FLAME UNIVERSITY

EVERLASTING *learning*

FUNDAMENTALS OF COMPUTER GRAPHICS (CSIT304)

INTRODUCTION

CHIRANJOY CHATTOPADHYAY

Associate Professor,

FLAME School of Computation and Data Science

COURSE OVERVIEW AND PLAN

COURSE OBJECTIVES AND LEARNING OUTCOMES

OBJECTIVES

- To introduce computer graphics techniques
- To develop algorithms for 2D and 3D modeling
- To render and synthesize images and videos
- Introduce OpenGL Library and its usage
- Introduce 3D Graphics Modelling Software

OUTCOMES

- Write programs using OpenGL Library
- Explain and implement the mathematical properties of graphical objects
- Develop 2D games using Graphics Gaming Library
- Demonstrate 3D computer graphics animation

SEMESTER TEACHING PLAN

January 2024		February 2024		March 2024		April 2024	
Date	Topic	Date	Topic	Date	Topic	Date	Topic
1 Jan 2024		1 Feb 2024	L8 - 3D Transformation	1 Mar 2024	DIP	1 Apr 2024	
2 Jan 2024		2 Feb 2024		2 Mar 2024		2 Apr 2024	L22 - Blender (3D Model Creation)
3 Jan 2024		3 Feb 2024		3 Mar 2024		3 Apr 2024	
4 Jan 2024		4 Feb 2024		4 Mar 2024		4 Apr 2024	L23 - Blender (Lights and Shading)
5 Jan 2024		5 Feb 2024		5 Mar 2024	L15 - Curves	5 Apr 2024	
6 Jan 2024		6 Feb 2024	L9 - 3D Transformation	6 Mar 2024		6 Apr 2024	
7 Jan 2024		7 Feb 2024		7 Mar 2024	L16 - Curves	7 Apr 2024	
8 Jan 2024		8 Feb 2024	L10 - 3D Projection - 1	8 Mar 2024		8 Apr 2024	
9 Jan 2024	L1 - Introduction, Installation OpenGL	9 Feb 2024		9 Mar 2024		9 Apr 2024	Gudi Padwa
10 Jan 2024		10 Feb 2024		10 Mar 2024		10 Apr 2024	
11 Jan 2024	L2 - Scan Converting Lines	11 Feb 2024		11 Mar 2024		11 Apr 2024	Ramzam
12 Jan 2024		12 Feb 2024		12 Mar 2024	L17 - Curves	12 Apr 2024	
13 Jan 2024		13 Feb 2024	L11 - 3D Projection-2	13 Mar 2024		13 Apr 2024	
14 Jan 2024		14 Feb 2024		14 Mar 2024	L18 - Surface	14 Apr 2024	
15 Jan 2024		15 Feb 2024	L12 - 3D Clipping	15 Mar 2024		15 Apr 2024	
16 Jan 2024	L3 - Scan Conversion (Circle, Ellipse)	16 Feb 2024		16 Mar 2024		16 Apr 2024	L24 - Blender (Animation)
17 Jan 2024		17 Feb 2024		17 Mar 2024		17 Apr 2024	
18 Jan 2024	L4 - 2D Transformation	18 Feb 2024		18 Mar 2024		18 Apr 2024	L25 - Q4 (Blender)
19 Jan 2024		19 Feb 2024		19 Mar 2024	L19 - Surface	19 Apr 2024	
20 Jan 2024		20 Feb 2024	L13 – Problem Solving	20 Mar 2024		20 Apr 2024	
21 Jan 2024		21 Feb 2024		21 Mar 2024		21 Apr 2024	Mahabir Jayanti
22 Jan 2024		22 Feb 2024	L14 - Q2 - Blender	22 Mar 2024		22 Apr 2024	
23 Jan 2024	L5 - 2D Viewing and Clipping	23 Feb 2024		23 Mar 2024		23 Apr 2024	L26 - Presentation + Demo + Viva
24 Jan 2024		24 Feb 2024		24 Mar 2024		24 Apr 2024	
25 Jan 2024	L6 - 2D Viewing and Clipping	25 Feb 2024		25 Mar 2024	Holi	25 Apr 2024	L27 - Presentation + Demo + Viva
26 Jan 2024	Republic Day	26 Feb 2024	DIP	26 Mar 2024	L20 - VSD	26 Apr 2024	
27 Jan 2024		27 Feb 2024	DIP	27 Mar 2024		27 Apr 2024	
28 Jan 2024		28 Feb 2024	DIP	28 Mar 2024	L21 - Q3, Blender	28 Apr 2024	
29 Jan 2024		29 Feb 2024	DIP	29 Mar 2024	Good Friday	29 Apr 2024	
30 Jan 2024	L7 - Q1, Introduction to Blender			30 Mar 2024		30 Apr 2024	End Sem
31 Jan 2024				31 Mar 2024			

SYLLABUS/ COURSE OUTLINE

Course content

- Introduction to computer graphics & graphics system: Overview of computer graphics, representing pictures, preparing, presenting & interacting with pictures for presentations
- Scan conversion: Points & lines, Line drawing algorithms, Circle generation algorithm; Ellipse generating algorithm; scan line polygon, fill algorithm, boundary fill algorithm, flood fill algorithm. Clipping algorithms: line and polygon, anti-aliasing
- Transformations and viewing: Basic transformations: translation, rotation, scaling; Matrix representations & homogeneous coordinates, transformations between coordinate systems; reflection shear. Viewing pipeline, Window to viewport co-ordinate transformation, clipping operations, viewport clipping, 3D viewing.
- Curves and Surfaces: Conics, parametric and non-parametric forms; Bezier (Bernstein Polynomials) Curves, Cubic-Splines, B-Splines; Quadratic surfaces, Bezier surfaces and NURBS, 3-D modeling
- Hidden surfaces: Depth comparison, Z-buffer algorithm, Back face detection, BSP tree method, the Painter's Algorithm, scan-line algorithm; Hidden line elimination, wire frame methods , fractal - geometry
- Color & shading models: Phong's shading model, Gouraud shading, Shadows and background, Color models, Photo-realistic rendering
- Animation and OpenGL primitives: Functions, pipeline, sample programs for drawing 2-D, 3-D objects; event handling and view manipulation, Introduction to GPU and animation

Refer Moodle

GRADING/ EVALUATION PLAN

Sl. No	Component	Assessment Type	Weightage
1	Quiz (Best 3 out of 4)	Continuous	30
2	Assignment/ Project (Individual)		
a	OpenGL	Comprehensive	10
b	Blender	Comprehensive	10
c	Presentation	Comprehensive	5
d	Report	Comprehensive	5
4	Classwork	Continuous	20
5	Homework	Continuous	10
6	Viva	Comprehensive	10
		Total	**100**

IMPORTANT DATES

Date	Purpose	Date	Purpose
30 January	Quiz 1	31 March	OpenGL Project Submission
22 February	Quiz 2	21 April	Blender Project Submission
26, 28 February	DIP (No Class)	23 April – 25 April	PROJECT DEMO, VIVA
28 March	Quiz 3	4 May	Updated/ Final Submission
18 April	Quiz 4		

INTRODUCTION

WHAT IS COMPUTER GRAPHICS?

- Creation, Manipulation, and Storage of geometric objects (modelling) and their images (rendering)
- Display those images on screens or hardcopy devices
- Image processing
- Others: GUI, Haptics, Displays (VR)...

PURPOSE OF COMPUTER GRAPHICS?

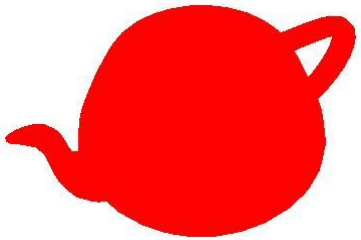
Communication is the purpose

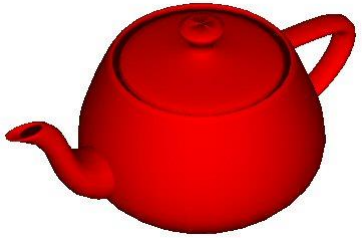
Human perception is the context

- Techniques *leverage* visual perception abilities

Fidelity is a tool, not (necessarily) the goal

- Virtual reality is great, but
- Don't want to be limited to reality
  - Want to do super reality
  - Non-photorealistic rendering (NPR) is valuable
    - Bill Buxton, *Sketching User*
- **No apology is required for "approximations"**
  - Especially for interactive

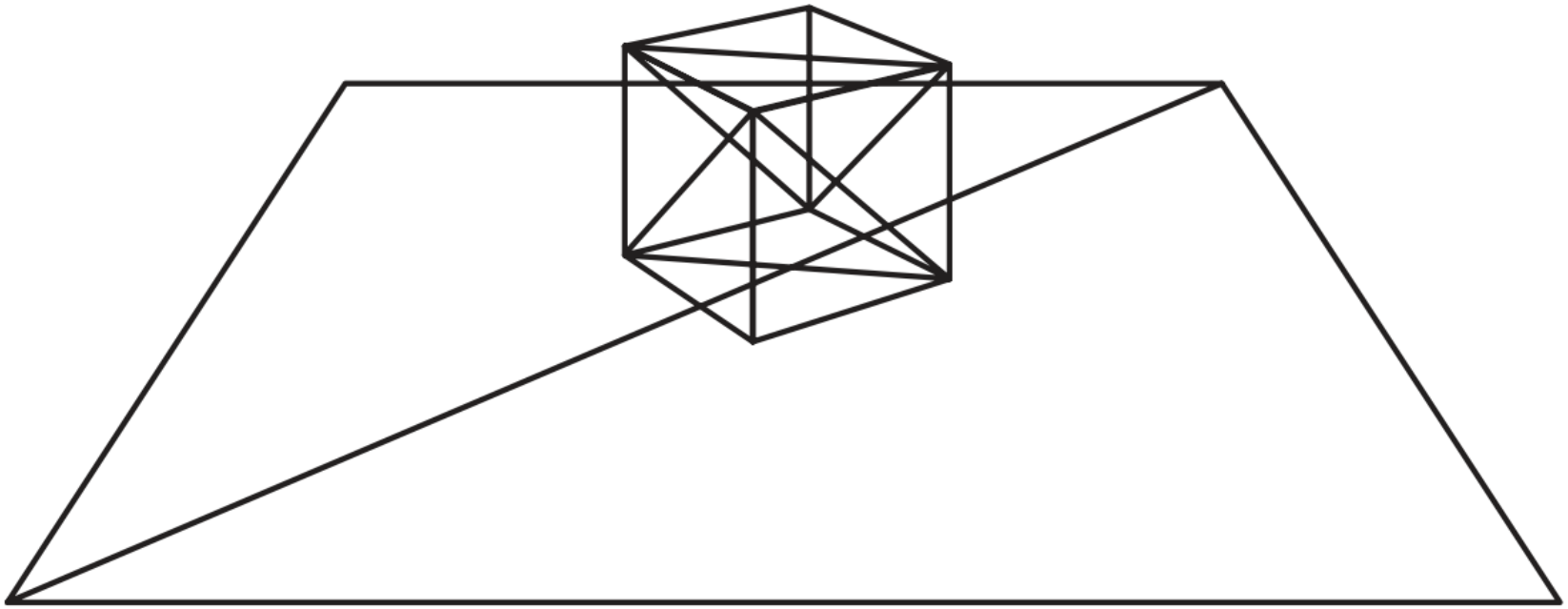




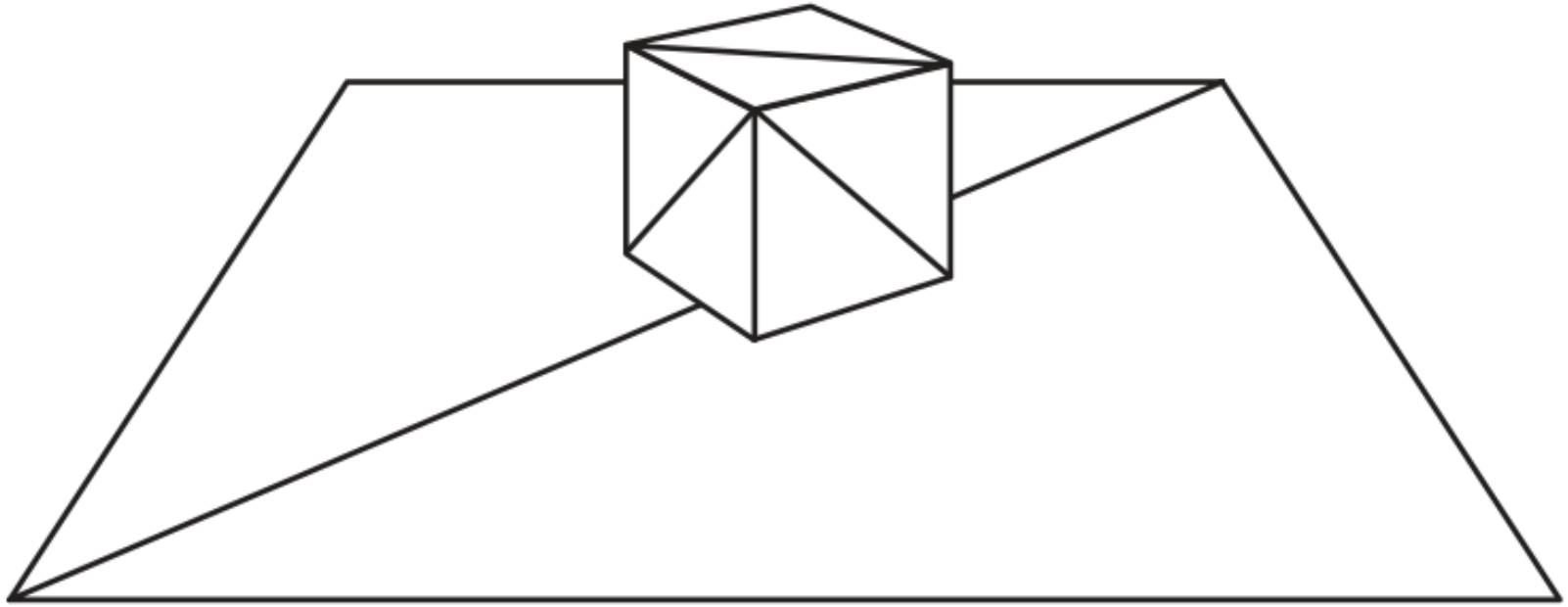
TENTATIVE FLOW OF THE COURSE

Month	Topics
January	• Intro to OpenGL • 2D Graphics • 3D Graphics • Viewing • Scan Conversion
February	• Clipping • Curves and Surfaces • Tessellation
March	• Solid Modeling • Rendering • Visible Surface Detection
April	• Illumination and Shedding • Animations

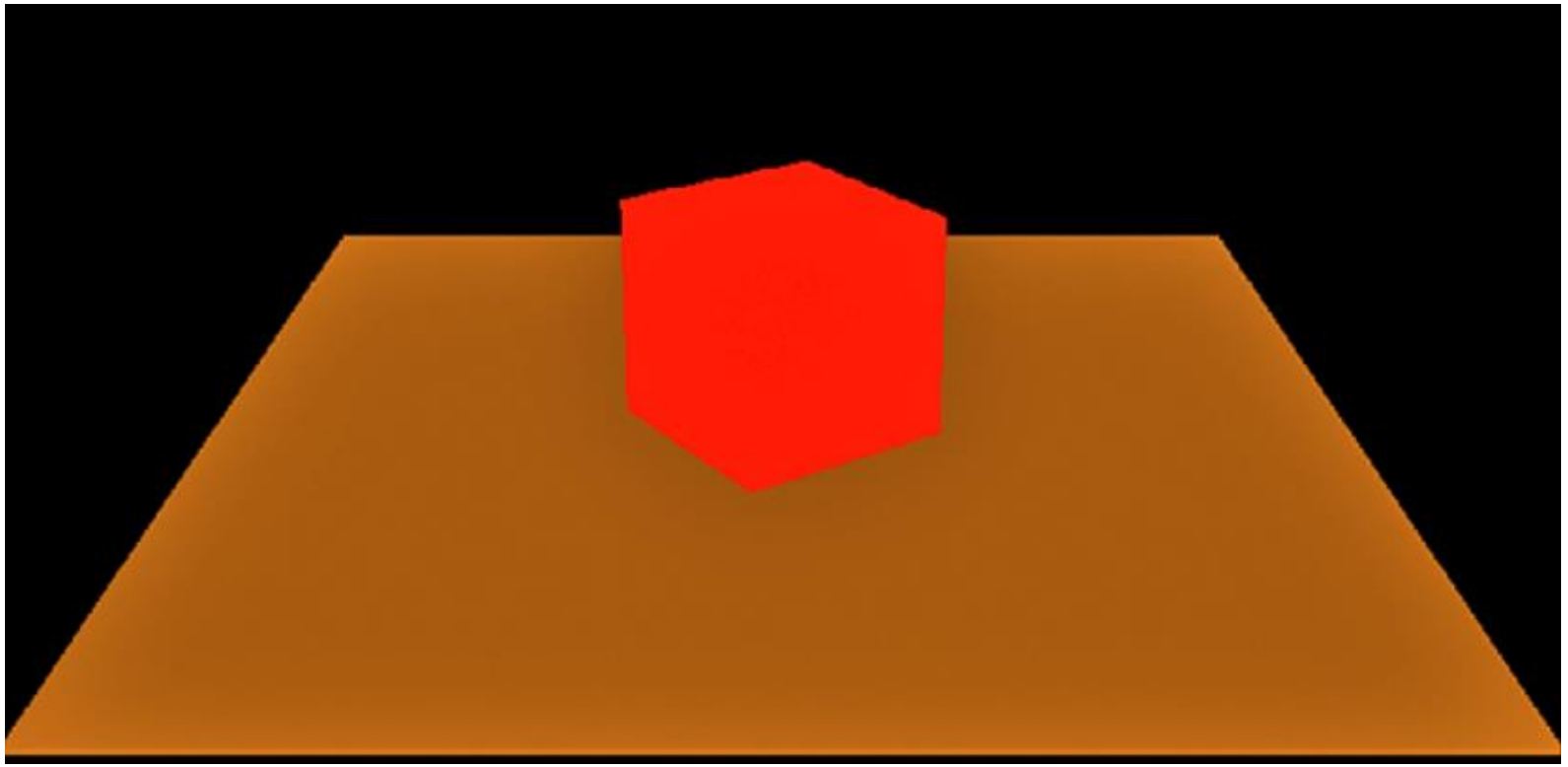
ILLUSTRATION



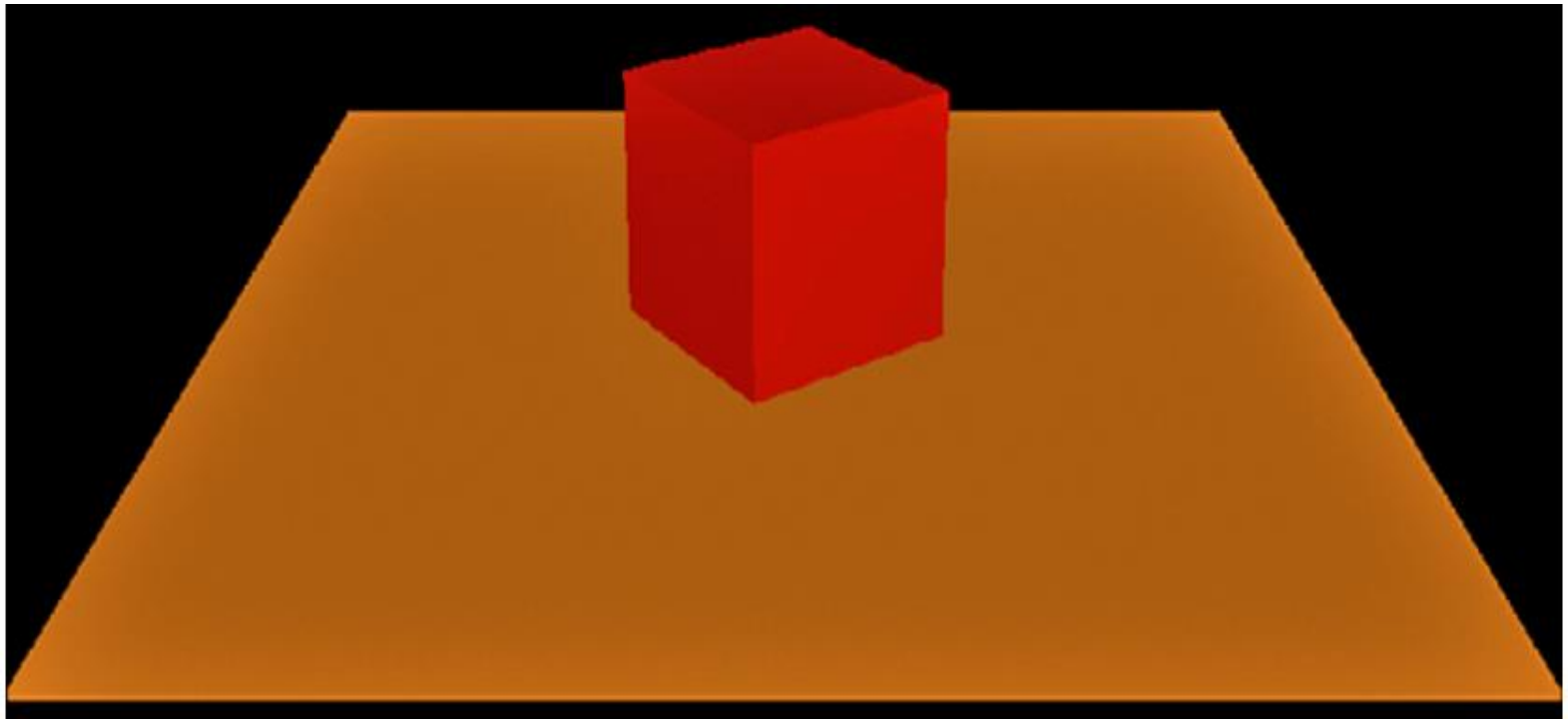
HIDDEN SURFACE REMOVAL



COLORING



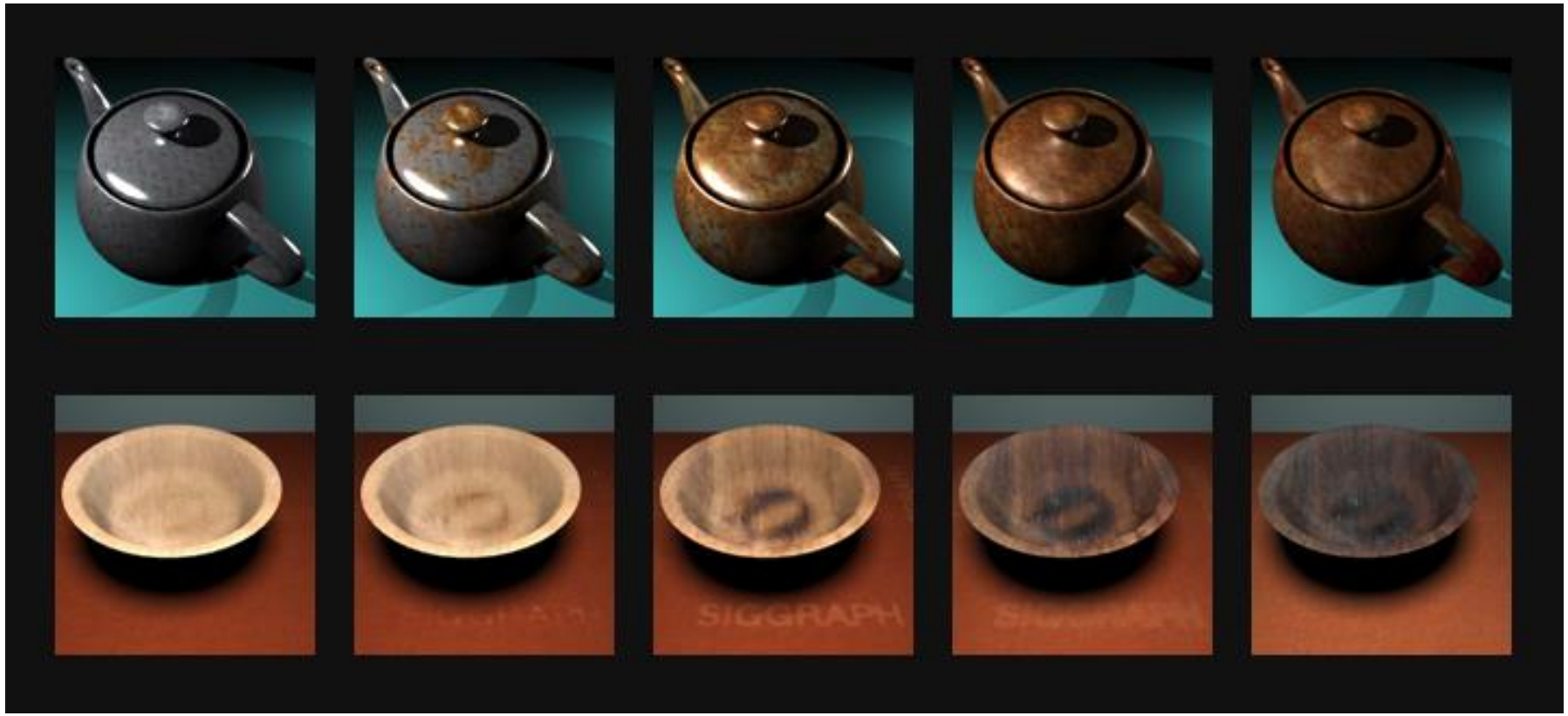
SHADING



TEXTURE MAPPING

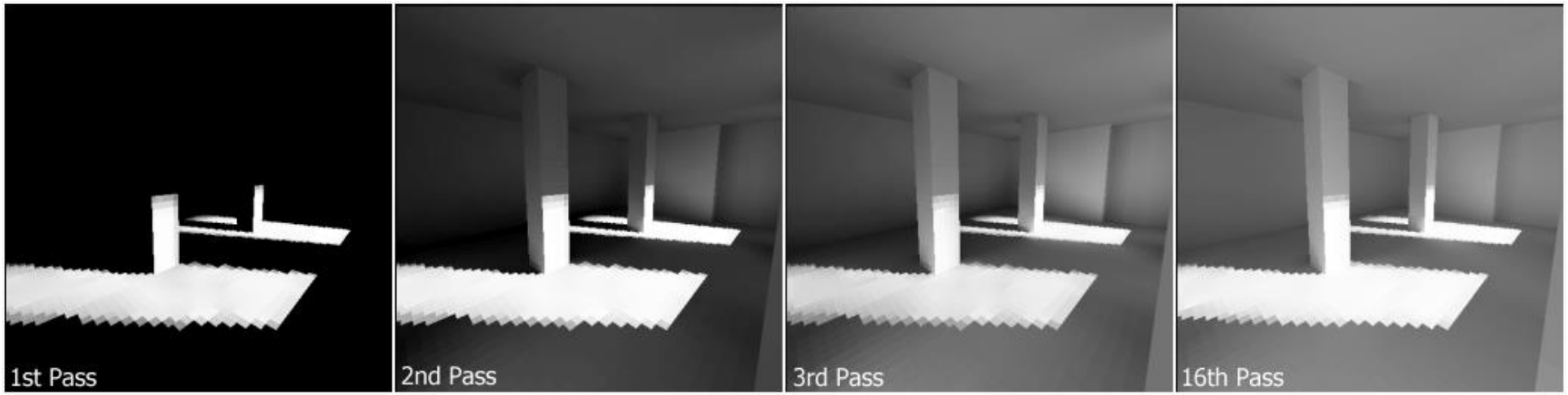
BLENDING

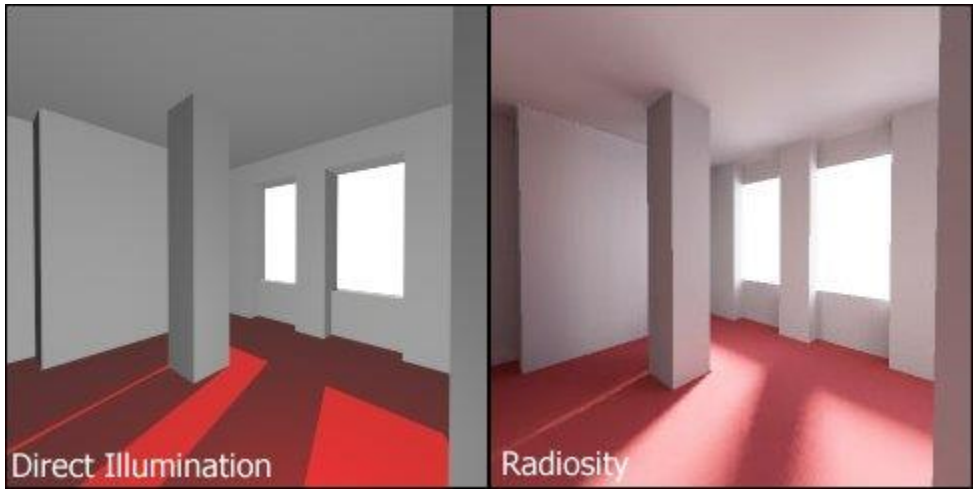
RENDERING EXAMPLE



Time-varying Surface Appearance: Acquisition, Modeling, and Rendering, SIGGRAPH 2006

REALISTIC RENDERING





EVALUATION PATTERN

- Different components to be considered for final grading
  - End semester
  - Quiz (3 best out of 4)
  - Assignments
  - Viva
- Weightage for individual components TBA

WHAT IS CG? (1/2)

- Term coined in 1960, by William Fetter

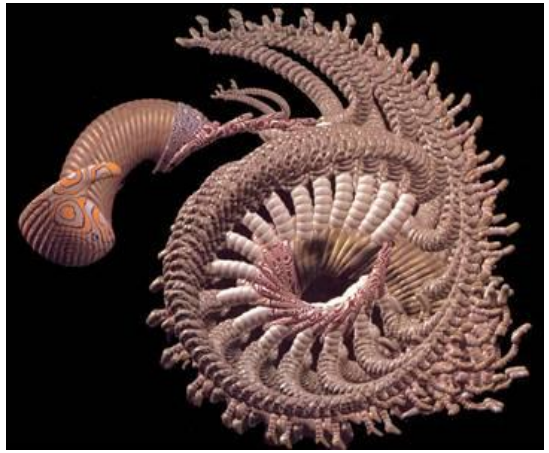
- To describe new design methods he was pursuing at Boeing for cockpit ergonomics

- Created a series of widely reproduced images on “pen plotter” exploring cockpit design, using 3D model of human body.

WHAT IS CG? (2/2)

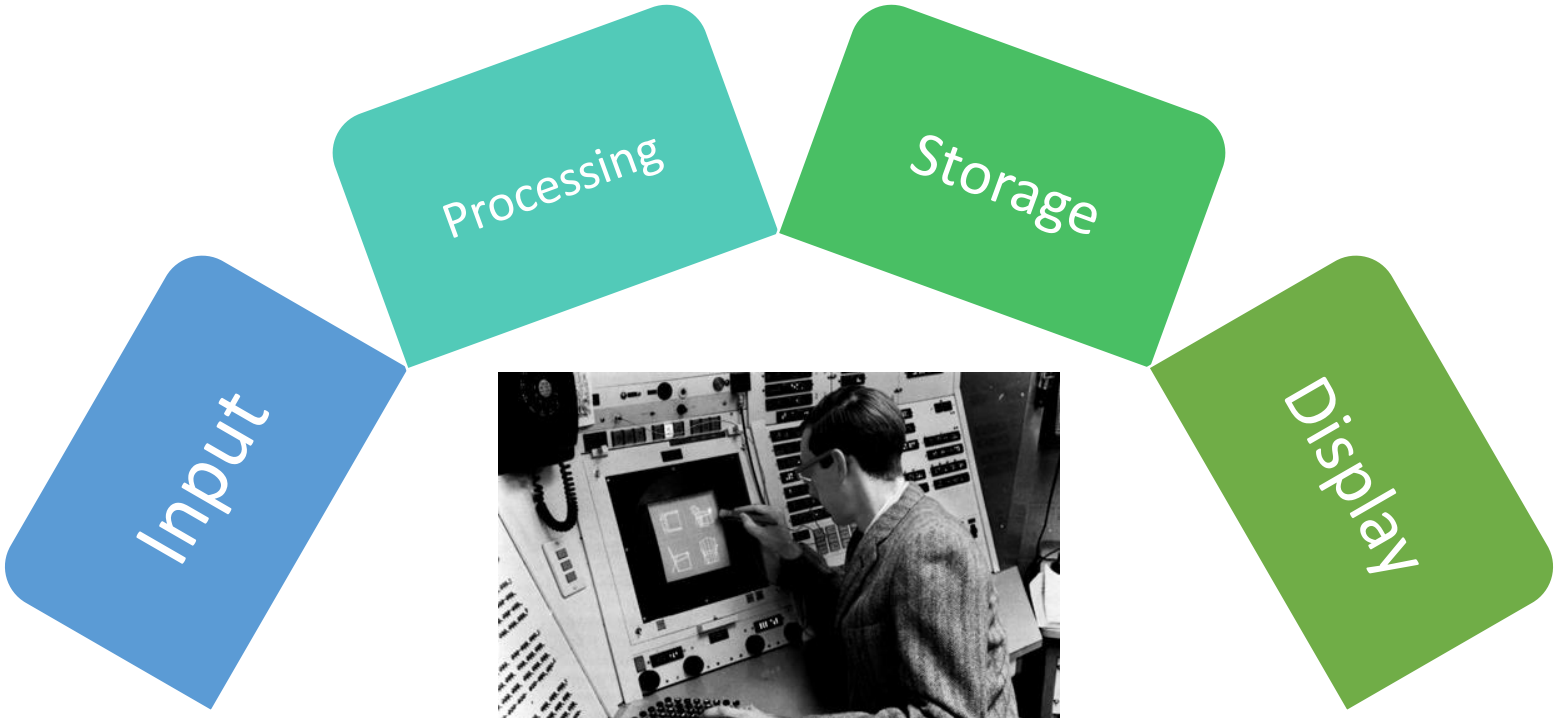
- Creation, storage and manipulation of models and images
- Such models come from
  - Diverse and expanding set of fields
  - E.g. physical, biological, mathematical, artistic, and conceptual/abstract structures

Frame from animation by William Latham, shown at **SIGGRAPH 1992**. Latham creates his artwork using rules that govern patterns of natural forms.



WHAT IS INTERACTIVE COMPUTER GRAPHICS?

- User controls content, structure, and appearance of objects and their displayed images via rapid visual feedback



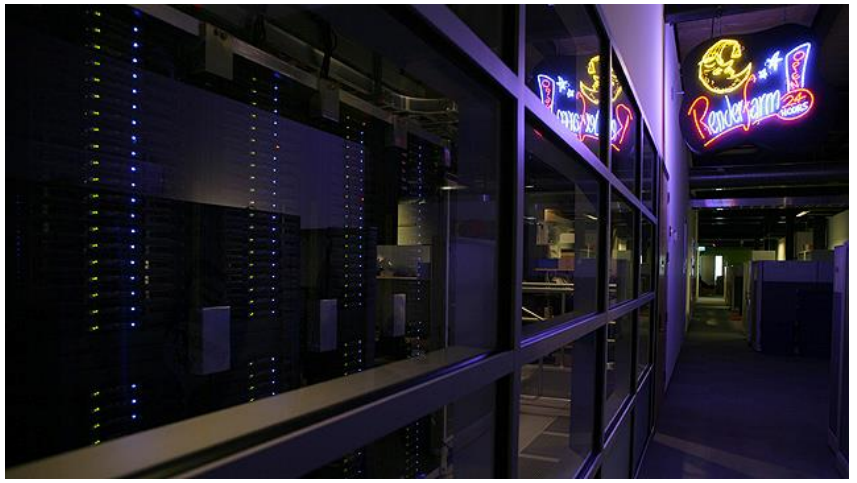
First truly interactive graphics system, **Sketchpad**, pioneered by Ivan Sutherland 1963 Ph.D. thesis *Sketchpad, A Man-Machine Graphical Communication System*

SKETCHPAD DEMO

WHAT IS BATCH COMPUTER GRAPHICS?

- Today, still use non-interactive batch mode for final production-quality video and film (special effects – FX).
- Rendering a single frame of Monsters University (a 24 fps movie) averaged 29 hours on a 24,000-core render farm!

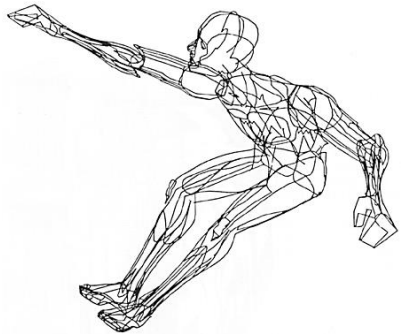
Still from Monsters University



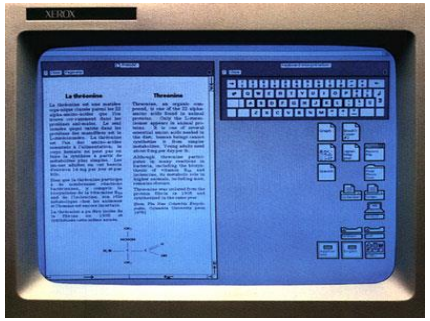
Render farm

ENVIRONMENTAL EVOLUTION

(1960s – now)

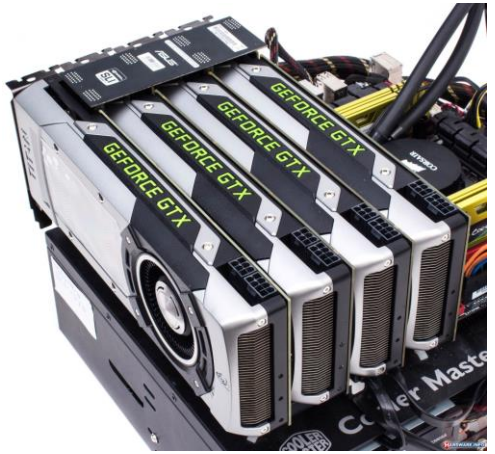


Displays (1963 – 1980s)



(1972 at Xerox PARC - now)

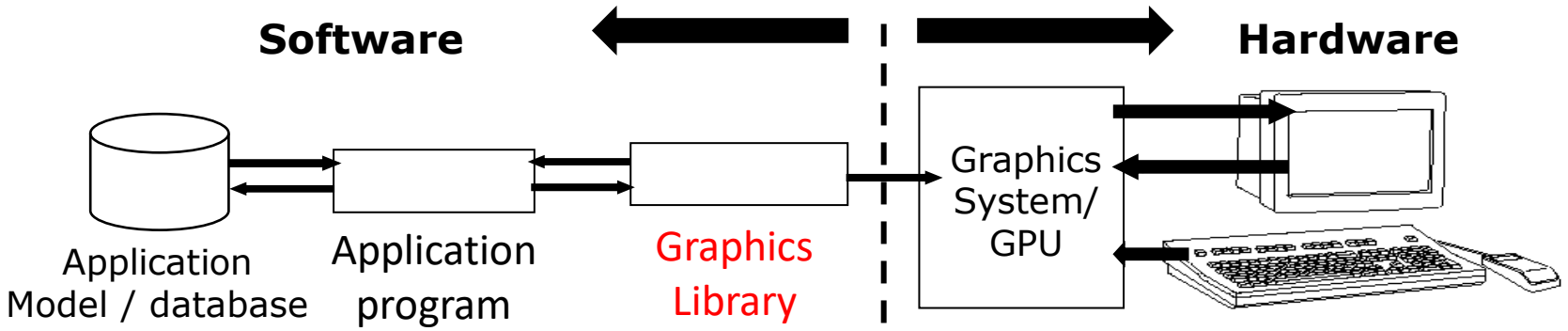
3D graphics workstations (1984 at SGI – now)



You can put multiple GPUs together in your computer using SLI.

CONCEPTUAL FRAMEWORK

- Graphics library/package is **intermediary** between application and display hardware
- Application program maps objects to views (images) of those objects by calling on graphics library.
- Application model may contain lots of non-graphical data (e.g., object properties)
- User interaction results in modification of image and/or model



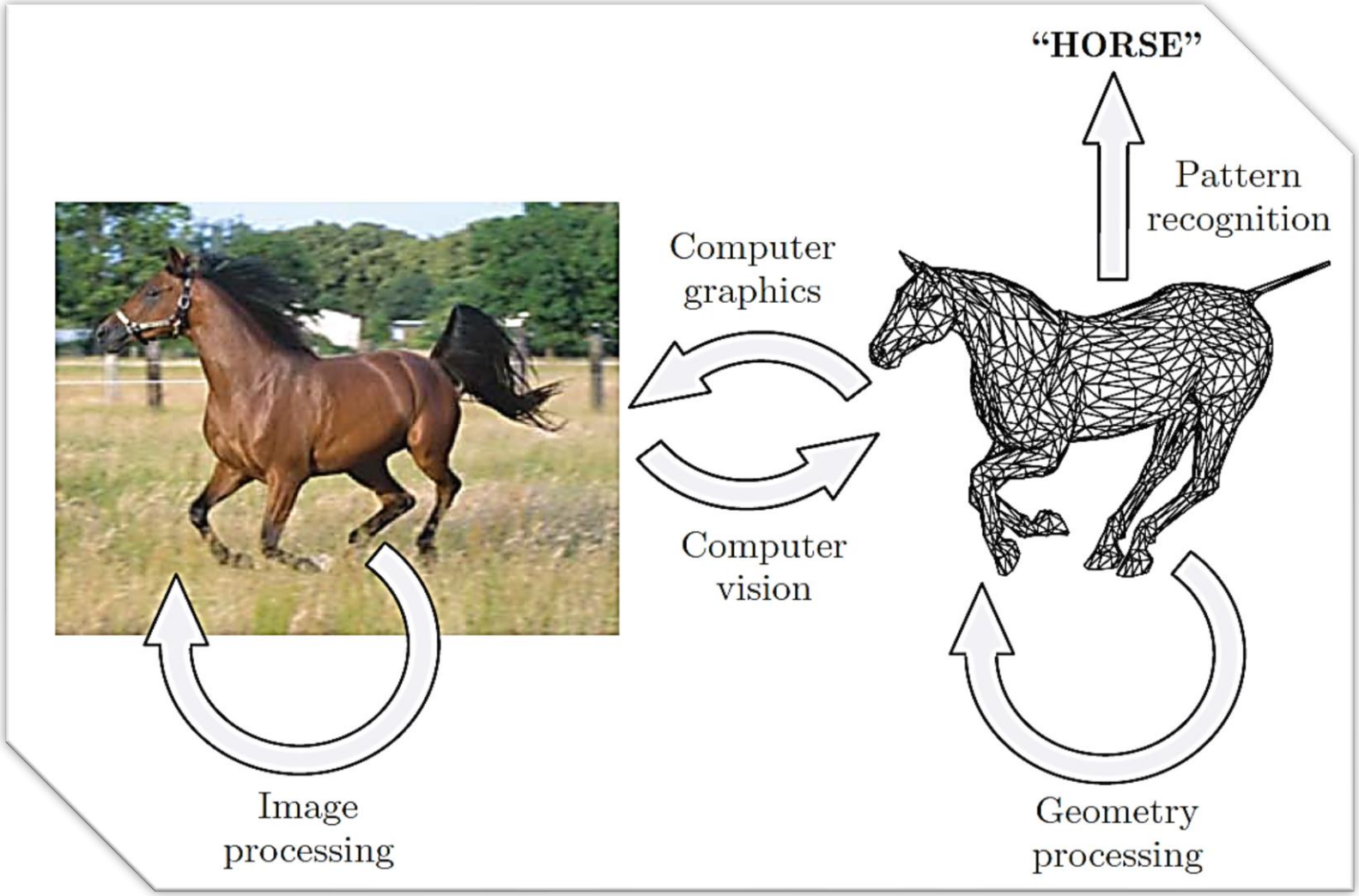
GRAPHICS LIBRARY

- Examples: OpenGL™, DirectX™, Windows Presentation Foundation™ (WPF), RenderMan™, HTML5 + WebGL™
- Primitives (characters, lines, polygons, meshes,…)
- Attributes
  - Color, line style, material properties for 3D
- Lights
- Transformations
- Immediate mode vs. retained mode
- Immediate mode: no stored representation, package holds only attribute state, and application must completely draw each frame
- Retained mode: library compiles and displays from scenegraph that it maintains, a complex DAG. It is a display-centered extract of the Application Model

PREREQUISITE OF THE COURSE

- You need to be interested in programming
- Keen on doing mathematical calculation
- Having knowledge of linear algebra
  - vector and matrix arithmetic, dot and cross products
- Self motivated

SOME RELATED FIELD



OPENGL INSTALLATION

INSTALLATION GUIDELINES

- Please refer moodle

FLAME UNIVERSITY | EVERLASTING learning

THANK YOU