Introduction à l'Informatique Graphique

Introduction

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Contact Information

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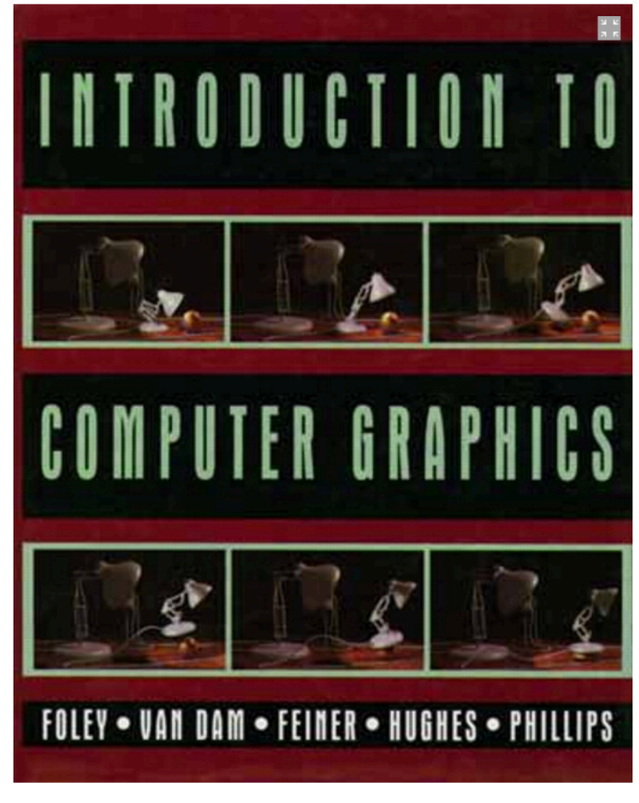
Always send an email before coming to my office !

Resources



- Book: Introduction to Computer Graphics / Introduction à l'infographie. James Foley, Andries van Dam, Steven K. Feiner, John F. Hughes and Richard L. Phillips. Addison-Wesley.
- Slides: Adapted from Andries van Dam

Lecture Webpage

- **ENT : INF2110 - Introduction à l'Informatique Graphique**

INF2110 - Introduction à l'Informatique Graphique

Le premier cours aura lieu lundi 25 septembre, a 14h.

Volume horaire
CM : 20H, TP : 22H

Crédits
ECTS : 5

Objectifs
Ce cours est une introduction à l'informatique graphique. Il s'agit de comprendre comment dessiner des primitives 2D à l'écran, puis comment modéliser et transformer une scène 3D pour l'afficher sur un écran 2D. Une fois les bases posées, nous verrons comment modéliser des objets plus complexes et comment leur associer des matériaux afin de leur donner un aspect plus ou moins métallique et de les colorer. Ces notions seront mises en pratiques avec OpenGL et GLSL.

MCC
Session 1: 0.3*CP + 0.7*CC
Session 2: 0.3*CP + 0.7*max(CT, (CC+CT) / 2)

Fraude

- La copie directe d'information sans citation de sources constitue un plagiat et est par conséquent considérée comme une fraude par l'Université.
- Le partage de code ou de TP, ou la préparation en groupe d'un TP individuel est considérée comme une fraude par l'Université.

Toute fraude (plagiat, copie de TP, tricherie pendant un contrôle…) entraine un rapport suivi d'un conseil de discipline.

Fraude

Une fraude (plagiat ou triche) peut entraîner les conséquences suivantes:

- **Interdiction de se présenter à l'examen**
- **Interdiction de se présenter à tout examen universitaire pendant X années (à vie…)**
- **Interdiction d'exercer toute profession du secteur public**
- **Suppression du permis de conduire pendant 5 ans**
- **…**

Motivation

- Computer Graphics is a branch of Computer Science

Motivation

- Computer Graphics is a branch of Computer Science
- Used by people from all disciplines
  - Art
  - Science
  - Music
  - Dance
  - Film Making
  - …

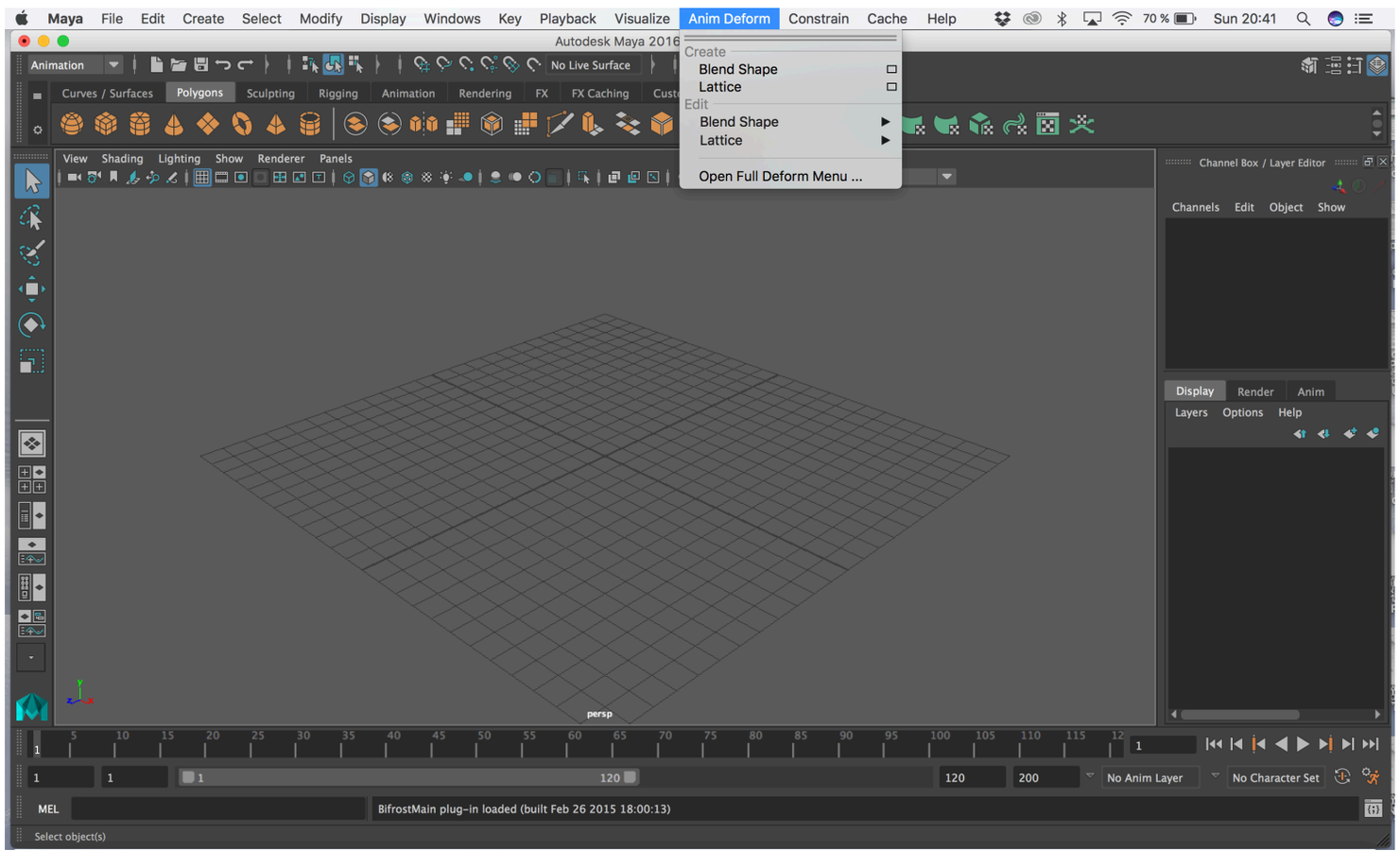
Motivation

- Computer Graphics is a branch of Computer Science
- Used by people from all disciplines
- In many different areas
  - Industry
  - Business
  - Government
  - Education
  - Entertainment
  - ...

Application Domains

User Interfaces

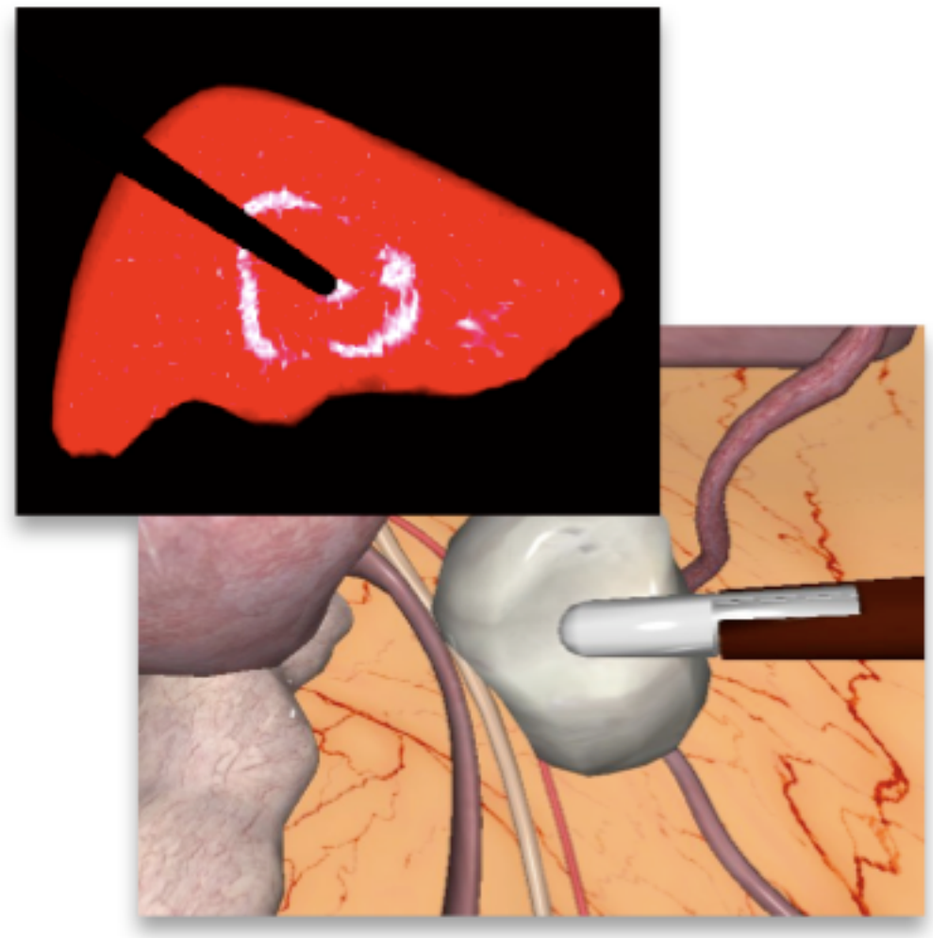
- Most computer programs have a graphical user interface (GUI)
  - Windows
  - Mouse pointer
  - Menus
  - Icons

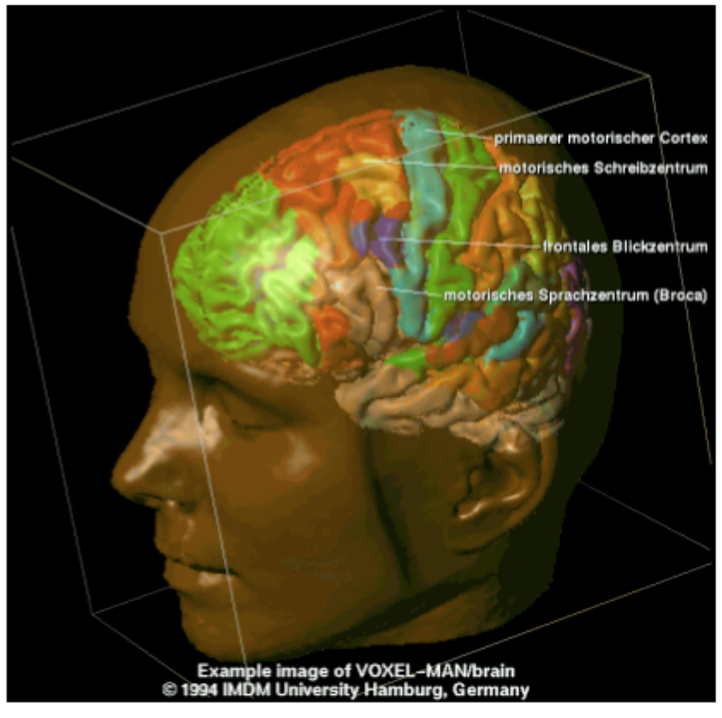


Application Domains

Medicine

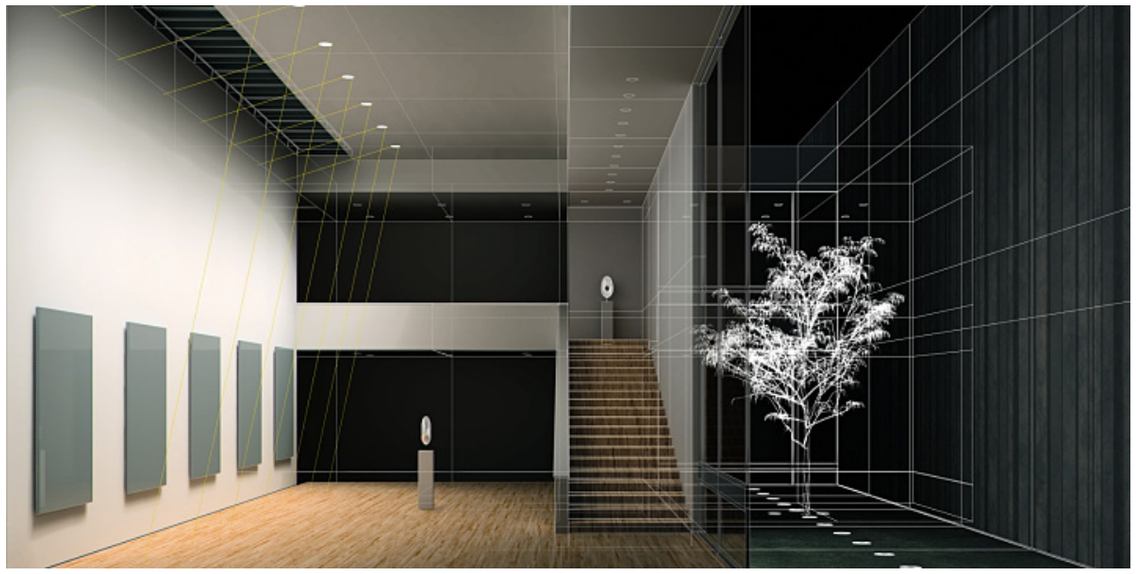
- Surgery simulator
- Surgery planning
- 3D visualisation





Application Domains

Computer Aided Design (CAD)

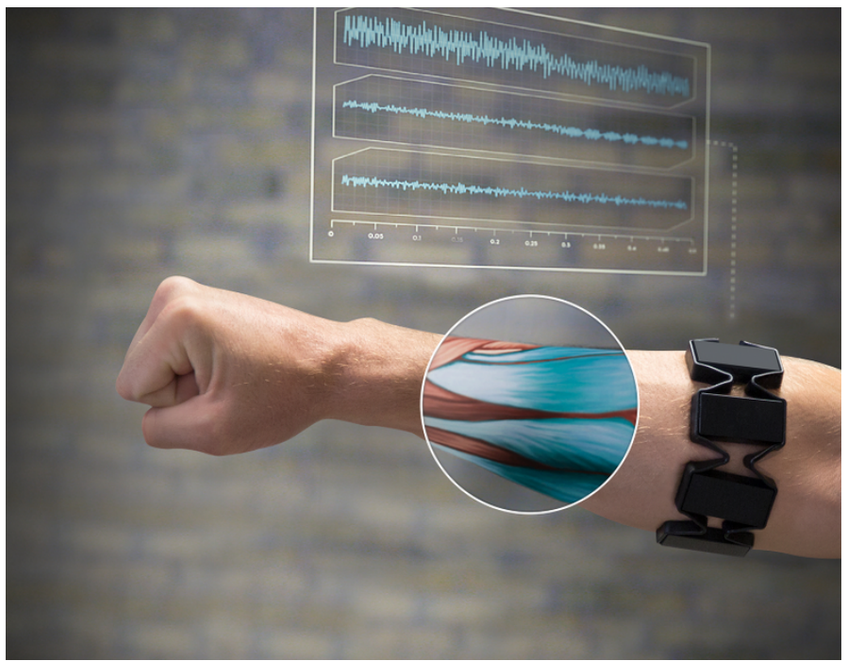
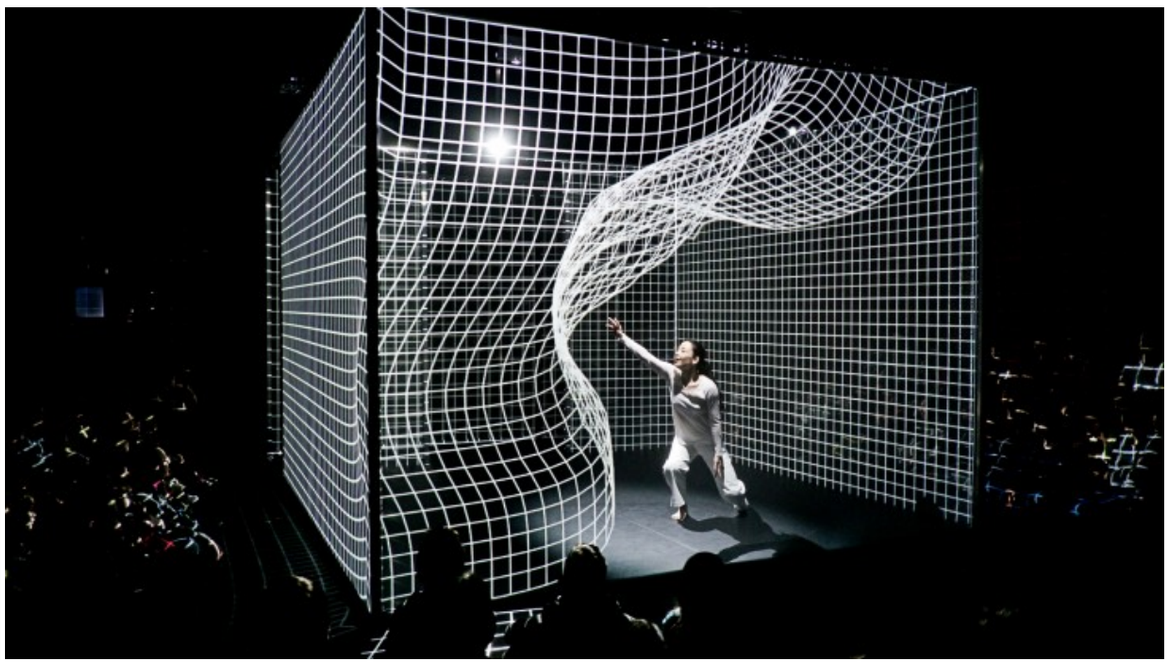


- Architecture
- Mechanics
- Electrical Engineering
- Car / plane / boat design
- Communication networks

Application Domains

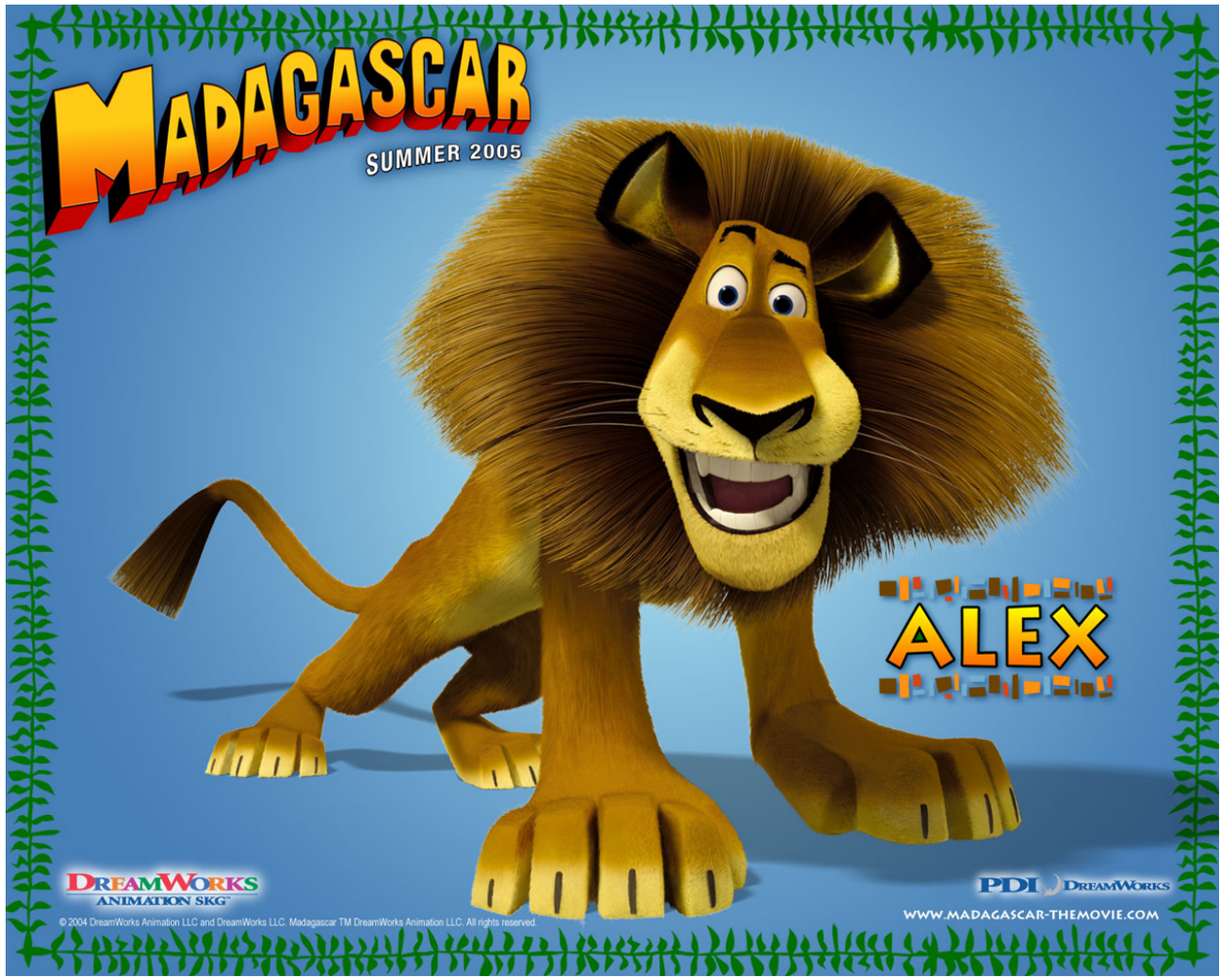
Multi-Media Systems

- Systems that involve more than one combination medium: graphics, text, sound
  - Interactive applications
  - Animation / rendering software (Autodesk Maya)

Application Domains

Movies / Commercials



Application Domains

Videos Games

World of Warcraft

Star Wars: The Force Unleashed

Application Domains

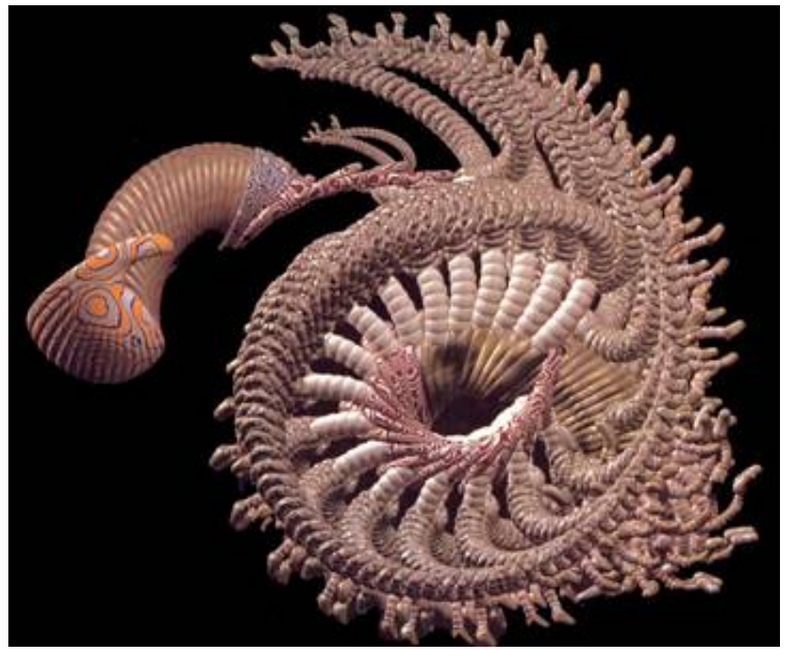
Digital Art

Computer Graphics

Definition

- Computer Graphics generally means
  - creation,
  - storage and
  - manipulation

  of models and images
- Models describe physical, biological, mathematical, artistic or abstract structures



[W. Latham 1992]

Computer Graphics

Definition

- **Term "Computer Graphics" coined by William Fetter in 1960, a graphic designer for Boeing**

> "Perhaps the best way to define computer graphics is to find out what it is not. It is not a machine. It is not a computer, nor a group of computer programs. It is not the know-how of a graphic designer, a programmer, a writer, a motion picture specialist, or a reproduction specialist.
>
> Computer graphics is all these – a consciously managed and documented technology directed toward communicating information accurately and descriptively."
>
> ***Computer Graphics***, by William A. Fetter, 1966

Computer Graphics

Overview

- Processing:
  - Interactive vs Batch Computer Graphics

Computer Graphics

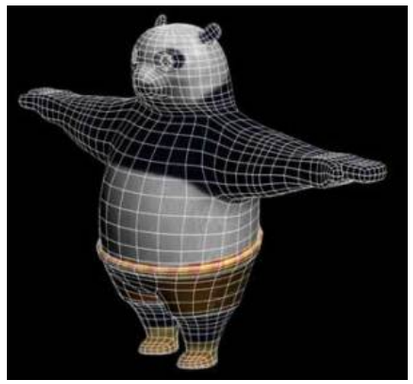
Overview

- Processing:
  - Interactive vs Batch Computer Graphics
- Display Hardware:
  - Vector vs Raster Display (2D)

Computer Graphics

Overview

- Processing:
  - Interactive vs Batch Computer Graphics
- Display Hardware:
  - Vector vs Raster Display (2D)
- Modeling / Representation (2D/3D):
  - Sample-based vs geometry-based Graphics



Computer Graphics

Overview

- Processing:
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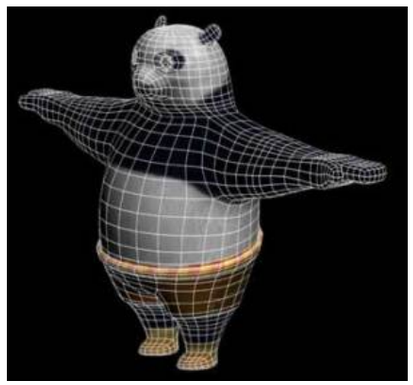


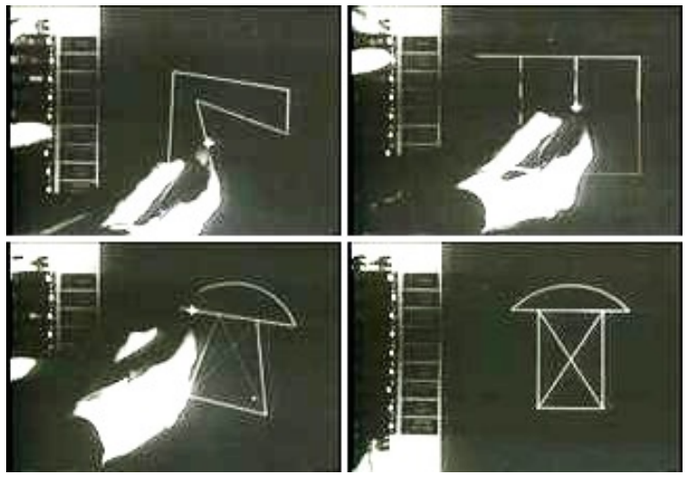
Interactive Computer Graphics

- Control of content, structure and appearance of objects via rapid visual feedback
- Components
  - Input (mouse, stylus, multi-touch, body…)
  - Processing (movement + rendering + storage)
  - Output/Display (screen, printer, video recorder, VR/AR systems…)

Interactive Computer Graphics

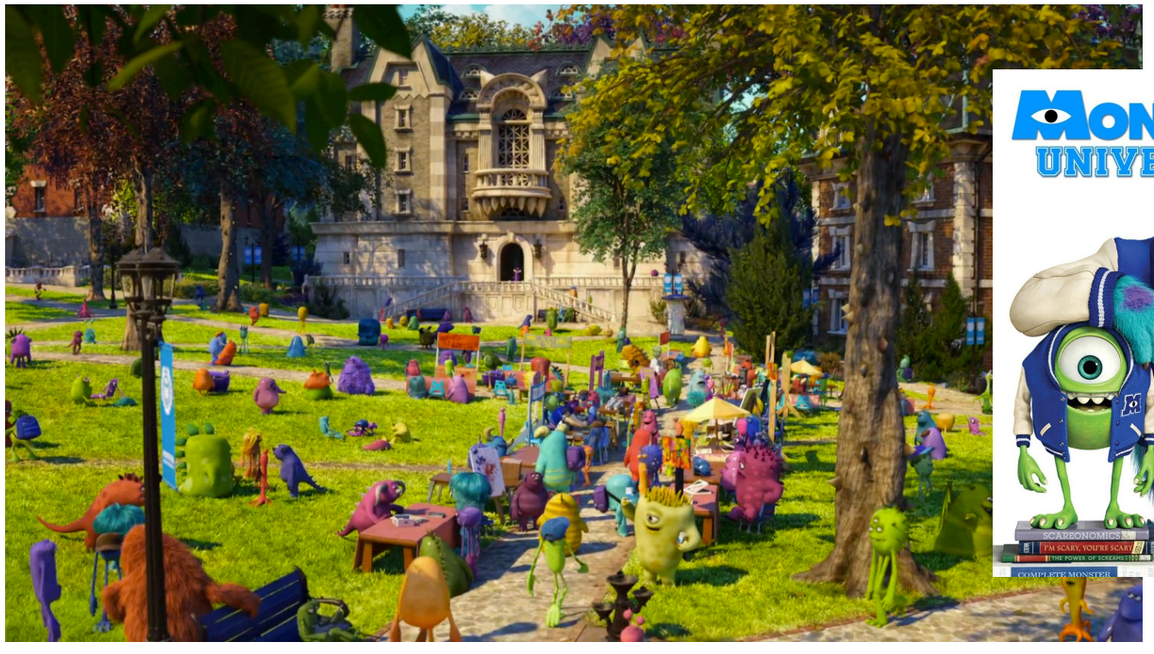
- **First truly interactive system: SKETCHPAD**
- **Ivan Sutherland Ph.D. thesis 1963:** *Sketchpad, A Man-Machine Graphical Communication System*
- **MIT Lincoln Lab**
- **Control console: CRT monitor, light pen, push buttons and switches**

https://youtu.be/J6UAYZxFwLc

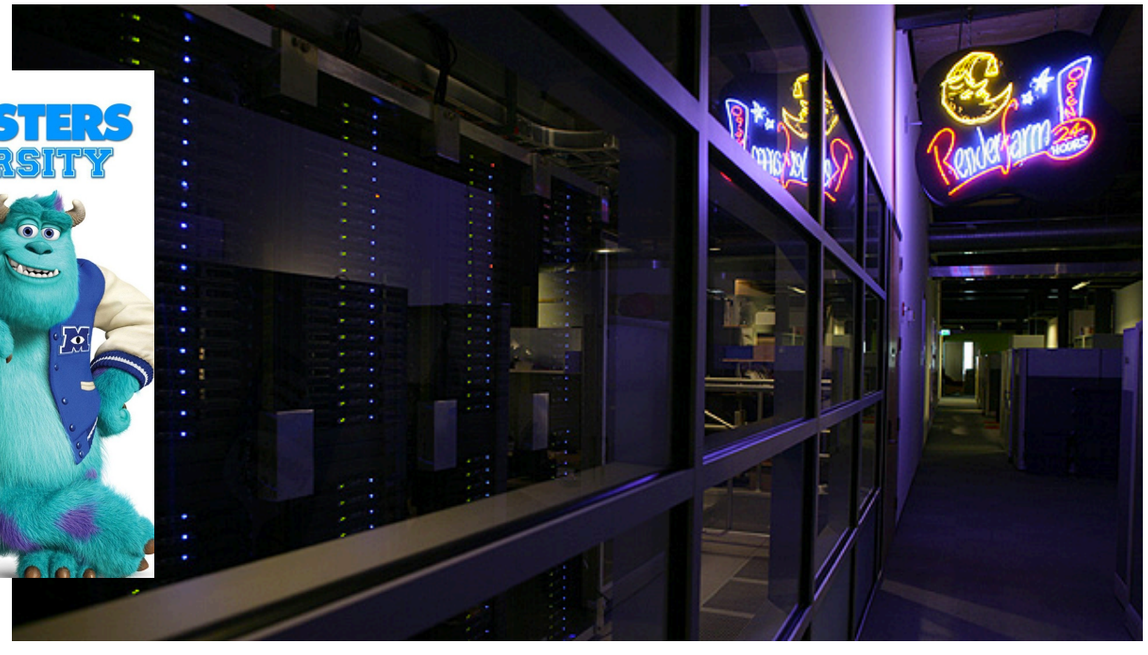


Batch Computer Graphics

- Batch mode means non-interactive
- Used for final production-quality video and film (Maya, FX-special effects), 24 fps
- Slow to compute: rendering of 1 frame of Monsters University (2013) averaged 29 hours on a 24000-core render farm



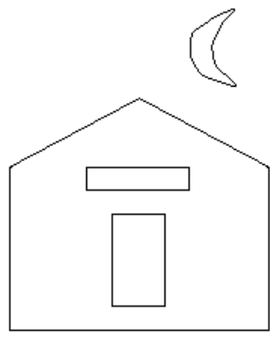
Still from Monsters University



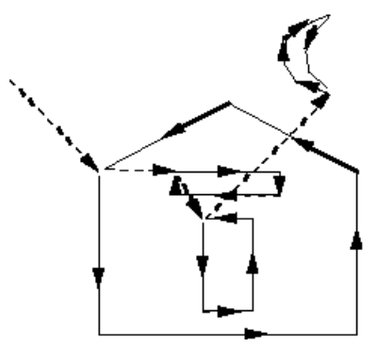
Render farm

Vector Display Hardware

- Calligraphic (laser beam), stroke (oscilloscope), random-scan (electron beam)
- Driven by display commands
  - moveto(x,y)
  - char(“A”)
  - lineto(x,y)
- Scalable (indefinite zoom)



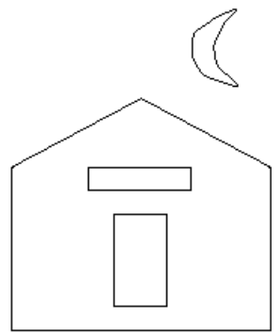
Ideal Drawing



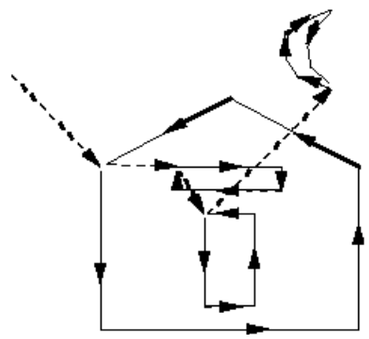
Vector Drawing

Raster Display Hardware

- TV / screens, bitmap, pixmap
- Driven by an array of pixels
  - No semantics
  - Lowest level of representation
- Aliasing errors (jaggies) due to discrete sampling of continuous primitives



Ideal Drawing



Vector Drawing

Outline

Filled

Sample-based

Graphics (2D)

- Discrete samples are used to describe visual information
- Image is defined as pixel-array
- Pixels are point locations with associated sample values: light intensities/colors, transparency, and other control information
- Created by digitizing images, using a sample-based “painting” program, camera, scanner
- Input numerically (e.g., with numbers from computed dataset): for example, some aspect of the physical world is sampled for visualization, such as temperature across the US

Sample-based

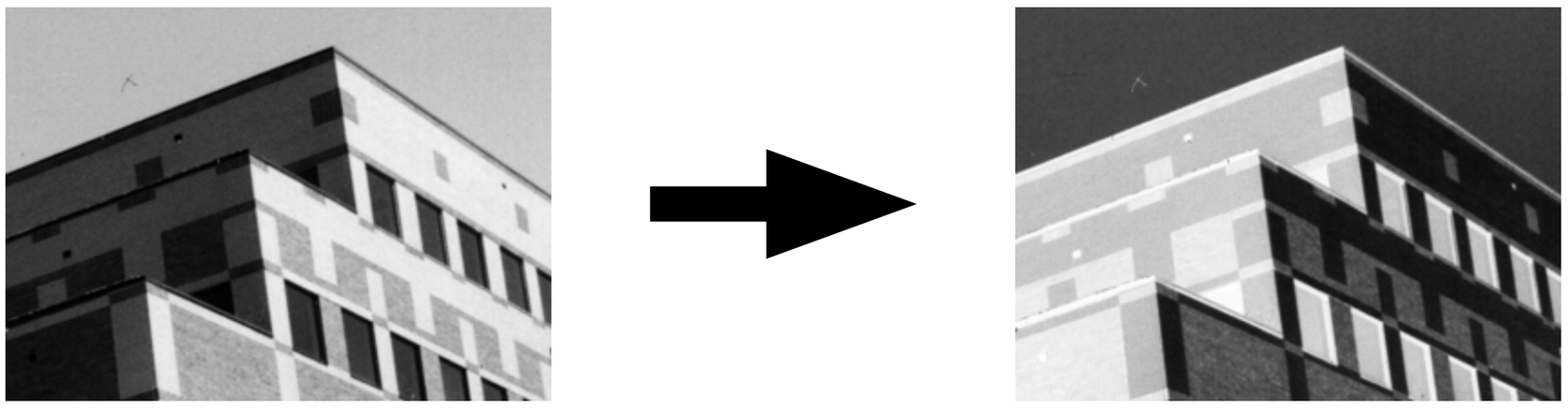
Graphics

- Image Editing: changes made by user, such as cutting and pasting sections, brush-type tools, and processing selected areas
- Image Processing: algorithmic operations that are performed on image (or portion of image) without user intervention. Blurring, sharpening, edge-detection, color balancing, rotating, warping. These are front-end processes to Computer Vision.
- Applications: Adobe Photoshop™, GIMP™ , Adobe AfterEffects™

Sample-based

Graphics : advantages

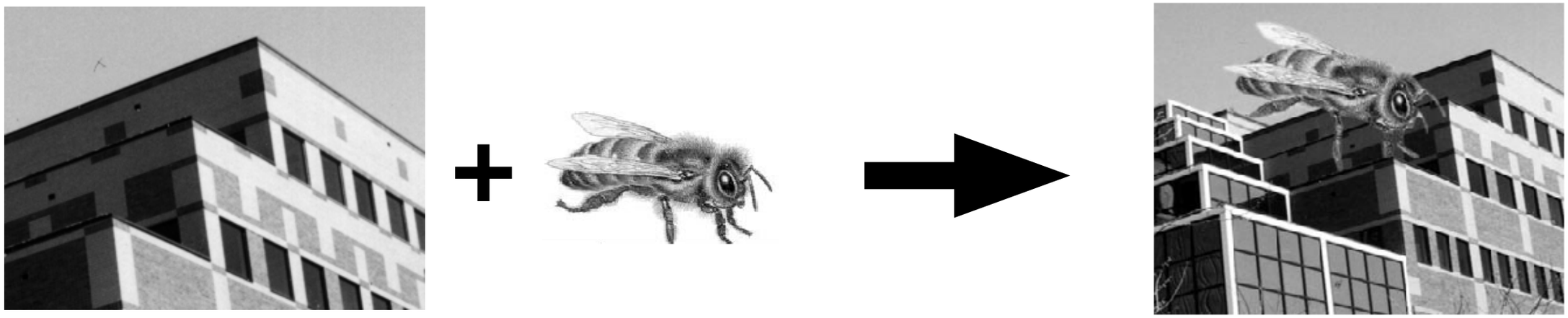
- Once image is defined in terms of colors at locations (x, y) on grid, image change is easy by altering location or color values
- Example: reversing color mapping and make 10 = white, 0 = black



Sample-based

Graphics : advantages

- Once image is defined in terms of colors at locations (x,y) on grid, image change is easy by altering location or color values
- Example: pixel information from one image can be copied and pasted into another, replacing or combining with previously stored pixels



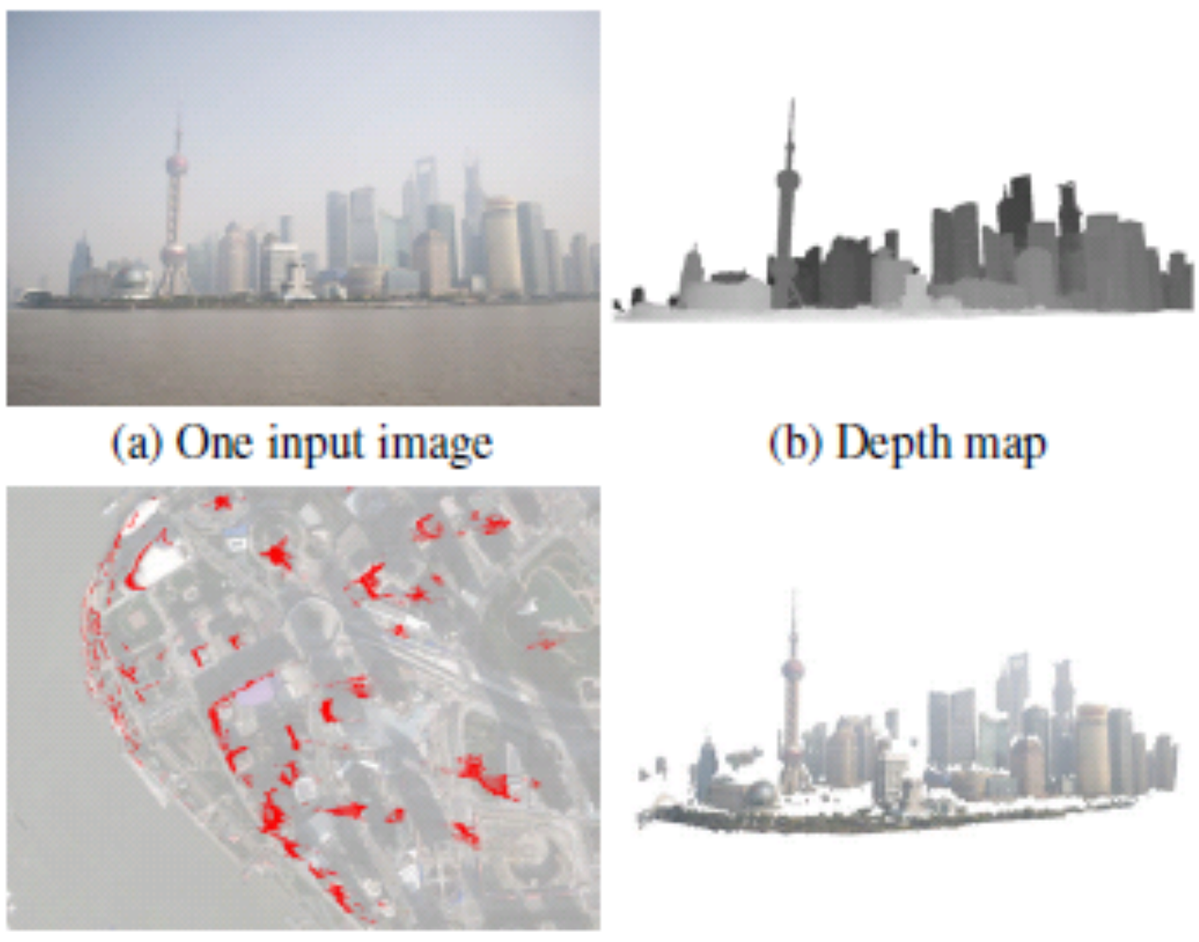
Sample-based

Graphics : drawbacks

- WYSIAYG (What You See Is All You Get): No additional information
  - No depth information
  - Can’t change point of view
  - At most can play with the individual pixels or groups of pixels to change colors, enhance contrast, find edges, etc.
  - But increasingly great success in image-based rendering to fake 3D scenes and arbitrary camera positions. New images constructed by interpolation, composition, warping and other operations.

Sample-based

Graphics : image-based rendering



(a) One input image (b) Depth map

(c) Map overlay (d) Rendering

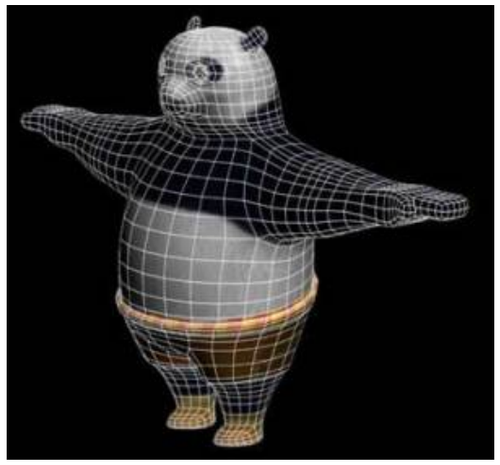
Figure 15: *Results on a challenging unstructured light field, obtained by hand-held capture (a) from a floating boat. (b) A resulting depth map. (c) Overlay of our reconstruction on a satellite image ©2013 DigitalGlobe, Google. (d) Rendering from a novel viewpoint.*

Change of Viewpoint

"Scene Reconstruction from High Spatio-Angular Resolution Light Fields" **[Kim, Zimmer et al., 2013]**

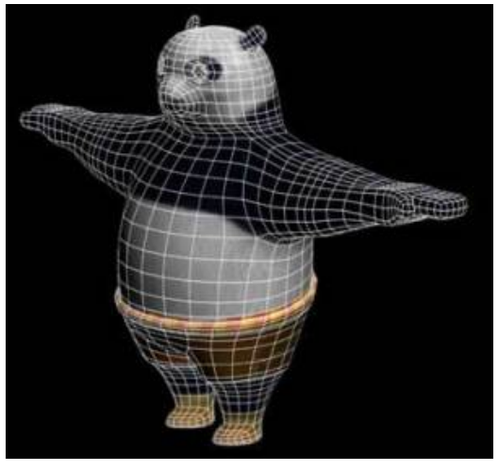
Geometry-based

Graphics: modeling



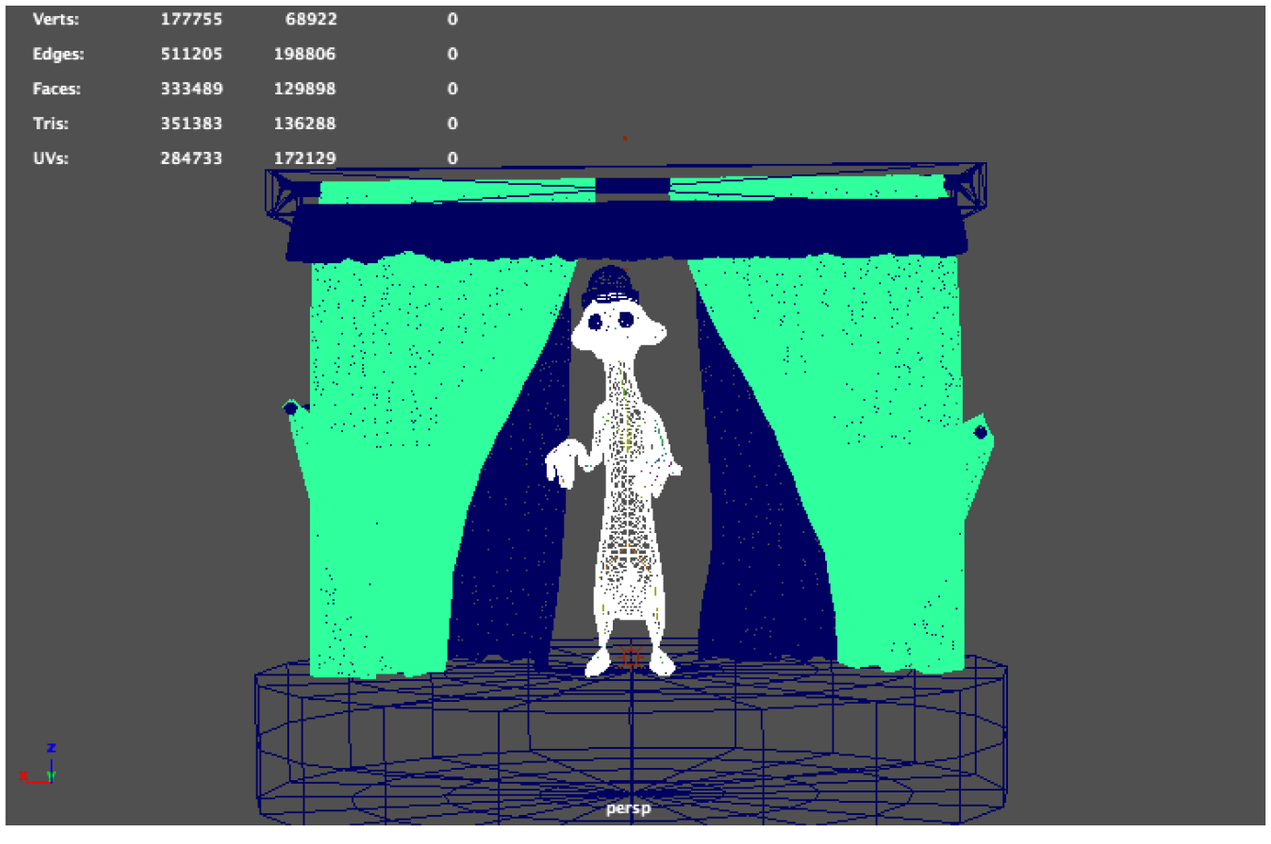
- Also called scalable vector graphics or object-oriented graphics
- Geometrical models are created and stored along with various appearance attributes (e.g., color, material properties)
- Models are mathematical descriptions of geometric elements - lines, polygons, polyhedrons, polygonal meshes…
- Geometric elements are primitive shapes, i.e. primitives

Geometry-based



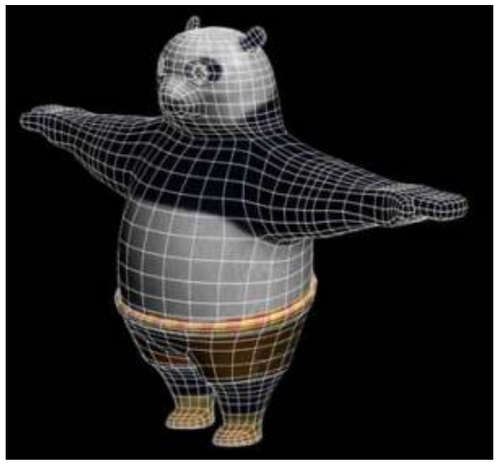
Graphics: rendering

- Images are synthesized for visualization via sampling of geometry: rendering



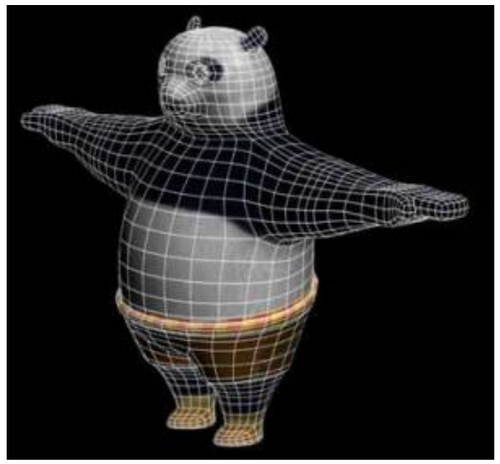
Geometry-based

Graphics: rendering



- Images are synthesized for visualization via sampling of geometry: rendering
- 2D applications: Adobe Illustrator™, Adobe Freehand™, Corel CorelDRAW™
- 3D applications: Autodesk AutoCAD™, Autodesk Maya™, Autodesk 3D Studio Max™

Geometry-based

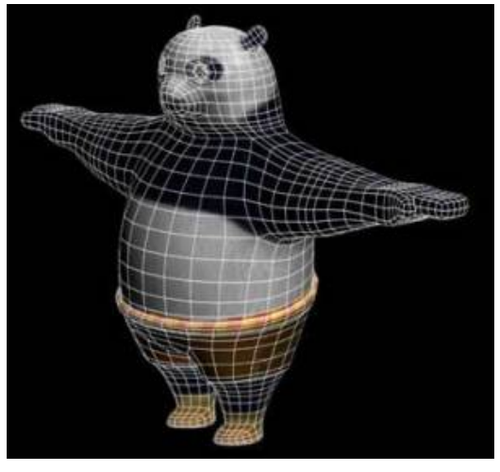


Graphics: advantages

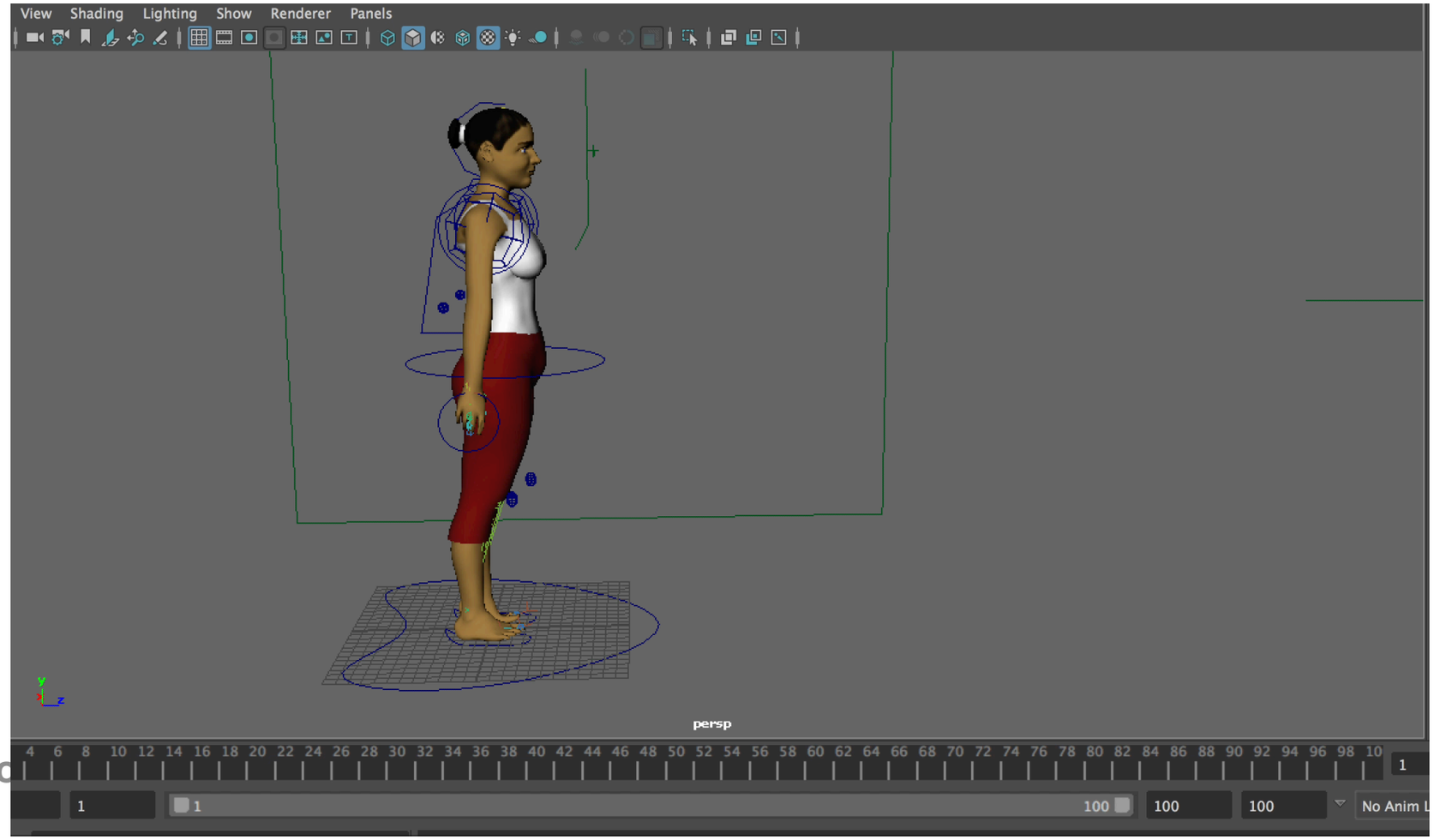
- Aspects of physical world can be simulated
  - Clothes
  - Hair
  - Fluids
  - Liquids

Geometry-based

Graphics: advantages

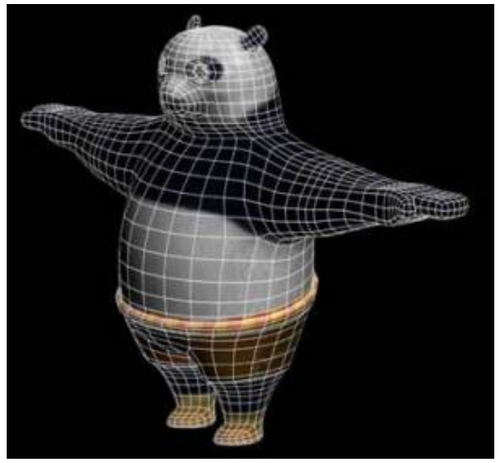


- Aspects of physical world can be simulated
- Animation is done using keyframes and interpolation

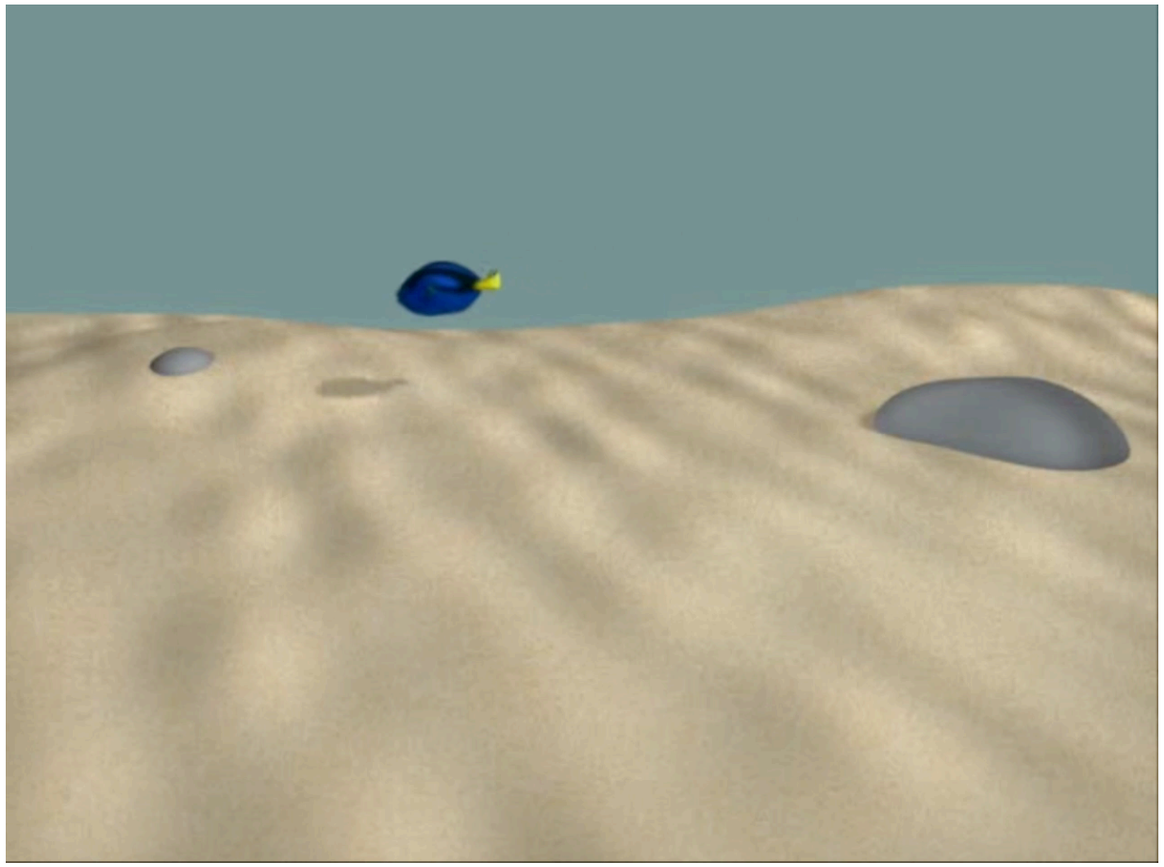


Geometry-based

Graphics: advantages

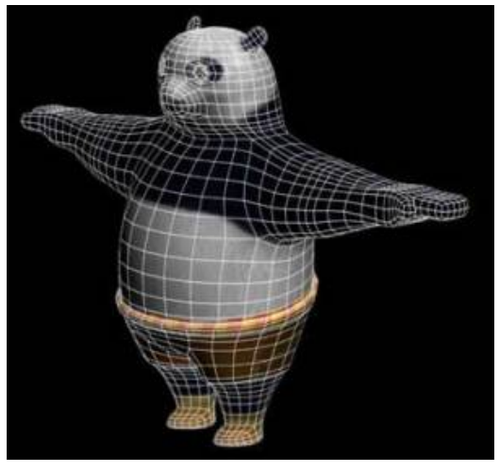


- Aspects of physical world can be simulated
- Animation is done using keyframes and interpolation
- High-level control



Geometry-based

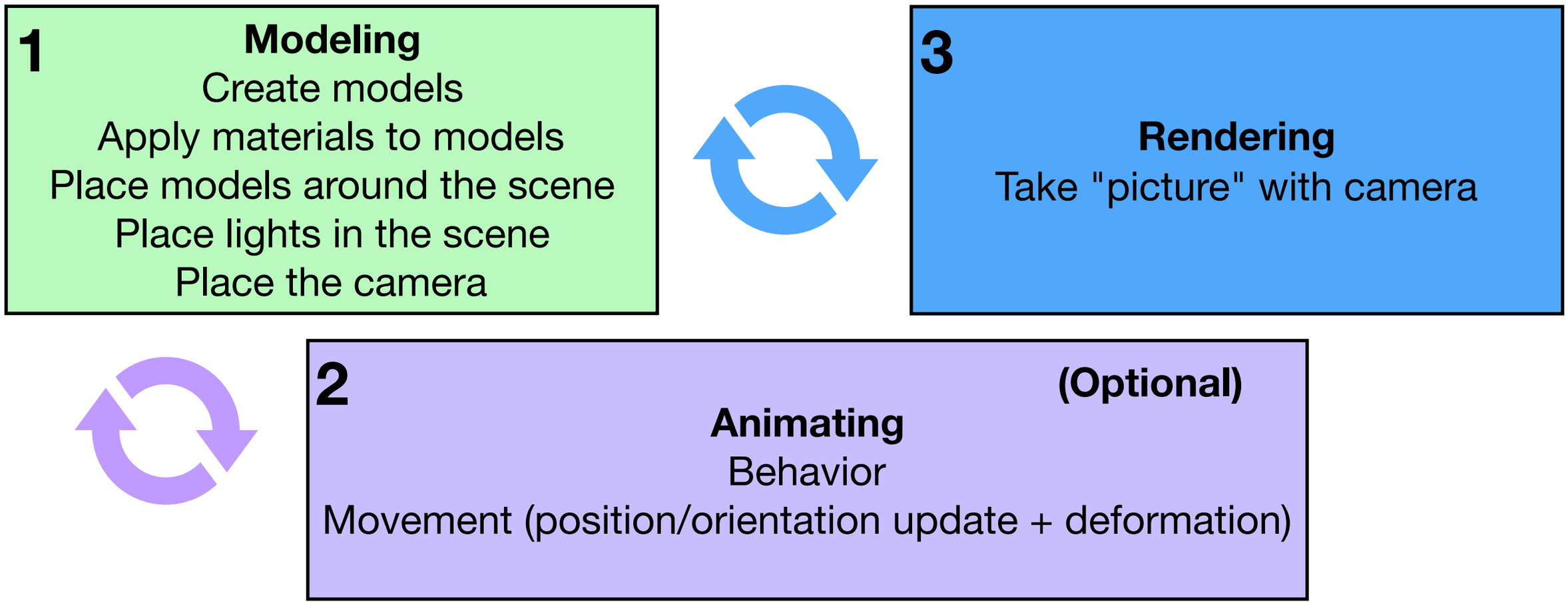
Graphics: drawbacks



- Users cannot work directly with individual pixels as user manipulates geometric elements, program resamples and redisplays elements (except with shaders)
- Increasingly, rendering combines geometry- and sample-based graphics, both as performance hack and to increase quality of final product

Animation Pipeline

- 3 steps: modeling, animating, rendering

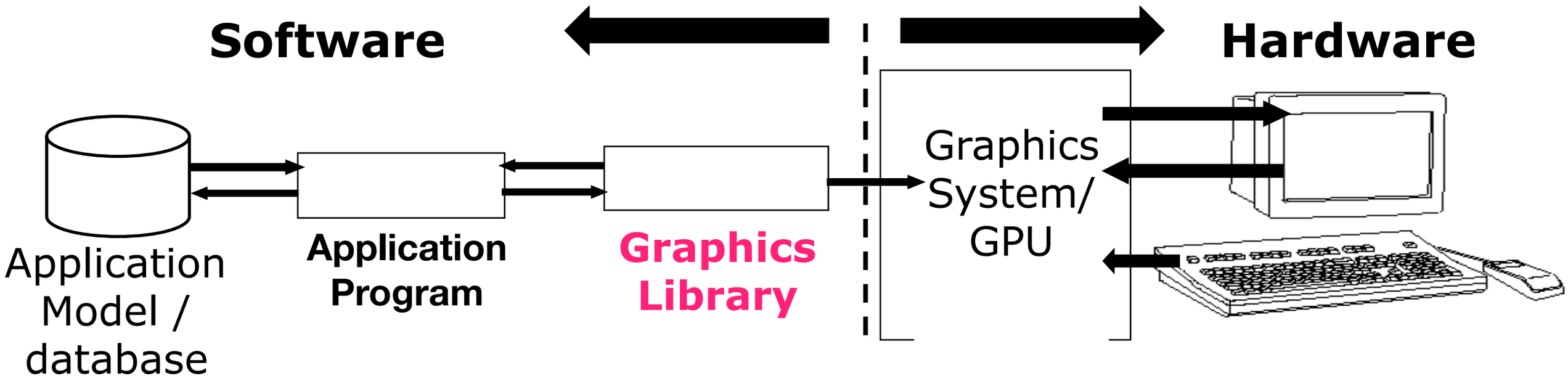


Commercial software: Autodesk Maya™, Autodesk 3D Studio Max™, Blender™

Conceptual Framework

Interactive Graphics

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

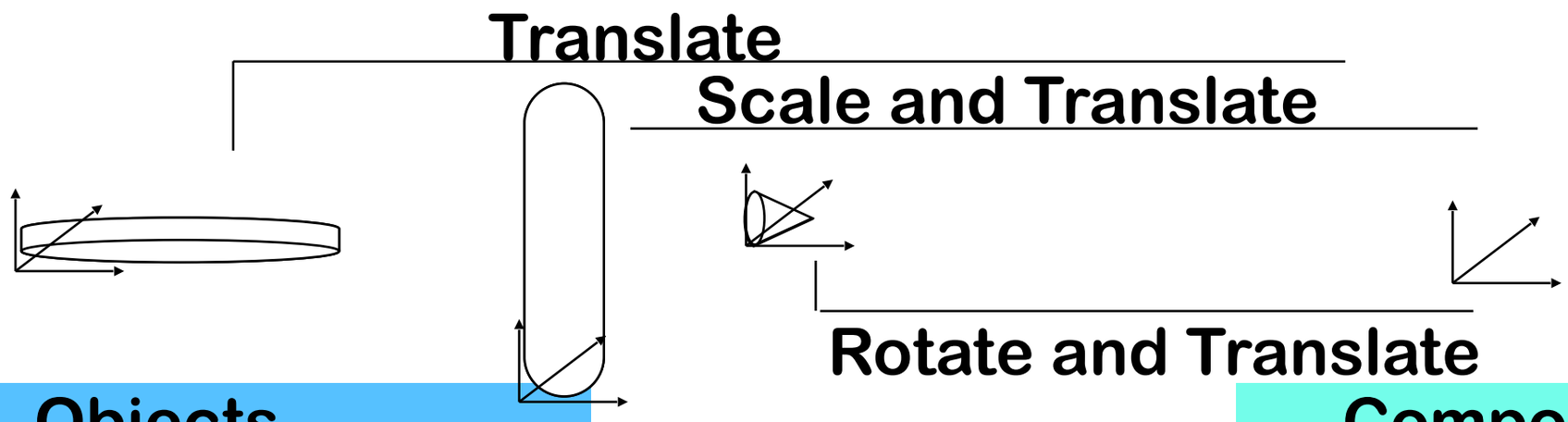


Graphics Library

- 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

Scenegraph

- Composition of a scene
- Stores objects and relations to one another
  - Objects created in decomposition process must be assembled to create final scene.
- Done with affine transformations: T, R, S (not commutative, order matters !)

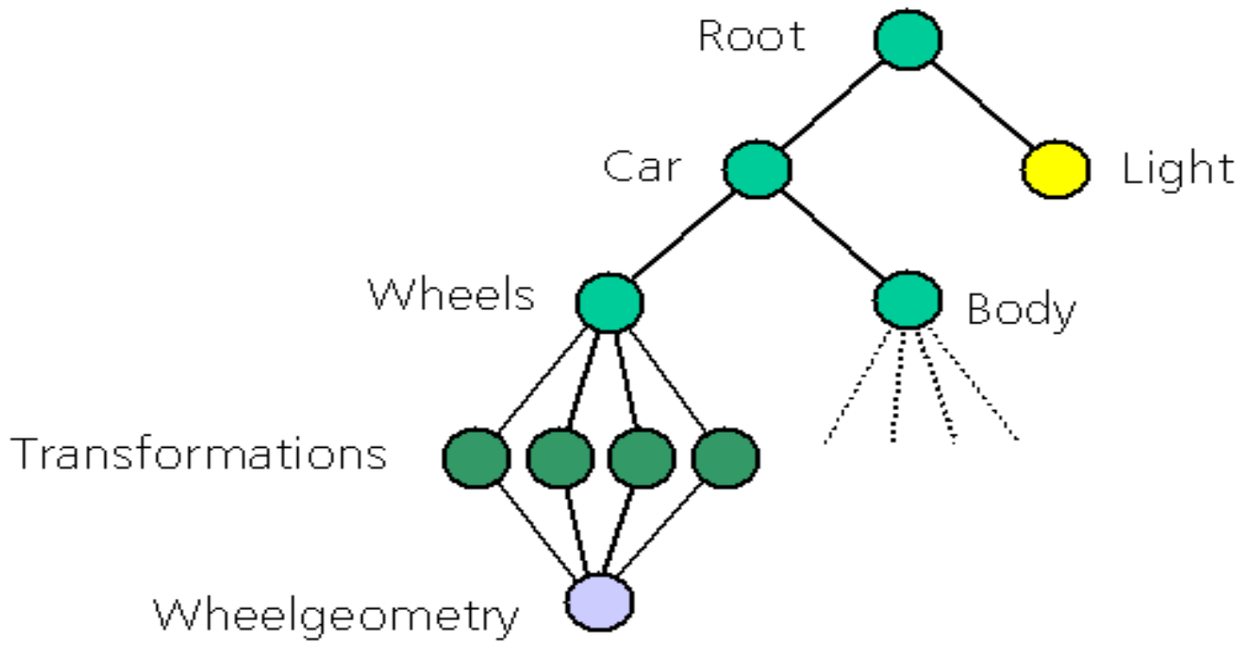


Objects
in their own modeling coordinate system (local)

Composition
in world coordinate system (global)

Scenegraph

Car example



Lecture's Overview

- Geometric transformations (translation, rotation, scale) are essential for model organization, process of composing complex objects from simpler components and animation (lecture 2)
- Once object's geometry is established, it must be viewed on screen: from 3D geometry to 2D projections for viewing (lecture 3)
- While mapping from 3D to 2D, object (surface) material properties and lighting effects are used in rendering one's constructions. This rendering process is also called image synthesis (lecture 5)

Course Outline

1. Drawing 2D primitives
2. Geometrical Transformations
3. Viewing in 3D
4. Surface Models
5. Rendering
6. Colors / Textures

- OpenGL
- GLSL (Shaders)