CST 304	COMPUTER GRAPHICS AND IMAGE PROCESSING	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble:
The purpose of this course is to make awareness about strong theoretical relationships between computer graphics and image processing. This course helps the learner to understand three-dimensional environment representation in a computer, transformation of 2D/3D objects, basic mathematical techniques and algorithms used to build useful applications, imaging, and image processing techniques. The study of computer graphics and image processing develops the ability to create image processing frameworks for different domains and develops algorithms for emerging display technologies.

Prerequisite: A sound knowledge of Mathematics and a programming language.

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Describe the working principles of graphics devices**(Cognitive Knowledge level: Understand)**
CO2	Illustrate line drawing, circle drawing and polygon filling algorithms(Cognitive Knowledge level: Apply)
CO3	Demonstrate geometric representations, transformations on 2D & 3D objects, clipping algorithms and projection algorithms(Cognitive Knowledge level: Apply)
CO4	Summarize visible surface detection methods(Cognitive Knowledge level: Understand)
CO5	Summarize the concepts of digital image representation, processing and demonstrate pixel relationships(Cognitive Knowledge level: Apply)
CO6	Solve image enhancement and segmentation problems using spatial domain techniques(Cognitive Knowledge level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓								✓
CO4	✓		✓									✓
CO5	✓	✓	✓	✓								
CO6	✓	✓	✓	✓		✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30

Apply	**40**	**40**	**40**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests (Average of SeriesTests1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one full question. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module – 1(Basics of Computer graphics and Algorithms)

Basics of Computer Graphics and its applications. Video Display devices- Refresh Cathode Ray Tubes, Random Scan Displays and systems, Raster scan displays and systems. Line drawing algorithms- DDA, Bresenham's algorithm. Circle drawing algorithms- Midpoint Circle generation algorithm, Bresenham's algorithm.

Module - 2(Filled Area Primitives and transformations)

Filled Area Primitives- Scan line polygon filling, Boundary filling and flood filling. Two dimensional transformations-Translation, Rotation, Scaling, Reflection and Shearing, Composite transformations, Matrix representations and homogeneous coordinates. Basic 3D transformations.

Module - 3 (Clipping and Projections)

Window to viewport transformation. Cohen Sutherland Line clipping algorithm. Sutherland Hodgeman Polygon clipping algorithm. Three dimensional viewing pipeline. Projections- Parallel and Perspective projections. Visible surface detection algorithms- Depth buffer algorithm, Scan line algorithm.

Module - 4 (Fundamentals of Digital Image Processing)

Introduction to Image processing and applications. Image as 2D data. Image representation in Gray scale, Binary and Colour images. Fundamental steps in image processing. Components of image processing system. Coordinate conventions. Sampling and quantization. Spatial and Gray Level Resolution. Basic relationship between pixels– neighbourhood, adjacency, connectivity. Fundamentals of spatial domain-convolution operation.

Module - 5 (Image Enhancement in Spatial Domain and Image Segmentation)

Basic gray level transformation functions - Log transformations, Power-Law transformations, Contrast stretching. Histogram equalization. Basics of spatial filtering - Smoothing spatial filter-Linear and nonlinear filters, and Sharpening spatial filters-Gradient and Laplacian.

Fundamentals of Image Segmentation. Thresholding - Basics of Intensity thresholding and Global Thresholding. Region based Approach - Region Growing, Region Splitting and Merging. Edge Detection - Edge Operators- Sobel and Prewitt.

Text Book

1. Donald Hearn and M. Pauline Baker, Computer Graphics, PHI, 2e, 1996
2. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. Pearson, 4e, 2017

References

1) William M. Newman and Robert F. Sproull, Principles of Interactive Computer Graphics. McGraw Hill, 2001

2) Zhigang Xiang and Roy Plastock, Computer Graphics (Schaum's outline Series), McGraw Hill, 2019.
3) David F. Rogers , Procedural Elements for Computer Graphics, Tata McGraw Hill,2001.
4) M. Sonka, V. Hlavac, and R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson India Edition, 4e, 2017.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare the working principle of raster scan systems and random scan systems.
2. How much time is spent scanning across each row of pixels during screen refresh on a raster system with resolution of 1280*1024 and a refresh rate of 60 frames per second?

Course Outcome 2 (CO2):

1. Rasterize the line with end points(2,3) and (5,8) using Bresenham's line drawing algorithm.
2. Explain how the 4-connected area filling approach differs from 8- connected area filling in boundary filling algorithm

Course Outcome 3 (CO3):

1. Rotate a triangle ABC 45 degree counter clockwise about the pivot point (10,3), where the position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3).
2. Given a clipping window A(20,20), B(60,20), C(60,40) and D(20,40). Using Cohen Sutherland algorithm, find the visible portion of the line segment joining the points P(40,80) and Q(120,30)

Course Outcome 4 (CO4):

1. Explain scan line algorithm for detecting visible surfaces in an object.

Course Outcome 5 (CO5):

1. Give an image representation model and describe how the representation changes in grayscale, binary and colour images.
2. Consider an image segment shown below.

3 1 2 1 (q)

2 2 0 2

1 2 1 1

(p) 1 0 1 2

(a) Let V={0,1} and compute the length of the shortest 4-,8- and m- path between p and q. If a particular path does not exist between these two points , explain why?

(b) Repeat for V={1,2}.

3. The spatial resolution of an image is given by 128 X 128.What is its storage requirements if it is represented by 64 gray levels?

Course Outcome 6 (CO6):

1. A skilled medical technician is charged with the job of inspecting a certain class of monochrome images generated by electronic microscope. To facilitate the inspection, the technician uses image processing aids. However when he examines the images he finds the following problems.
   (a) Presence of bright isolated dots that are not of interest.
   (b) Lack of sharpness
   (c) Poor contrast

   Identify the sequence of preprocessing steps that the technician may use to overcome the above mentioned problems and explain it.

2. A 4x4, 4 bits/pixel original image is given by

10	12	8	9
10	12	12	14
12	13	10	9
14	12	10	12

   (a) Apply histogram equalisation to the image by rounding the resulting image pixels to integers
   (b) Sketch the histogram of the original image and the histogram-equalised image.
3. You have Sobel operator and Laplacian operator for edge detection. Which operator will you select for edge detection in the case of noisy image? Explain.**(Assignment)**

Model Question Paper

QP CODE:

Reg No: _____

Name: _____ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 304

Course Name: Computer Graphics and Image Processing

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Justify the approach of using integer arithmetic in Bresenham's line drawing algorithm.

2. Consider a raster system with a resolution of 1024*1024. What is the size of the raster needed to store 4 bits per pixel? How much storage is needed if 8 bits per pixel are to be stored?

3. Show that two successive reflections about either of the coordinate axes is equivalent to a single rotation about the coordinate origin.

4. Determine a sequence of basic transformations that are equivalent to the x-direction shearing matrix.

5. Find the window to viewport normalization transformation with window lower left corner at (1,1) and upper right corner at (2,6).

6. Find the orthographic projection of a unit cube onto the x=0, y=0 and z=0 plane.

7. Define Sampling and Quantization of an image.

8. Give any three applications of digital image processing.

9. A captured image appears very dark because of wrong lens aperture setting. Describe an enhancement technique which is appropriate to enhance such an image.

10. Suggest an approach of thresholding that should be used in case of uniform illumination. **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Write Midpoint circle drawing algorithm and use it to plot a circle with radius=20 and center is (50,30). **(10)**

(b) Draw the architecture of raster scan display systems and explain its working principle. **(4)**

OR

12. (a) Derive the initial decision parameter of Bresenham's line drawing algorithm and use the algorithm to rasterize a line with endpoints (2,2) and (10,10). **(10)**

(b) Explain the working principle of color CRT monitors with suitable illustrations. **(4)**

13. (a) Compare boundary fill algorithm and flood fill algorithm. **(5)**

(b) Reflect a triangle ABC about the line 3x-4y+8=0. The position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3). **(9)**

OR

14. (a) Explain the need of using vanishing points in projections. **(4)**

(b) Explain Cohen-Sutherland line clipping algorithm. Use the algorithm to clip line P1(70, 20) and P2(100,10) against a window lower left hand corner (50,10) and upper right hand corner (80,40). **(10)**

15. (a) Describe Sutherland Hodegman polygon clipping algorithm and what are its **(7)**

limitations.

(b) Explain how visible surfaces can be detected using depth buffer algorithm. **(7)**

OR

16. (a) Describe Sutherland Hodegman polygon clipping algorithm and what are its limitations. **(7)**

(b) Explain how visible surfaces can be detected using depth buffer algorithm. **(7)**

17. (a) Explain the components of an image processing system with suitable diagram **(9)**

(b) Define Resolution of an image. Explain the spatial and gray level resolution of an image with an example. **(5)**

OR

18. (a) Define 4-adjacency, 8 adjacency and m-adjacency. Consider the image segment shown. **(7)**

	4	2	3	2 (q)
	3	3	1	3
	2	3	2	2
(p)	2	1	2	3

Let V={1,2} and compute the length of the shortest 4- ,8- and m- path between p and q. If a particular path does not exist between these two points, explain why?

(b) Using any one application, explain the steps involved in image processing. **(7)**

19. (a) A 5x5 image patch is shown below. Compute the value of the marked pixel if it is smoothened by a 3x3 average filter and median filter. **(4)**

$$f(m,n)=\begin{pmatrix} 0 & 1 & 2 & 3 & 2 \\ 5 & 6 & 7 & 8 & 4 \\ 4 & 3 & \textcircled{2} & 1 & 2 \\ 8 & 7 & 6 & 5 & 3 \\ 1 & 5 & 3 & 7 & 6 \end{pmatrix}$$

(b) Define Image segmentation and describe in detail method of edge and region based segmentation technique. **(10)**

OR

20. (a) Distinguish between smoothing and sharpening filters in terms of **(10)**

(i) Functionality
(ii) Types
(iii) Applications
(iv) Mask Coefficients

(b) Describe how an image is segmented using split and merge technique in association with the region adjacency graph. **(8)**

Teaching Plan

No	Contents	No of Lecture Hrs (45 hrs)
Module – 1 (Basics of Computer Graphics and Algorithms) (9 hrs)		
1.1	Basics of Computer Graphics and applications	1 hour
1.2	Refresh Cathode Ray Tubes	1 hour
1.3	Random Scan Displays and systems	1 hour
1.4	Raster scan displays and systems	1 hour
1.5	DDA Line drawing Algorithm	1 hour
1.6	Bresenham's line drawing algorithm	1 hour
1.7	Midpoint Circle generation algorithm	1 hour
1.8	Bresenham's Circle generation algorithm	1 hour
1.9	Illustration of line drawing and circle drawing algorithms	1 hour
Module - 2 (Filled Area Primitives and transformations) (9 hrs)		
2.1	Scan line polygon filling	1 hour
2.2	Boundary filling and flood filling	1 hour
2.3	Basic 2D transformations-Translation	1 hour

2.4	Basic 2D transformations- Rotation and Scaling	1 hour
2.5	Reflection and Shearing	1 hour
2.6	Composite transformations	1 hour
2.7	Matrix representations and homogeneous coordinates	1 hour
2.8	Basic 3D transformation-Translation and scaling	1 hour
2.9	Basic 3D transformation-Rotation	1 hour
Module - 3 (Clipping and Projections) (8 hrs)		
3.1	Window to viewport transformation	1 hour
3.2	Cohen Sutherland Line clipping algorithm	1 hour
3.3	Sutherland Hodgeman Polygon clipping algorithm	1 hour
3.4	Practice problems on Clipping algorithms	1 hour
3.5	Three dimensional viewing pipeline, Projections-Parallel projections	1 hour
3.6	Projections- Perspective projections	1 hour
3.7	Visible surface detection algorithms- Depth buffer algorithm	1 hour
3.8	Scan line visible surface detection algorithm	1 hour
Module - 4 (Fundamentals of Digital Image Processing) (8 hrs)		
4.1	Introduction to Image processing-Image as a 2D data, Image representation-Gray scale, Binary and Colour images.	1 hour
4.2	Fundamental steps in image processing and applications	1 hour
4.3	Components of image processing system	1 hour
4.4	Coordinate conventions, Sampling and quantization, Spatial and Gray Level Resolution	1 hour
4.5	Basic relationship between pixels – neighbourhood, adjacency, connectivity	1 hour
4.6	Illustration of basic relationship between pixels– neighbourhood,	1 hour

	adjacency, connectivity	
4.7	Fundamentals of spatial domain - Convolution operation	1 hour
4.8	Illustration of Convolution operation	1 hour
Module - 5 (Image Enhancement in spatial domain and Image Segmentation) (11 hrs)		
5.1	Basic gray level transformation functions- Log transformations.	1 hour
5.2	Power-Law transformations, Contrast stretching	1 hour
5.3	Histogram equalization	1 hour
5.4	Illustration of Histogram equalization	1 hour
5.5	Basics of spatial filtering, Smoothing spatial filter- Linear and nonlinear filters	1 hour
5.6	Sharpening spatial filtering-Gradient filter mask	1 hour
5.7	Sharpening spatial filtering-Laplacian filter mask	1 hour
5.8	Fundamentals of Image Segmentation, Basics of Intensity thresholding, Basic Global Thresholding	1 hour
5.9	Region Based Approach- Region Growing, Region Splitting and Merging	1 hour1
5.10	Basics of Edge Detection	1 hour
5.11	Sobel and Prewitt edge detection masks	1 hour