorithms is done only one time and is retained by it but in image space algorithm the calculation once done is over written later.

The object-space method is initiated for the vector graphics system and is generally used for accuracy and continuous operation. For example, Back-Face Detection.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=dqsVQ31ZfuE>

<https://www.youtube.com/watch?v=wUovjubxmPo>

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- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989
- Tarbiat Modares University, Mechanical Engineering Department, Tehran, P.O.Box: 14115-116, Iran



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LECTURE HANDOUTS

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VI / III

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design : Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Hidden surface removal algorithms

Introduction :

Hidden-surface removal and hidden-line removal are one problem.

Most of the line algorithms are applicable here and vice versa.

The following are image-space algorithms only for hidden-surface removal.

A wide variety of these algorithms exist.

Prerequisite knowledge for Complete understanding and learning of Topic:

The z-buffer algorithm, Watkin's algorithm, Warnock's algorithm, and Painter's algorithm.

The Watkin's algorithm is based on scanline coherence, while the Warnock's algorithm is an area-coherence algorithm.

The Painter's algorithm is a priority algorithm for raster displays.

Detailed content of the Lecture:

z-Buffer Algorithm:

This is also known as the depth-buffer algorithm.

In addition to the frame buffer, this algorithm requires a z-buffer in which z values can be sorted for each pixel.

The z-buffer is initialized to the smallest z-value, while the frame buffer is initialized to the background pixel value. Both the frame- and z-buffers are indexed by pixel coordinates (x, y) .

These coordinates are actually screen coordinates.

The z-buffer algorithm works as follows. For each polygon in the scene, find all the pixels (x, y) that lie inside or on the boundaries of the polygon when projected onto the screen.

For each of these pixels, calculate the depth z of the polygon at (x, y) . If $z > \text{depth}(x, y)$, the polygon is closer to the viewing eye than others already stored in the pixel.

In this case, the z-buffer is updated by setting the depth at (x, y) to z .

Similarly, the intensity of the frame-buffer location corresponding to the pixel is

updated to the intensity of the polygon at (x, y). After all the polygons have been processed, the frame buffer contains the solution.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=j-q9fGZkKLM>

<https://www.youtube.com/watch?v=TsjYPu7piY0>

<https://www.youtube.com/watch?v=johvsXKB8mk>

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LECTURE HANDOUTS

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VI / III

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Hidden surface removal algorithms - Warnock's Algorithm

Introduction : (Maximum 5 sentences)

An interesting approach to the hidden-surface problem was developed by Warnock. He developed area subdivision algorithm which subdivides each area into four equal squares.

At each stage in the recursive-subdivision process, the relationship between projection of each polygon and the area of interest is checked for four possible relationships:

Prerequisite knowledge for Complete understanding and learning of Topic:

The z-buffer algorithm, Watkin's algorithm, Warnock's algorithm, and Painter's algorithm. The Watkin's algorithm is based on scanline coherence, while the Warnock's algorithm is an area-coherence algorithm.

Detailed content of the Lecture:

This is one of the first area-coherence algorithms.

Essentially, this algorithm solves the hidden-surface problem by recursively subdividing the image into sub images.

It first attempts to solve the problem for a window that covers the entire image.

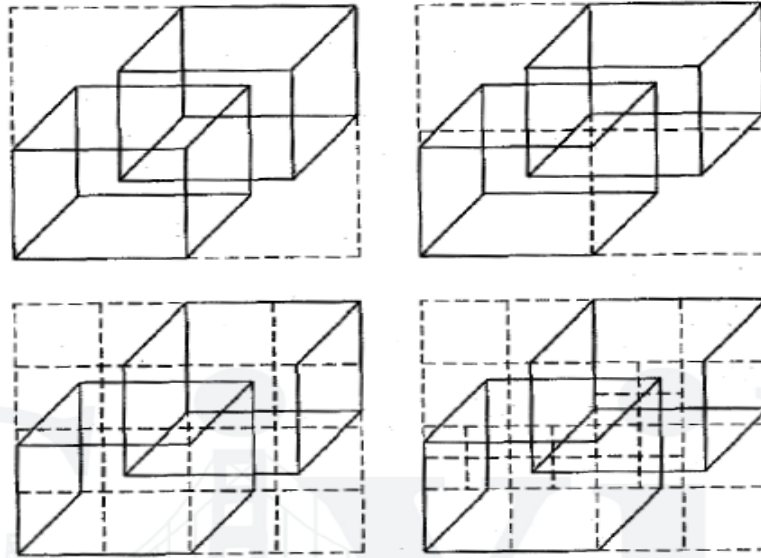
Simple cases as one polygon in the window or none at all are easily solved.

If polygons overlap, the algorithm tries to analyze the relationship between the polygons and generates the display for the window.

If the algorithm cannot decide easily, it subdivides the window into four smaller windows and applies the same solution technique to every window.

If one of the four windows is still complex, it is further subdivided into four smaller windows.

The recursion terminates if the hidden-surface problem can be solved for all the windows or if the window becomes as small as a single pixel on the screen.



In this case, the intensity of the pixel is chosen equal to the polygon visible in the pixel. The subdivision process results in a window tree. One would devise a rule that any window is recursively subdivided unless it contains two polygons.

In such a case, comparing the z depth of the polygons determines which one hides the other.

While the subdivision of the original window is governed by the complexity of the scene, the subdivision of any window into four equal windows makes the algorithm inefficient. A better way would be to subdivide a window according to the complexity of the scene in the window.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=e3mmFnDO670>

https://www.youtube.com/watch?v=2tL_HBrGga8

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LECTURE HANDOUTS

L

RA

VI / III

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design : Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Hidden solid removal algorithms

Introduction : (Maximum 5 sentences)

Solid objects are usually modeled by polyhedra in a computer representation. A face of a polyhedron is a planar polygon bounded by straight line segments, called edges. Curved surfaces are usually approximated by a polygon mesh.

Computer programs for line drawings of opaque objects must be able to decide which edges or which parts of the edges are hidden by an object itself or by other objects.

This problem is known as hidden-line removal.

Prerequisite knowledge for Complete understanding and learning of Topic:

Problem sizes for hidden-Solid removal

Extension of wire frame model

visibility problem

Detailed content of the Lecture:

The hidden-solid removal problem involves the display of solid models with hidden lines or surfaces removed.

Due to the completeness and unambiguity of solid models, the hidden-solid removal is fully automatic.

CAD systems provide users with menu choices to display models including shaded, hidden lines removed, or wireframe (no hidden lines removed).

For displaying CSG models, both the visibility problem and the problem of combining the primitive solids into one composite model have to be solved.

There are three approaches to displaying CSG models.

The first approach converts the CSG model into a boundary model that can be rendered with the standard hidden-surface algorithms.

The second approach utilizes a spatial subdivision strategy.

The third approach uses a CSG hidden-surface algorithm, which combines the CSG evaluation with the hidden-surface removal on the basis of ray classification.

Ray-Tracing Algorithm:

The virtue of ray tracing is its simplicity and reliability.

The most complicated numerical problem of the algorithm is finding the points at which lines (rays) intersect surfaces.

Therefore a wide variety of surfaces and primitives can be covered.

Ray racing has been used to enhance the visual realism of solids by generating line drawings with hidden solids removed, animating solids, and shading pictures.

It has also been utilized in solid analysis, mainly calculating mass properties.

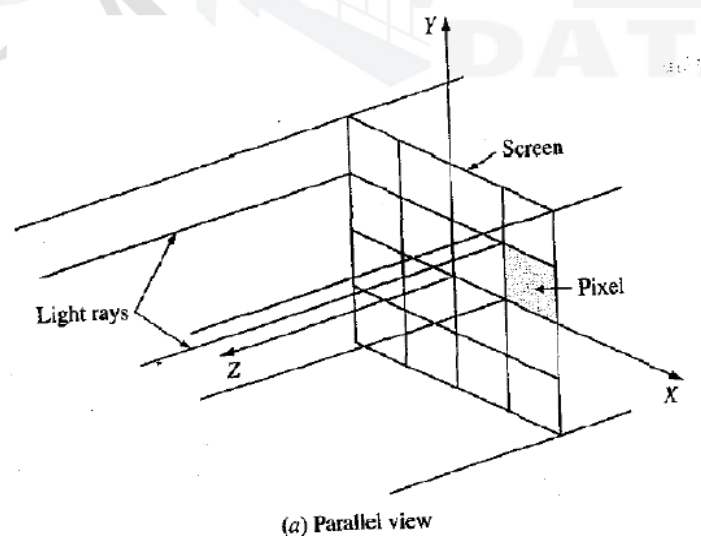
The idea of using ray tracing to generate shaded images of solids is to emulate the photographic process in reverse.

For each pixel in the screen, a light ray is cast through it into the scene to identify the visible surface.

The first surface intersected by the ray, found by "tracing" along it, is the visible one.

At the ray/surface intersection point, the surface normal is computed and knowing the position of the light source, the brightness of the pixel can be calculated.

Ray tracing is considered a brute force method for solving problems. The basic ray-tracing algorithm is simple, but slow.



Video Content / Details of website for further learning (if any):

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LECTURE HANDOUTS

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RA

VI / III

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Shading

Introduction : (Maximum 5 sentences)

Shading refers to the process of altering the colour of an object surface polygon in the 3D scene based on its angle on lights and its distance from lights to create a photorealistic effect. They also can convey features other than shape such as surface finish or material type (plastic or metallic look).

Prerequisite knowledge for Complete understanding and learning of Topic:

Shaded images
Line drawings,
geometry of parts,

Detailed content of the Lecture:

Shaded-image rendering algorithms filter information by displaying only the visible surface. Many spatial relationships that are unresolved in simple wireframe displays become clear with shaded displays.

Shaded Images are easier to interpret because they resemble the real objects.

Shaded images have viewing problems not present in wireframe displays.

Solids of interest may be hidden or partially obstructed from view, in which case various shaded images may be obtained from various viewing points.

Critical geometry such as lines, arcs, and vertices are not explicitly shown.

Well-known techniques such as shaded-Image/wireframe overlay, transparency, and sectioning can be used to resolve these problems.

In shading a scene (rendering an image), a pinhole camera model is almost universally used. Rendering begins by solving the hidden-surface removal problem to determine which objects and/or portions of objects are visible in the scene.

This process must take into account the position and color of the light sources and the position, orientation, and surface properties of the visible objects.

Shading models simulates the way visible surfaces of objects reflect light.

They determine the shade of a point of an object in terms of light sources, surface characteristics, and the: positions and orientations of the surfaces and sources.

Two types of light sources can be identified: point light source and ambient light.

Objects illuminated with only point light source look harsh because they are illuminated from one direction only.

This produces a flashlight-like effect in a black room. Ambient light is a light of uniform brightness and is caused by the multiple reflections of light from the many surfaces present in real environments.

Shading models are simple. The inputs to a shading model include intensity and color of light source (S), surface characteristics at the point to be shaded, and the positions and orientations of surfaces and light sources.

The output from a shading model is an intensity value at the point. Shading models are applicable to points only. To shade an object, a shading model is applied many times to many points on the object.

These points are the pixels of the display. To compute a shade for each point on a 1024 x 1024 raster display, the shading model must be calculated over one million times.

Flat Shading	Smooth Shading
Single intensity is calculated for each polygon and hence looks less realistic.	Intensity at each point of a surface can be obtained using an interpolation scheme.
Uses the same colour for every pixel in a face.	Smooth shading uses linear interpolation of colours between vertices.
Edges appear more pronounced than they would on a real object.	The edges disappear with this technique.
Individual faces are visualized.	Underlying surface is visualized.
Same colour for any point of the face.	Each point of the face has its own colour.
Not suitable for smooth objects.	Suitable for any objects.
Less computationally expensive.	More computationally expensive.
Used for high speed rendering.	Used for more realistic rendering.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=Jh9QQVGupwc>

https://www.youtube.com/watch?v=YYpUSgT_uYk

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
5. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.



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LECTURE HANDOUTS

L

RA

VI / III

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarajan

Unit : III

Topic of Lecture: Colouring

Introduction : (Maximum 5 sentences)

The two main ingredients of shaded images are colours and textures. The display of realistic scenes is mostly in colour.

Colours are used for realism, aesthetics and to distinguish the different areas in the geometry of an object.

Prerequisite knowledge for Complete understanding and learning of Topic:

Designer To Classify Components In An Assembly
Highlight the sectional views
Dimensions of the model.

Detailed content of the Lecture:

Neutral colours such as black, white or grey are called achromatic colours, provided by black and white raster displays.

The only attribute of achromatic light is its intensity or amount which is assigned a value between 0 and 1.

Colour is created by taking advantage of the fundamental trichromacy of the human eye.

A typical colour CRT uses three electron beams and a triad of colour dots on the phosphor screen to provide each of the three colours, red, green and blue.

In the other hand, colour raster can terminate superior colour graphics capabilities and are usually available with 1024 X 1024 resolution but require large memory for the refresh buffer.

Three colour parameters are Hue Saturation or Purity Brightness The combination of frequencies present in the reflected light from an object is perceived as the colour of the object.

The Hue or simply the colour is the dominant wavelength or dominant frequency.

Saturation is the purity of a colour. It describes how washed out or how pure the colour appears.

It defines a range from pure colour (100%) to gray(0%) at a constant lightness level.

Brightness represents the perceived intensity of light. It refers to the lightness or darkness of a colour.

Colour Models

A colour model is an abstract mathematical model describing the way colours can be presented as tuples of numbers, typically as three or four colour components.

It is used to describe colour as accurately as possible.

The range of colours that can be described by a combination of other colours is called a colour gamut.

Additive colour models

Subtractive colour models

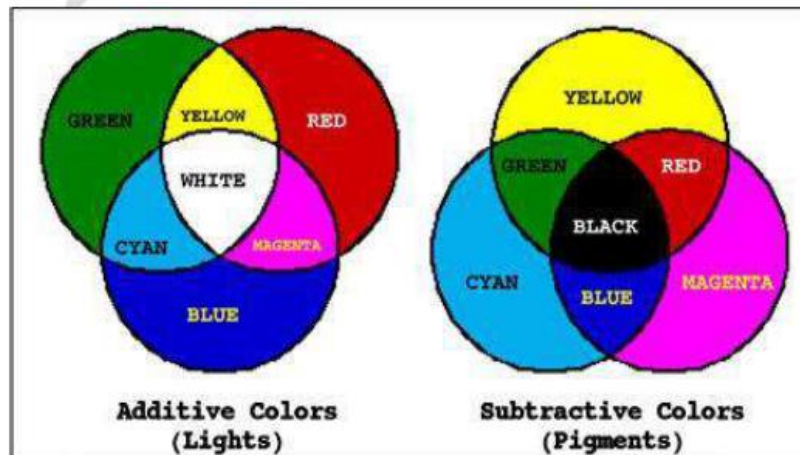
Additive Color models

Additive Color models are based on the principle of transmitted light.

It is created by mixing a number of different colours, the primary colours red, blue and green being normally used.

This system includes monitors, liquid crystal displays, digital projectors and televisions.

Each pixel on a monitor screen starts out as black but when red, green and blue phosphors of the pixel are illuminated simultaneously, that pixel becomes white.



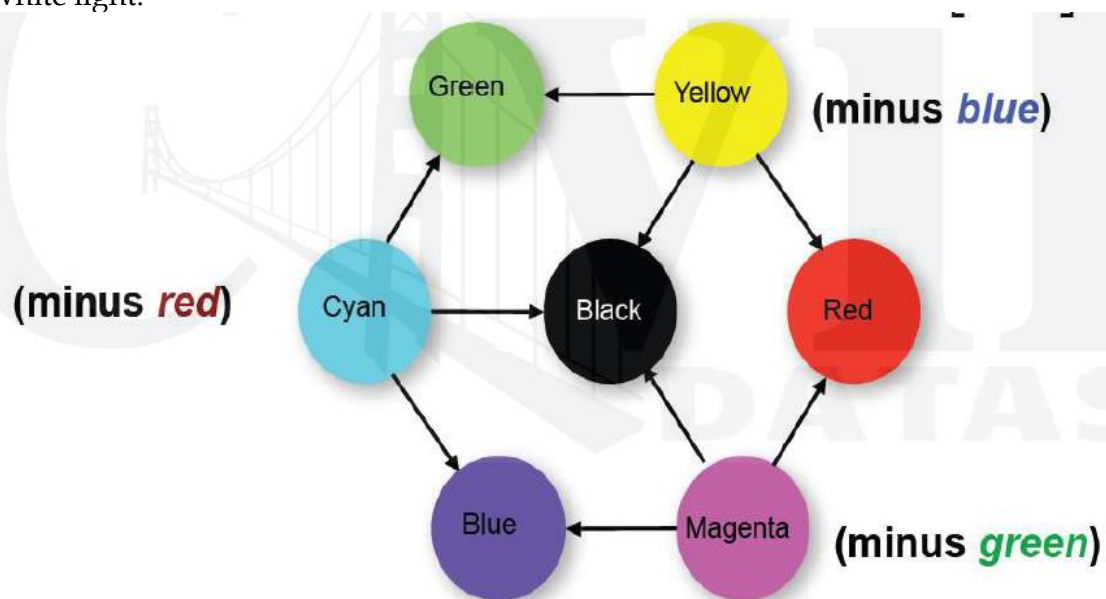
Subtractive Color models

This model perceives colour as a result of reflected light.

The colour that a surface displays depends on which parts of the visible spectrum are not absorbed and therefore remain visible.

If an object absorbs (subtracts) all the illuminating light, i.e., no light is reflected back to the viewer it appears black.

Subtractive colour models filter the red, green and blue components of the image from white light.



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=74Q5K5u9Sj4>

<https://www.youtube.com/watch?v=BqClfkjiISo>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics"". Prentice Hall, Inc, 1992.
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LECTURE HANDOUTS

L-

RA

VI / III

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : III

Topic of Lecture: Computer animation

Introduction : (Maximum 5 sentences)

The process of moving something which can't move by itself is called 'animation'.
Conventional animation is defined as a technique in which the illusion movement is created by photographing a series of individual drawings on successive frames of film.
Computer animation is the use of computer to create animation.

Prerequisite knowledge for Complete understanding and learning of Topic:

Object definitions
Recording animation sequence

Detailed content of the Lecture:

Virtual entities may contain and be controlled by attributes such as location, orientation and scale.
Animation is the change of an attribute over time. It generally refers to any time sequence of visual changes in a scene.
To create the illusion of movement, an image is displayed on the computer screen and then quickly replaced by a new image that is similar to the previous image but shifted slightly. To trick the eye and brain into thinking they are seeing a smoothly moving object, the images should be drawn at around 12 frames per second or faster.
A typical animation sequence for animated cartoons is:
Storyboard layout
Object definitions
Key-frame specifications
Generation of in-between frames
Recording animation sequence
Computer animation demands higher frame rates as it produces more realistic images.
Computer assisted and Computer generated
Computer assisted animation is mostly 2-dimensional that computerize the traditional animation process.
Computer generated or modeled animation or 3D animation utilizes available computer graphics and CAD techniques to create images, scenes and movements.

Applications of Computer animation

Engineering, Educational
Entertainment, Advertising, Art
Architecture, Forensics, Medicine
Military and Space exploration.

In CAD :

Kinematic Simulation
Analysis of Linkage mechanism
Planning of a robotic work cycle

Types of Animation

Frame buffer Animation

It provides the illusion animation for a variety of applications.

Limited real-time animation

Uses Static pictures which are stored in the image memory of a digital frame buffer.

The image once created and stored in the memory of the frame buffer remains completely unchanged.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=d11KNU0sUKI>

<https://www.youtube.com/watch?v=GXffCfO64O0>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
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LECTURE HANDOUTS

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RA

II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher :Mr.M.Soundarrajan

Unit : V

Topic of Lecture: Standards for computer graphics

Introduction : (Maximum 5 sentences)

The Graphical Kernel System (GKS) is a set of functions for computer graphics programming and became an International Standards Organization (ISO) standard 1 in July/August 1985. GKS is the first of a set of related international standards for computer graphics.

Prerequisite knowledge for Complete understanding and learning of Topic:

Graphics Standards. Agreed specifications which define the common interfaces between computer systems or subsystems. **Standards**, if they are generally observed by manufacturers, promote the interchangeability of computer equipment. When **standards** promote the portability of programs, this is called device independence.

Detailed content of the Lecture:

- The real issue with choosing the standards is portability and device independence.
- Complex CAD/CAM systems.
- Shape, Non shape, design and Manufacturing data.
- Need to integrate and automate design and manufacturing process to obtain maximum benefits from CAD/CAM.
- Direct Translators and neutral formats.

- Graphics Standards
 - GKS,PHIGS,NAPLPS,GKS 3D, IGES
- Standards for Exchange images
 - Open GL
- Data Exchange Standards
 - IGES,STEP,DXF,STL,CALS,PDES,VRML,CGM
- Communication Standards
 - LAN,WAN,CGI,VDI,

Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=_26E6QR_hmU

<https://www.youtube.com/watch?v=n8w1xOutFW4>

<https://www.youtube.com/watch?v=brRkLazDbmA>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007

- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989



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LECTURE HANDOUTS

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II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : V

Topic of Lecture: Graphical Kernel System (GKS)

Introduction :

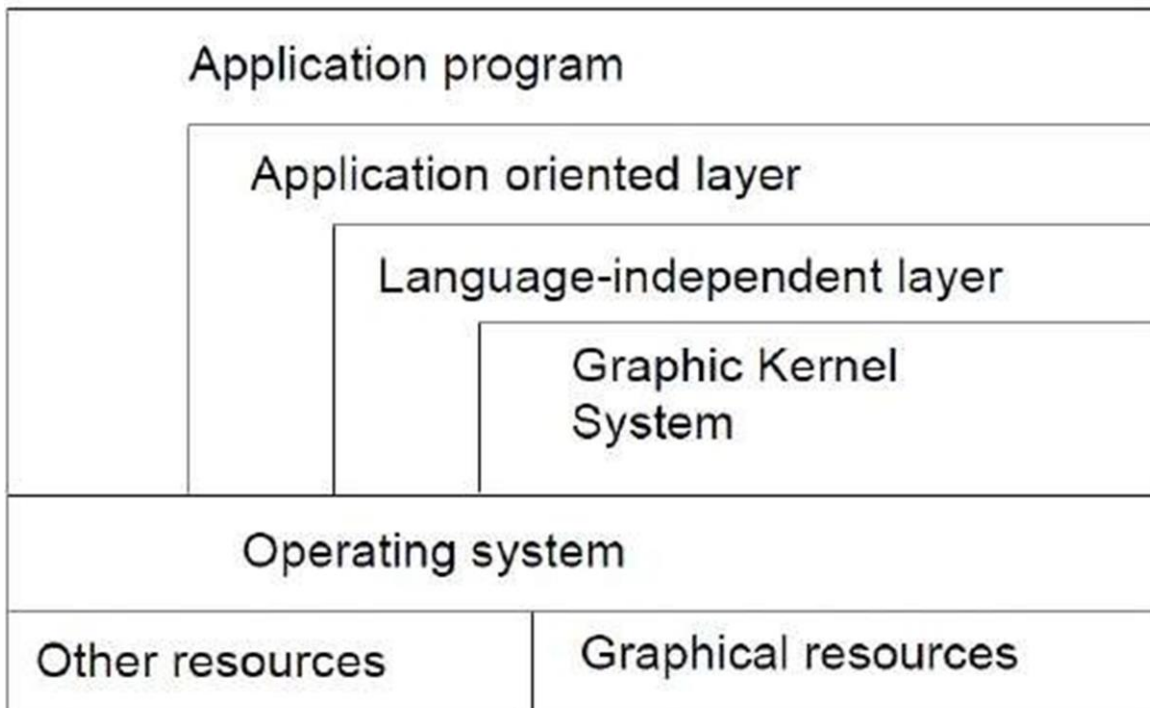
- GKS (Graphical Kernel System)
- PHIGS (Programmer's Hierarchical Interface for GraphicS)
- GKS -3D

Prerequisite knowledge for Complete understanding and learning of Topic:

The main objectives that were put forward for GKS are :

- To provide the complete range of graphical facilities in 2D, including the interactive capabilities.
- To control all types of graphical devices such as plotter and display devices in consistent manner.
- To be small enough for variety of programs.

Detailed content of the Lecture:



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=or4o0KgWqPE>

<https://www.youtube.com/watch?v=VrpQ8m8GZZo>

<https://www.youtube.com/watch?v=pxXy8OnJh2A>

https://www.youtube.com/watch?v=I-90d_gRnQU

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- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008



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LECTURE HANDOUTS

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II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Standards for data exchange

Introduction :

Data exchange depends not only on the compatibility of the applications data formats between the communicating systems, but also on compatibility of the physical means of communication. Computers are arranged to communicate with each other.

Local connections are known as local area networks (LANs) and involves the connection of digital devices over distance from a few meters up to a few kilometers.

Prerequisite knowledge for Complete understanding and learning of Topic:

Wide Area Networks (WANs) are used to connect the computers or machines of a number of university campuses, even if these sites are in different countries.

Detailed content of the Lecture:

Wide Area Networks

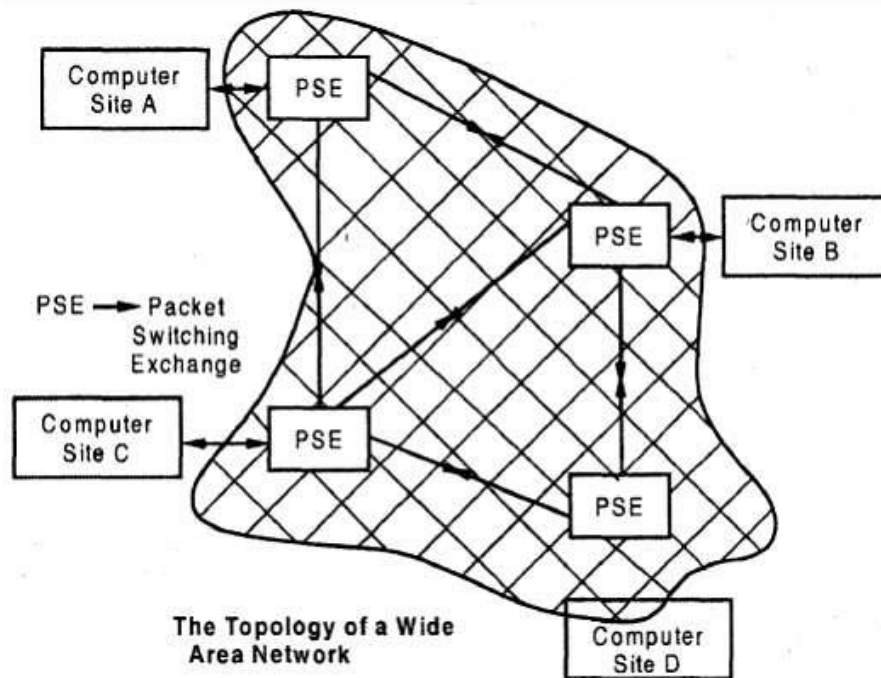
Wide Area Network is a computer network that covers relatively larger geographical area such as a state, province or country.

Contrast with personal area networks (PAN's), local area networks (LAN's) or metropolitan area networks (MAN's) that are usually limited to a room, building or campus.

WAN's are used to connect local area networks (LAN's) together, so that users and computers in one location can communicate with users and computers in other locations. It provides a solution to companies or organizations operating from distant geographical locations who want to communicate with each other for sharing and managing central data or for general communication.

WAN is made up of two or more Local Area Networks (LANs) or Metropolitan Area Networks (MANs) that are interconnected with each other, thus users and computers in one location can communicate with users and computers in other locations.

In 'Wide Area Network', Computers are connected through public networks, such as the telephone systems, fiber-optic cables, and satellite links or leased lines. The largest and most well-known example of a WAN is the Internet. WANs are mostly private and are building for a particular organization by 'Internet Service Providers (ISPs)' which connects the LAN of the organization to the internet.



The data carrying networks operated by the public utilities are known as public switched data networks.

When digital transmission is extended to subscriber equipment then at high-bitrate

switched transmission path will be available at each subscriber outlet, and network will be capable of supporting both digitized voice and data transmission without modems, as an integrated services digital network (ISDN).

In addition, WAN's also refer to Mobile Data Communications, such as GSM, GPRS and 3G.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=ZDeLwFwnFKg>

<https://www.youtube.com/watch?v=xQpSyRgy4cA>

<https://www.youtube.com/watch?v=4TzMyXmzL8M>

<https://www.youtube.com/playlist?list=PL13FD5F00C21BBC0B>

Important Books/Journals for further learning including the page nos.:

- Ibrahim Zeid Mastering CAD CAM Tata McGraw-Hill Publishing Co. 2007
- Radhakrishnan.P "CAD / CAM / CIM" New age international 2008
- William M Neumann and Robert F.Sproul Principles of Computer Graphics McGraw Hill Book Co. Singapore, 1989
- Tarbiat Modares University, Mechanical Engineering Department, Tehran, P.O.Box: 14115-116, Iran



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LECTURE HANDOUTS

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RA

II/IV

Course Name with Code : 19RAC11-Computer Aided

Course Teacher Design :Mr.M.Soundarrajan

Unit : II

Topic of Lecture: Open Graphics Library (OpenGL)

Introduction :

Open Graphics Library is a cross-language, cross-platform application programming interface for rendering 2D and 3D vector graphics. The API is typically used to interact with a graphics processing unit, to achieve hardware-accelerated rendering

Prerequisite knowledge for Complete understanding and learning of Topic:

- Direct Translators.
 - Translating the CAD data directly from one CAD/CAM system to another, in a single step.

Detailed content of the Lecture:

The shape of the Bezier curve is obtained or determined by the number of control points. Generally the Bezier curve approximates the data points and interpolates the end points. The position of the control points and vertices of Bezier characteristics polygon is used to define the Bezier curve.

4· The Bezier curve follows the shape of characteristics polygon.

The Bezier curve is tangent to the first and last polygon segment of the characteristic polygon.

The shape of the Bezier curve is defined uniquely by the characteristic polygon

Bezier curves, unlike B-splines, must have precisely n control points, where $n + 1$ is the degree of the Bezier polynomial.

To create a longer curve, it is necessary to connect multiple Bezier curves

B - Spline curves give another effective method, besides that of Bezier curves.

It has the ability to interpolate or approximate a set of given data points. Moreover B - spline curves are the proper and powerful generalization of Bezier curves.

In addition to Bezier curves, the B -spline curve separates the degree of the resulting curve from the number of the given control points.

The flexibility in the degree of the resulting curve is achieved by choosing the blending function of B - spline curves with an additional degree of freedom that does not exist in

Bernstein polynomials.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=ZDeLwFwnFKg>

<https://www.youtube.com/watch?v=xQpSyRgy4cA>

<https://www.youtube.com/watch?v=4TzMyXmzL8M>

<https://www.youtube.com/playlist?list=PL13FD5F00C21BBC0B>

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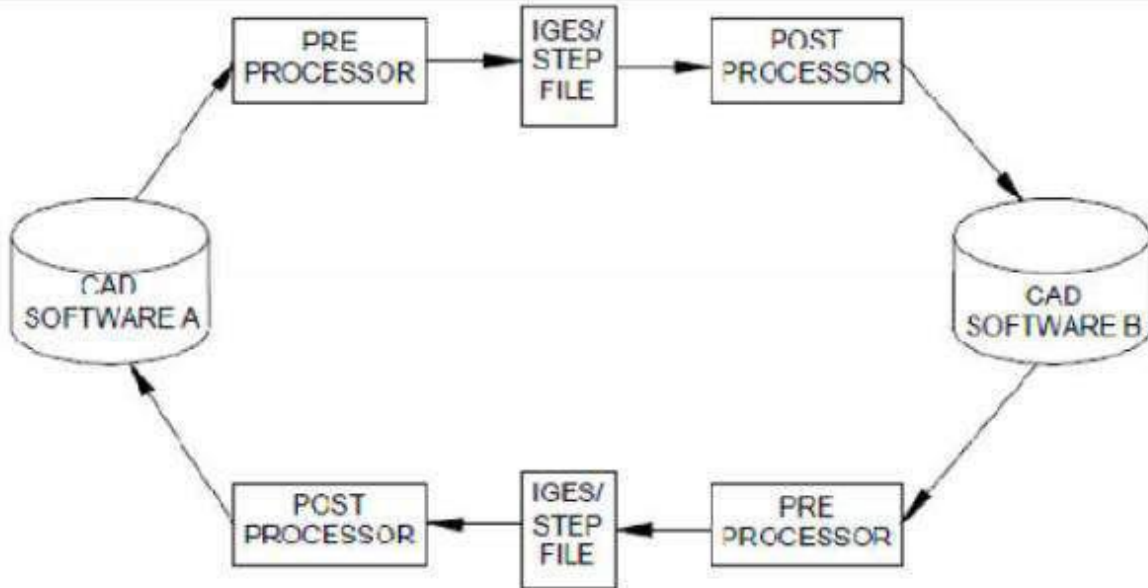
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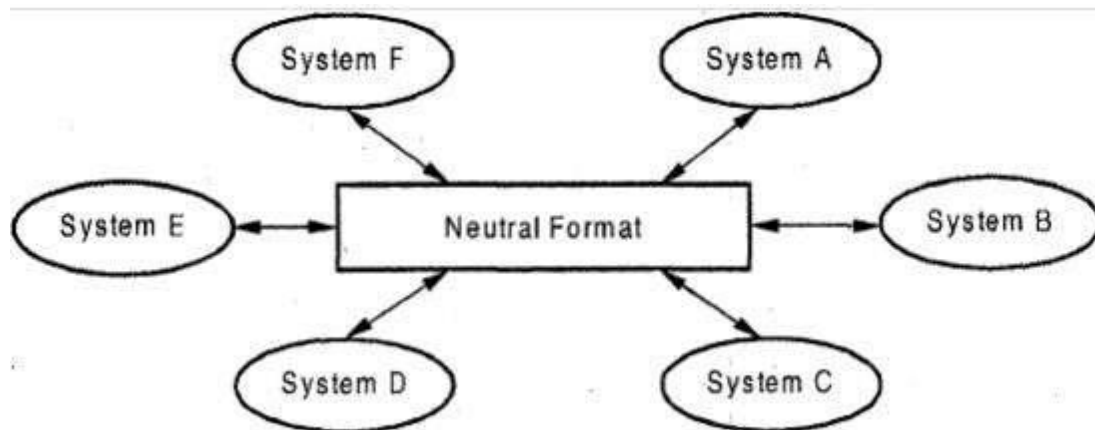
Course Teacher : Mr.M.Soundarrajan

Unit : V

Topic of Lecture: Data exchange standards
Introduction : (Maximum 5 sentences) Data Exchange Standards facilitate the sharing of structured data across different information systems. Data Exchange Standards are optimized to represent CDISC content, and flexible enough to be used by information systems that haven't implemented the Foundational Standards (e.g., legacy data , academic studies).
Prerequisite knowledge for Complete understanding and learning of Topic: NURBS (non uniform rational B-splines) Internal representation of all geometric entities Representation of objects (or) components by surfaces B-splines and NURBS (Non-Uniform Rational B-Splines) are used for creating surfaces.
Detailed content of the Lecture: The increase in CAD applications in many parts of the engineering industry has been accomplished by growth in product variety and broadening of the range of companies involved in the design of a particular product. The easiest way for two companies to exchange data is to use the same CAD software, operating at the same revision level. The transfer of data between the systems has been made possible by the neutral format of data exchange. The neutral files will have standard formats and software packages can have pre-processors to convert drawing data to neutral file and postprocessors to convert neutral file data to drawing file.



CAD Data Exchange Using Neutral Files



Neutral Format for Data Exchange

Video Content / Details of website for further learning (if any):

- https://www.youtube.com/watch?v=CeOV_tVo970
- <https://www.youtube.com/watch?v=az2s2WELn7o>
- <https://www.youtube.com/watch?v=TN9waino0f8>
- <https://www.youtube.com/watch?v=ONj8HDP4PYw>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
5. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.



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II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : V

Topic of Lecture: IGES

Introduction : (Maximum 5 sentences)

The IGES committee was established in the year 1979. The CAD/CAM Integrated Information Network (CIIN) of Boeing served as the preliminary basis of IGES. IGES version 1.0 was released in 1980.

IGES continues to undergo revisions. IGES is a popular data exchange standard today. There are eight vertices (marked as PNT 0 - PNT 8), 12 edges and two circles that form the entities of the model.

Prerequisite knowledge for Complete understanding and learning of Topic:

IGES (Initial Graphics Exchange Specification) is the first standard exchange format developed to address the concept of communicating product data among dissimilar CAD/CAM systems.

IGES has gone through various revisions since its inception. Currently it supports solid modeling, including both B-rep and CSG schemes.

Detailed content of the Lecture:

IGES has gone through various revisions since its inception. Currently it supports solid modeling, including both B-rep and CSG schemes.

IGES has three data types: geometric, annotation, and structure. The latter two are non geometric data types.

Geometric entities define the product shape and include curves, surfaces, and solids.

Non geometric entities provide views and drawings of the model to enrich its representation and include annotation and structure entities.

Annotation entities include various types of dimensions (linear, angular, and ordinate), centerlines, notes, general labels, symbols, and cross-hatching.

Structure entities include views, drawings, attributes (such as line and text fonts, colors, and layers), properties (e.g. mass properties), sub figures and external cross reference entities (for surfaces and assemblies), symbols (e.g.. mechanical and electrical symbols), and macros (to define parametric parts).

IGES files can also be generated for:

i. Surfaces

ii. Datum curves and points

IGES File structure

- An IGES file consists of six and the identification character, is also called the section code.

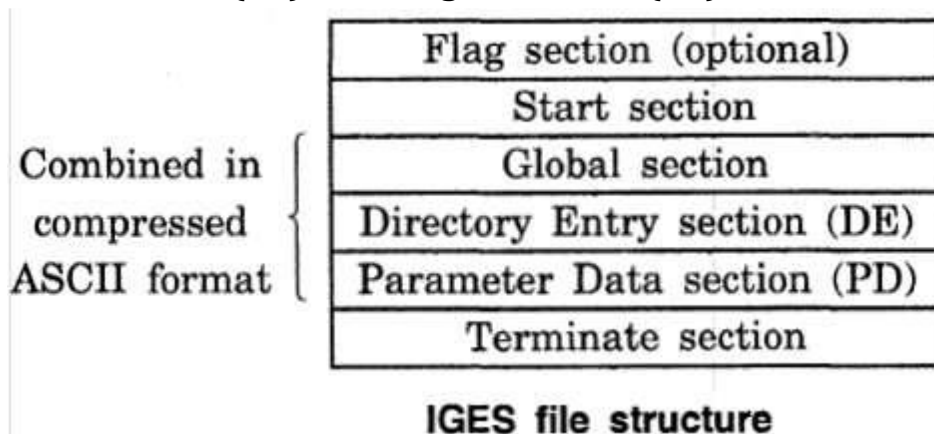
Start section

This section is setup manually by the person initiating the IGES file.

This contains the information that may help the user at the destination, such as the features of the originating system.

Global section

This section provides the 24 field parameters necessary to translate the file. It includes the delimiter characters (1 and 2), sender's identifier (3), file name (4), ID of the software which generate file (5), version of IGES processor (6), precision of integer (7 to 11), receiver's identifier (12), model space (13), units (14), name of the units (15), maximum number of line thickness (16, 17), time file generated (18), smallest distance (19), largest coordinate value (20), person and organization creating file (21 and 22), IGES version (23), drafting standards (24).



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=H6QBcrM4uso>

<https://www.youtube.com/watch?v=HyyWv9PuP5E>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahan and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
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II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : V

Topic of Lecture: STEP

Introduction : (Maximum 5 sentences)

The Standard for the Exchange of Product Data (STEP) is the enabler for such seamless data exchange.

It provides a worldwide standard for storing, sharing and exchanging product information among different CAD systems.

Although STEP itself is the basis for Product Data Management System (PDM), it covers border functionalities.

Prerequisite knowledge for Complete understanding and learning of Topic:

It includes methods of representing all critical product specifications such as shape information, materials, tolerances, finishes and product structure.

Whereas the Initial Graphics Exchange Specification (IGES) standard has widespread use, it has its shortcomings. It does not convey the extensive product information needed in the design and manufacturing cycle.

Often IGES translators are required to move design data from one CAD system to another.

Detailed content of the Lecture:

Coons patch:

STEP is often viewed as a replacement for IGES, though IGES is still expected to be in **active use** for some more time in the future.

Although the current focus of STEP is on mechanical parts, STEP is a data exchange standard that would apply to a wide range of product areas, including electronics, architectural, engineering and construction, apparel and shipbuilding.

STEP Architecture

STEP architecture has four main components:

EXPRESS modeling language

Data schemes including attributes such as geometry, topology, features and tolerance.

Application interface called Standard Data Access Interface (SDAI), which is a standard interface to enable applications to access and manipulate STEP data

STEP database, which has the following forms:

ASCII format file for data exchange

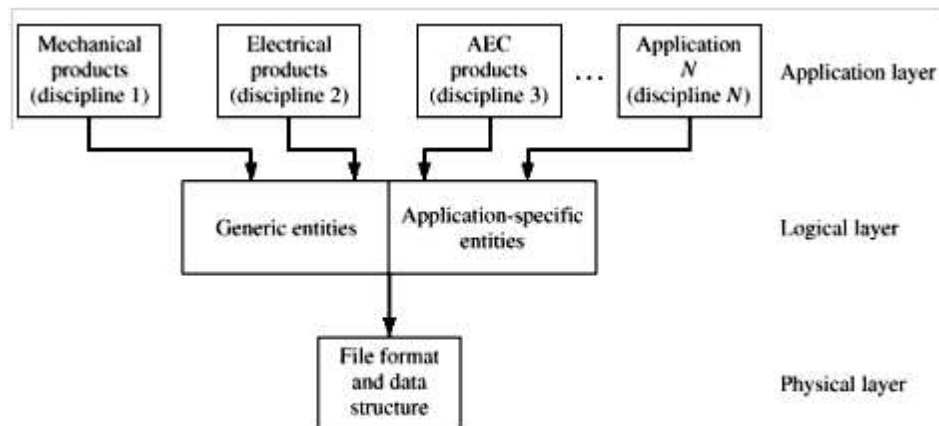
Working from file, usually in binary format, that can be shared by multiple systems

Shared database, involving object oriented database management system or relational database system

Knowledge base, with a database management system as a base coupled to an expert shell.

STEP has a three layer architecture as shown in that enables multiple application views and implementations.

The first layer comprises techniques for the implementation of STEP, in which the models are related to the EXPRESS language, and through this physical file.



STEP three-layer architecture.

The second layer provides context – independent information such as the description of the geometry, topology or product structure. Resource models are so called because they provide Resource to the 3rd layer. The third layer contains information related to a particular application domain such as draughting or electrical product modeling. This layer describes constrained subsets of the STEP standard which should ensure that the implementations by different vendors are very much more compatible than IGES implementations.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=qziWoZIK8tI>

https://www.youtube.com/watch?v=poY_nGzEEWM

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
3. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc, 1992.
5. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.



MUTHAYAMMAL ENGINEERING COLLEGE

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Rasipuram - 637 408, Namakkal Dist., Tamil Nadu



LECTURE HANDOUTS

L-

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher :Mr.M.Soundarrajan

Unit : V

Topic of Lecture: CALS

Introduction : (Maximum 5 sentences)

CALS (**Continuous Acquisition and Life-cycle Support**) is a United States Department of Defense (DoD) initiative for electronically capturing military documentation and linking related information.

Prerequisite knowledge for Complete understanding and learning of Topic:

In the past, technical data such as engineering drawings, illustrations, and textual data for a weapon system was delivered to the Government in paper form. This made it necessary for DoD activities involved in managing the acquisition of a weapon system to orient their processes around handling paper-based documentation.

These processes, however, were slow, error-prone and manpower intensive. In the mid 1980's the DoD sought to capitalize on advances in computer hardware and in the areas of computer-aided design, computer-aided engineering, and concurrent engineering

Detailed content of the Lecture:

This initiative grew into a joint DoD-industry Continuous Acquisition and Lifecycle Support (CALS) initiative and led to acquisition processes between defense contractors and DoD acquisition managers being conducted with technical data in digital formats.

With this change, there came a need for data management systems that could receive, store, and manipulate technical data in its various formats.

Additionally, many of the acquisition management processes required "reengineering" using concepts such as Business Process Reengineering in order to truly reap the benefits of receiving, handling, and managing technical data in digital formats.

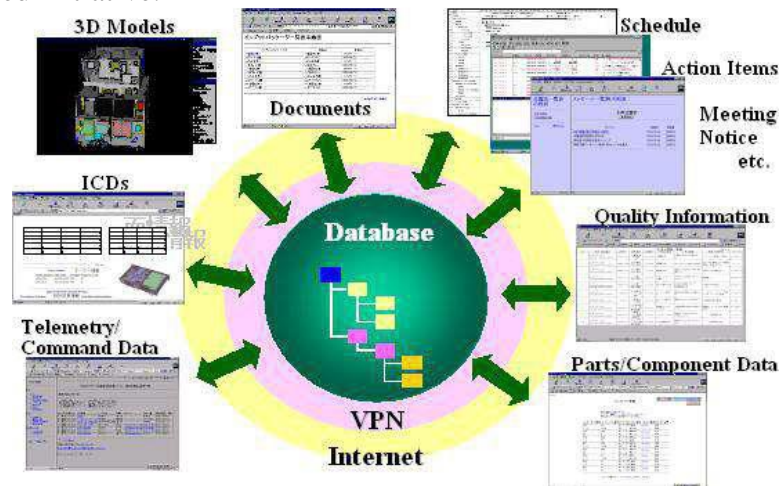
This CALS initiative has developed a number of standard specifications (protocols) for the exchange of electronic data with commercial suppliers.

It was thought that the CALS initiative could help the DoD reduce its costs for acquiring technical documentation while making it more accurate, current and timely.

In its beginnings, CALS primarily dealt with the logistics of support documentation.

It was originally called **Computer-Aided Logistics Support**.

Now renamed **Continuous Acquisition and Life-cycle Support**, the CALS initiative has been expanded from its roots in technical documentation and logistics support to CE and integrated business processes. These standards are often referred to as simply "CALS". CALS standards have been adopted by several other allied nations. It has gained acceptance outside the DoD and defense industries to become a joint DoD-industry managed initiative.



Two "flagship" CALS systems:

- Joint Computer-aided Acquisition and Logistics Support (JCALS) and the
- Joint Engineering Data Management Information and Control System (JEDMICS).

Joint Computer-aided Acquisition and Logistics Support

- JCALS concept originated from the US Army's Technical Information Management System (TIMS)

JCALs is an information management system that will support acquisition, logistics support, engineering, manufacturing, configuration control and materiel management processes throughout the life-cycle of a weapon system.

It uses multi weapon system IWSDBs and Global Data Dictionary and Directory (GDD/D) Services that are connected by a wide area computer network.

The interface for users is the JCALS Workbench that provides an environment to access all of JCAL's functionality transparently to the user.

Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=83Nsel2uv6k>

<https://www.youtube.com/watch?v=E5SngbIJ4fk>

Important Books/Journals for further learning including the page nos.:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing Management "Second Edition, Pearson Education, 1999.
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LECTURE HANDOUTS

L-

RA

II/IV

Course Name with Code : 19RAC11-Computer Aided Design

Course Teacher : Mr.M.Soundarrajan

Unit : V

Topic of Lecture: communication standards

Introduction : (Maximum 5 sentences)

Data exchange depends not only on the compatibility of the applications data formats between the communicating systems, but also on compatibility of the physical means of communication. Computers are arranged to communicate with each other. Local connections are known as local area networks (LANs) and involves the connection of digital devices over distance from a few meters up to a few kilometers.

Prerequisite knowledge for Complete understanding and learning of Topic:

A Local Area Network (LAN) is a network that is restricted to smaller physical areas e.g. a local office, school, or house. Approximately all current LANs whether wired or wireless are based on Ethernet. On a 'Local Area Network' data transfer speeds are higher than WAN and MAN that can extend to a 10.0 Mbps (Ethernet network) and 1.0 Gbps (Gigabit Ethernet).

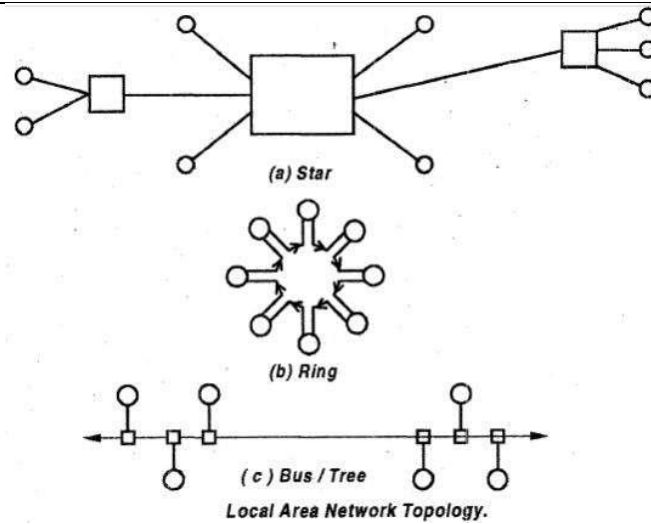
Detailed content of the Lecture:

Solid Model:

Computers and servers (provides services to other computers like printing, file storage and sharing) can connect to each other via cables or wirelessly in a same LAN. Wireless access in conjunction with wired network is made possible by Wireless Access Point (WAP). A WAP is able to connect hundreds or even more of wireless users to a network. Servers in a LAN are mostly connected by a wire since it is still the fastest medium for network communication. But for workstations (Desktop, laptops, etc.) wireless medium is a more suitable choice, since at some point it is difficult and expensive to add new workstations into an existing system already having complex network wiring.

The most obvious area of difference between a WAN and a LAN is in the topology of network itself.

LAN topology is generally rather simpler than the mesh arrangement. The method of controlling access to the network is also achieved in a number of different ways, of which perhaps the most important is the use of a control token, and carrier sense multiple access with collision detection (CSMA/CD). A wireless LAN or WLAN is a wireless Local Area Network, which is the linking of two or more computers without using wires. It uses radio communication to accomplish the same functionality that a wired LAN has. WLAN utilizes spread-spectrum technology based on radio waves to enable communication between devices in a limited area, also known as the basic service set. This gives users the mobility to move around within a broad coverage area and still be connected to the network.



Video Content / Details of website for further learning (if any):

<https://www.youtube.com/watch?v=aYRIRPdRO0c>

<https://www.youtube.com/watch?v=kECACbOriIg>

<https://www.youtube.com/watch?v=N1Vzv6AZYB0>

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