Introduction to Computer Graphics (CS360A)

Instructor: Soumya Dutta

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Logistics

Course Staff

- Instructor:
  - Soumya Dutta (soumyad@cse.iitk.ac.in)
    - https://soumyadutta-cse.github.io/
- TAs:
  - Abhay Kumar Dwivedi (abhaykd@cse.iitk.ac.in)
  - Abhishek Raghuvanshi (abhishekr@cse.iitk.ac.in)
  - Akash Shriwas (akashshriwas@cse.iitk.ac.in)
  - Allan Robey (allan@cse.iitk.ac.in)
  - Arabinda Karmakar (arabindakar@cse.iitk.ac.in)
  - Atul Kumar (atulk@cse.iitk.ac.in)
- We will use HelloIITK for this course
  - https://hello.iitk.ac.in/cs360asem12324/#/home

Class Timings

- Monday & Thursday
- Time: 10:30 am – 12:00 pm
- Location: H. R. Kadim Diwan Building, Room: 101 (KD - 101)
- Office hours: Thursday 4pm-5pm at KD-224 or by appointment

Course Topics

Index	Topics
1	Introduction, Math Basics, Raster Images, JavaScript
2	Graphics API, WebGL
3	Transformations 2D and 3D
4	Viewing & Projections
5	GPU Pipeline, GPU Shaders, and Shader Programming, GLSL
6	Basic Shape Generation and Polygonal Meshes
7	Illumination and Shading, Shading Transformations
8	Textures, Textures on GPU, Cube Environment Mapping, Bump mapping and Normal Mapping
9	Frame Buffer Objects (FBO), Rendering to FBO, Planer Reflections
10	Multi-pass rendering: Advanced Graphics Effects
11	Texture/Image Texture Post processing in Shader
12	Rendering Equation, Rendering Algorithms
13	Ray Tracing, Distributed Ray Tracing: Reflection, Shadow Mapping, and other advanced topics

Noteworthy Points

1. We might add new, drop existing, or reorder topics depending on the progress and class feedback. Things may be changed by mutual consent after discussion in class.
2. Lectures in the class are the best resources.
3. Grading will be relative.
4. If required, extra classes will also be conducted in weekends.

Grading/Evaluation Scheme

Category	Split
Class participation and/or Quiz	10%
Lab/Programming Assignments	65%
Mid Semester Examination	10%
Final Semester Examination	15%

Policies

- You are expected to be on time for the lectures. Attendance will be collected from time to time.
- You are expected to submit your assignments in time.
- If you are unwell, please follow the standard IITK procedure.

How To Succeed in This Course

- This will be a fun course, so most importantly enjoy!
  - You will learn techniques to generate cool realistic images from scratch
  - You will learn theories behind those
- This course will involve several coding assignments
  - You must have strong programming skills in general
  - We will use JavaScript and HTML as our base programming to generate 2D/3D graphics in a webpage
    - It is fine if you do not know JavaScript and HTML, but you should have good programming skills and knowledge in C/C++
- We will cover GLSL shader programming to generate real time graphics in GPUs
  - GPU Shader programming can be tricky and sometimes challenging to debug
  - You can not use print/cout statements in shader program

How To Succeed in This Course

- Sometimes graphics programming can be frustrating requiring long debugging if your understanding of the basics is not clear
  - So, start early for your lab assignments, do not start a day before the deadline
- Your lab assignments will be built on top of one another, from 2D to 3D graphics to more advanced topics
  - Hence you need to learn the basics well
  - Make sure your graphics engine works as expected from the very beginning
- The entire computer graphics domain is standing over linear algebra, matrices, vectors, and their manipulation
  - The intuition of these topics will be essential to understand how 2D/3D graphics works in a virtual world that we create

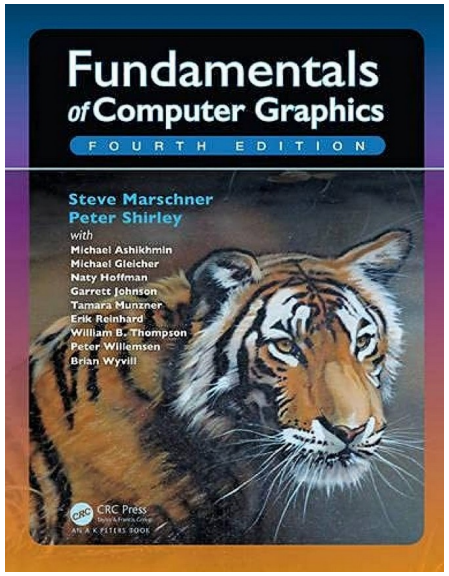
Academic Honesty

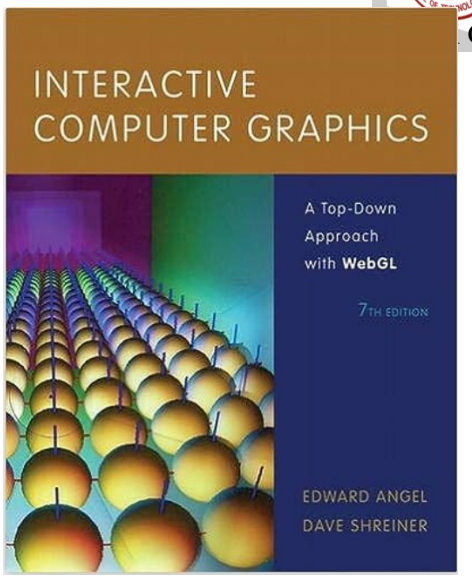
- Please DON'T CHEAT or Plagiarize!!
- Students caught cheating or plagiarizing will automatically fail the course and will be reported to the institute. No exceptions!
- You are expected to cite all sources in your work/reports.
- Your assignments should be your own original work.
- IITK CSE Anti-cheating policy: https://www.cse.iitk.ac.in/pages/AntiCheatingPolicy.html
- The List of Things I Never Want To Hear Again (by Prof. Tamara Munzner)
  - https://www.cs.ubc.ca/~tmm/courses/cheat.html

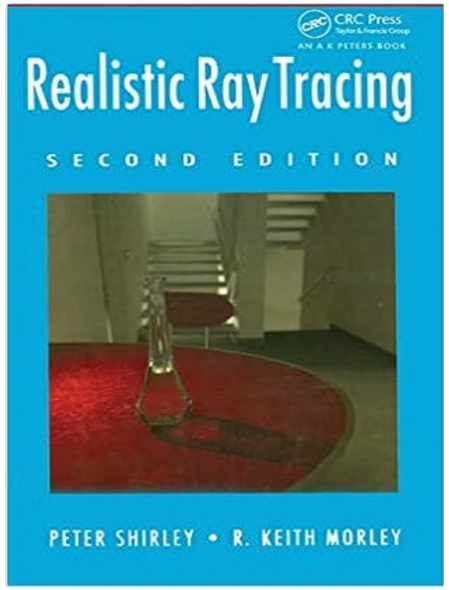
Do ask for help, we really want you to learn and succeed!!

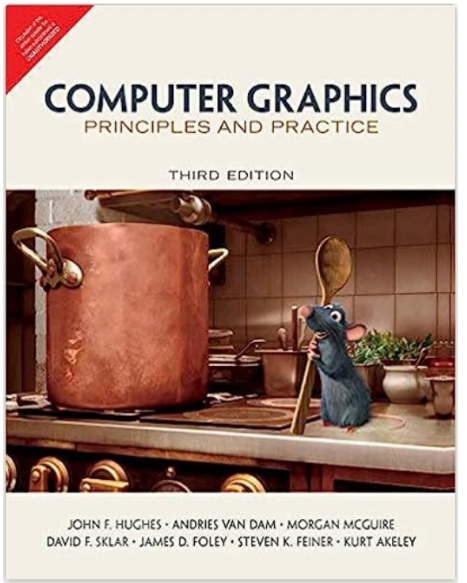
References

- Fundamentals of Computer Graphics, Steve Marschner and Peter Shirley, 4th Ed, CRC Press
- Interactive Computer Graphics, A Top-Down Approach with WebGL, Edward Angle and Dave Shreiner, 7th Ed, Pearson
- Realistic Ray Tracing, Peter Shirley and R. Keith Morley, AK Peters.
- Computer Graphics: Principle and Practice, James D. Foley, Andries van Dam, Steven K. Feiner, John Hughes, Morgan McGuire, David F. Sklar, and Kurt Akeley.
- The OpenGL® Shading Language Manual, John Kessenich, Dave Baldwin, and Randi Rost.





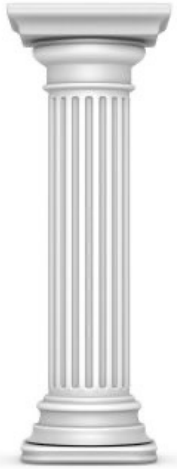


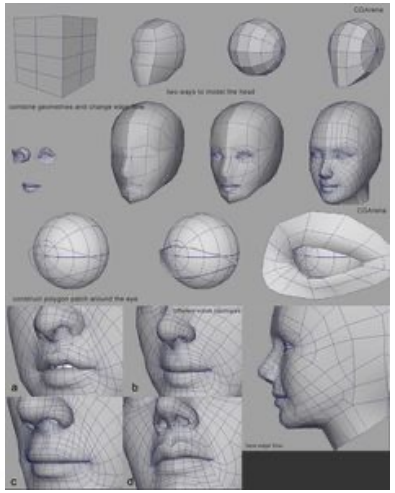


Computer Graphics

- Computer-generated images or sequences of images
- Any use of computers to create and manipulate images
- The study of the techniques and theories for generating such images
  - Generate synthetic images that look real
  - Real-time
  - Accurate visualization
  - Interaction

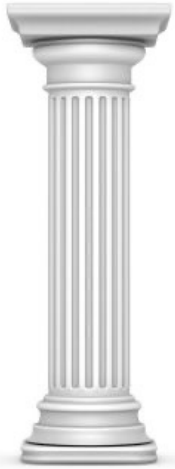
Computer Graphics: Three Pillars

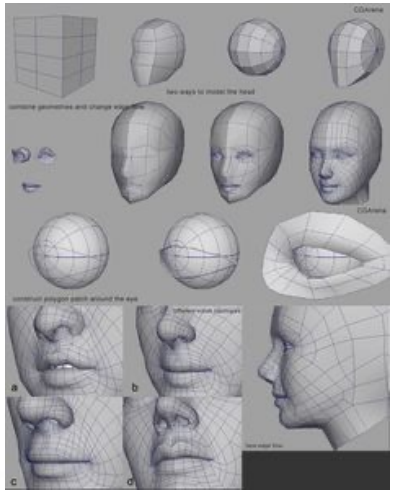


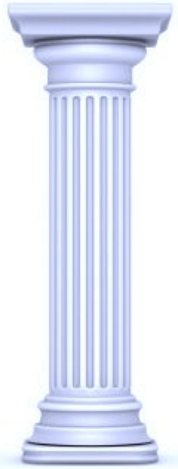


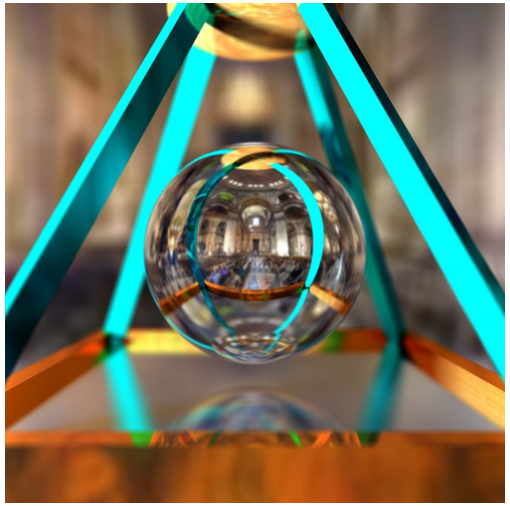
- Modeling: Deals with the mathematical specification of shape and appearance properties in a way that can be stored on the computer.

Computer Graphics: Three Pillars





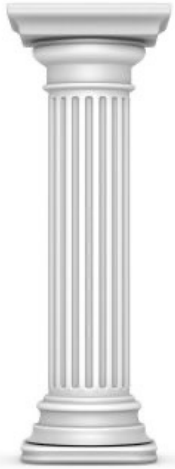
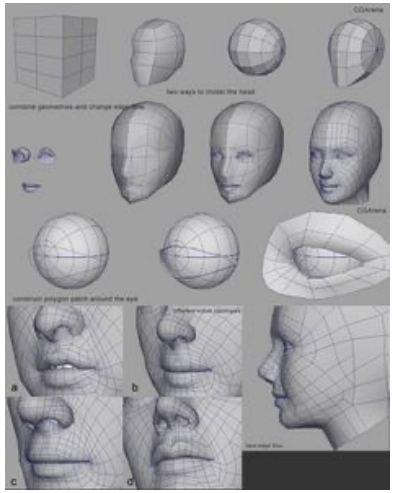
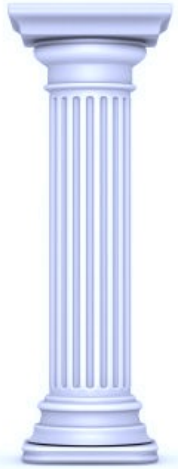
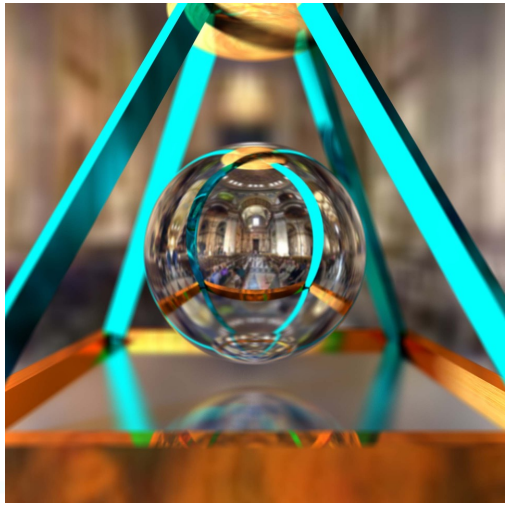
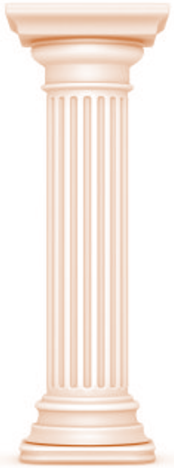




- Modeling: Deals with the mathematical specification of shape and appearance properties in a way that can be stored on the computer.

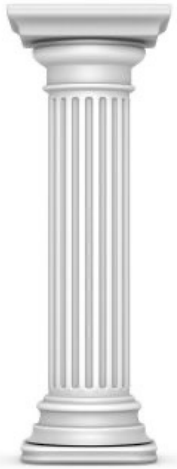
- Rendering: A term inherited from art and deals with the creation of shaded images from 3D computer models.

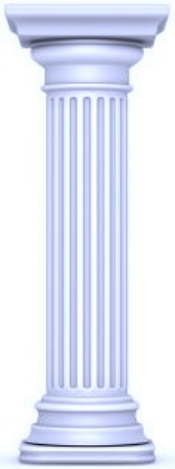
Computer Graphics: Three Pillars

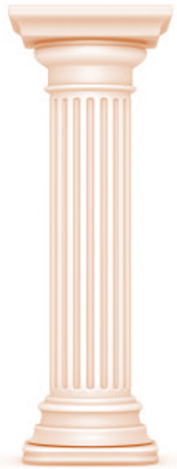







- Modeling: Deals with the mathematical specification of shape and appearance properties in a way that can be stored on the computer.
- Rendering: A term inherited from art and deals with the creation of shaded images from 3D computer models/world.
- Animation: A technique to create an illusion of motion through sequences of images.

Computer Graphics: Three Pillars







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- Rendering: A term inherited from art and deals with the creation of shaded images from 3D computer models.

- Animation: A technique to create an illusion of motion through sequences of images.

Major Applications of Computer Graphics

Major Applications of Computer Graphics

- Video Games: Unreal Engine Demo

Major Applications of Computer Graphics

- Video Games: Nvidia RTX Demo for Ray Tracing

Major Applications of Computer Graphics

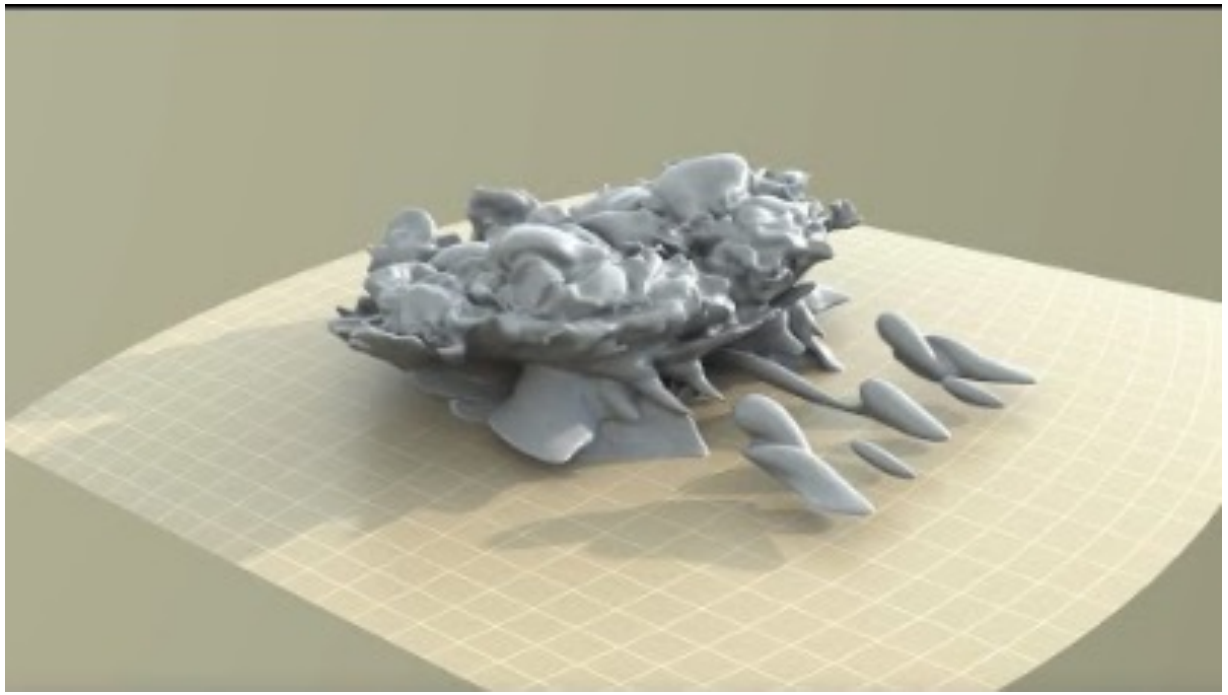
- Visual Effects in Movies

Major Applications of Computer Graphics

- Animated Movies

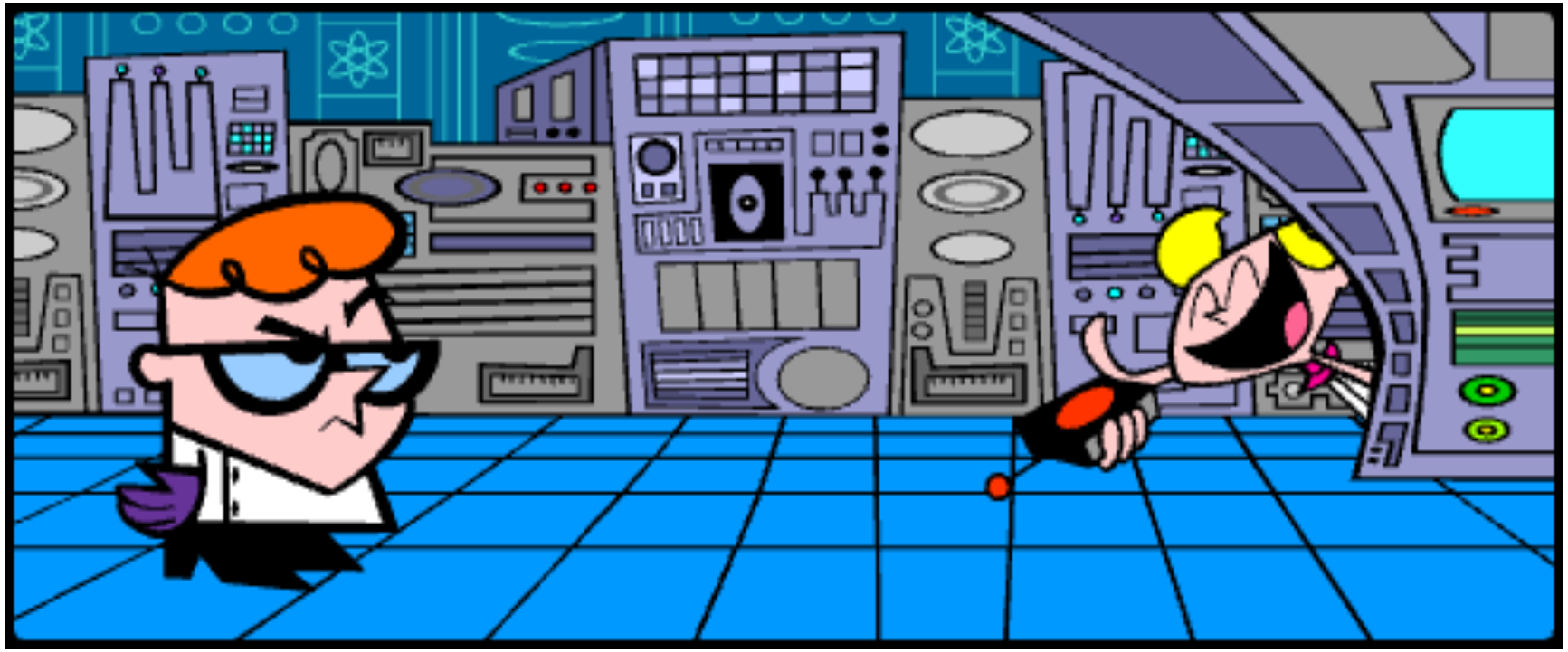
Major Applications of Computer Graphics

- Scientific Visualization and Data Analysis



Major Applications of Computer Graphics

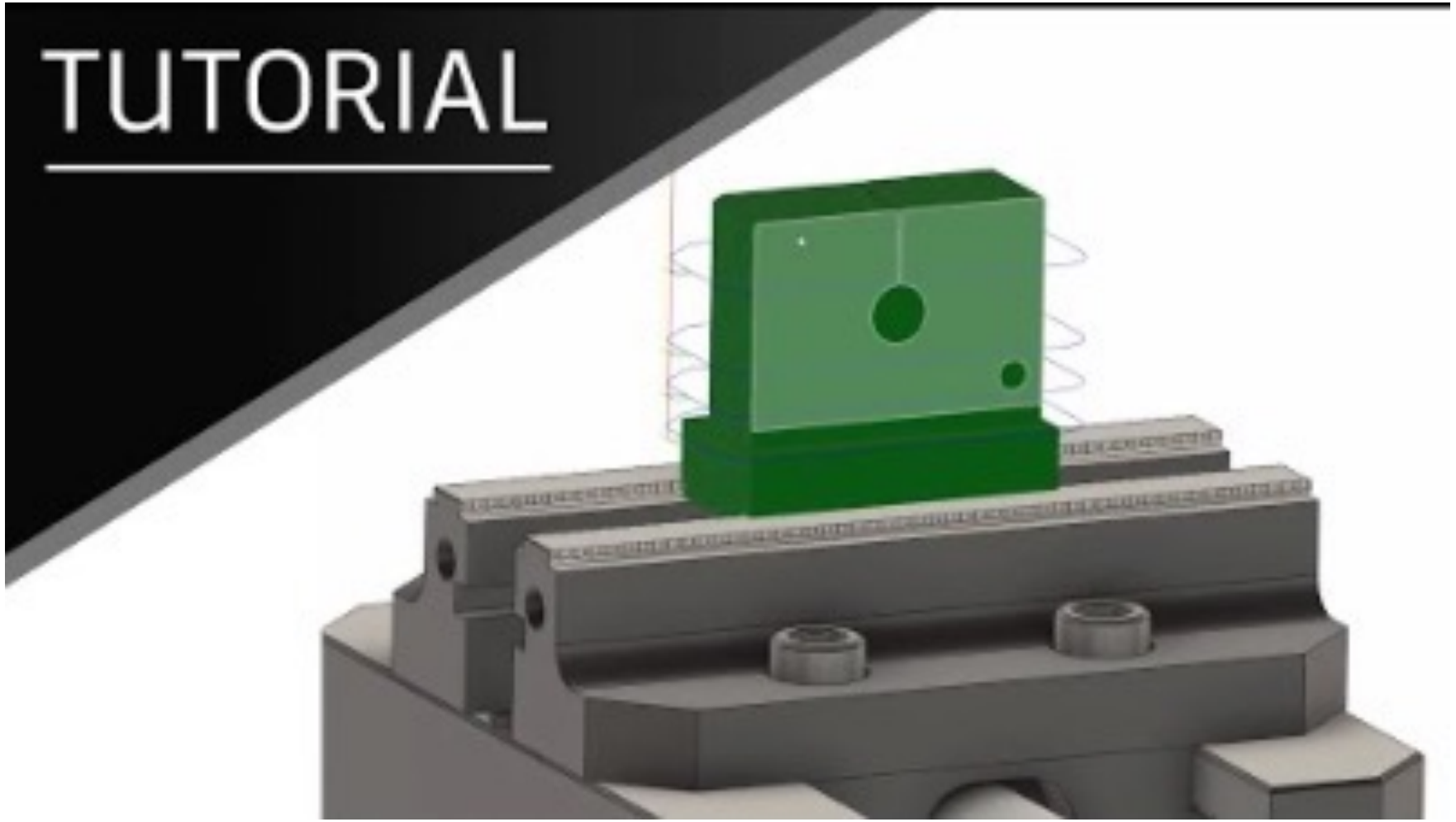
- Cartoons



Source: Google

Major Applications of Computer Graphics

- CAD/CAM



Major Applications of Computer Graphics

- Simulation

Source: Google

Major Applications of Computer Graphics

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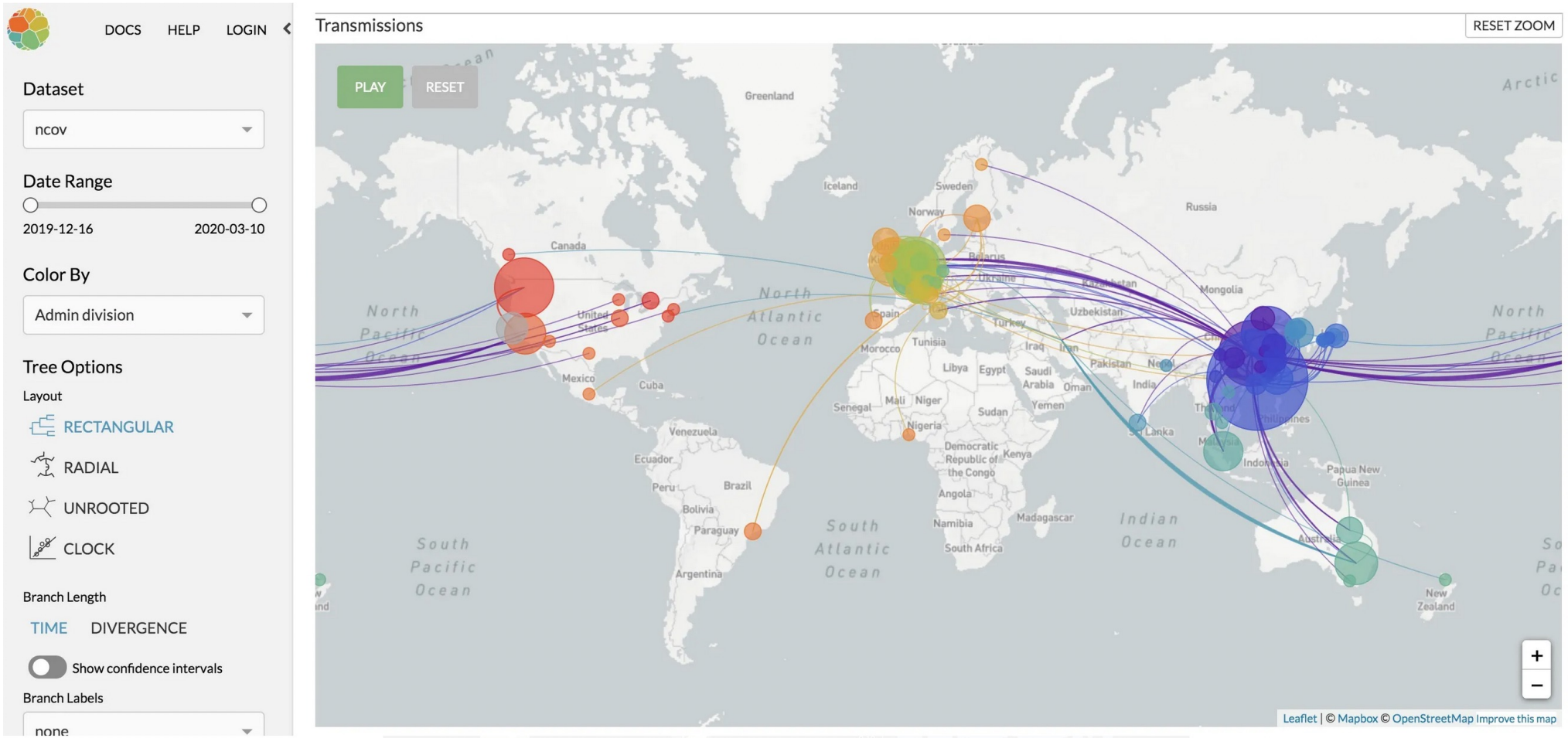
- Information Visualization

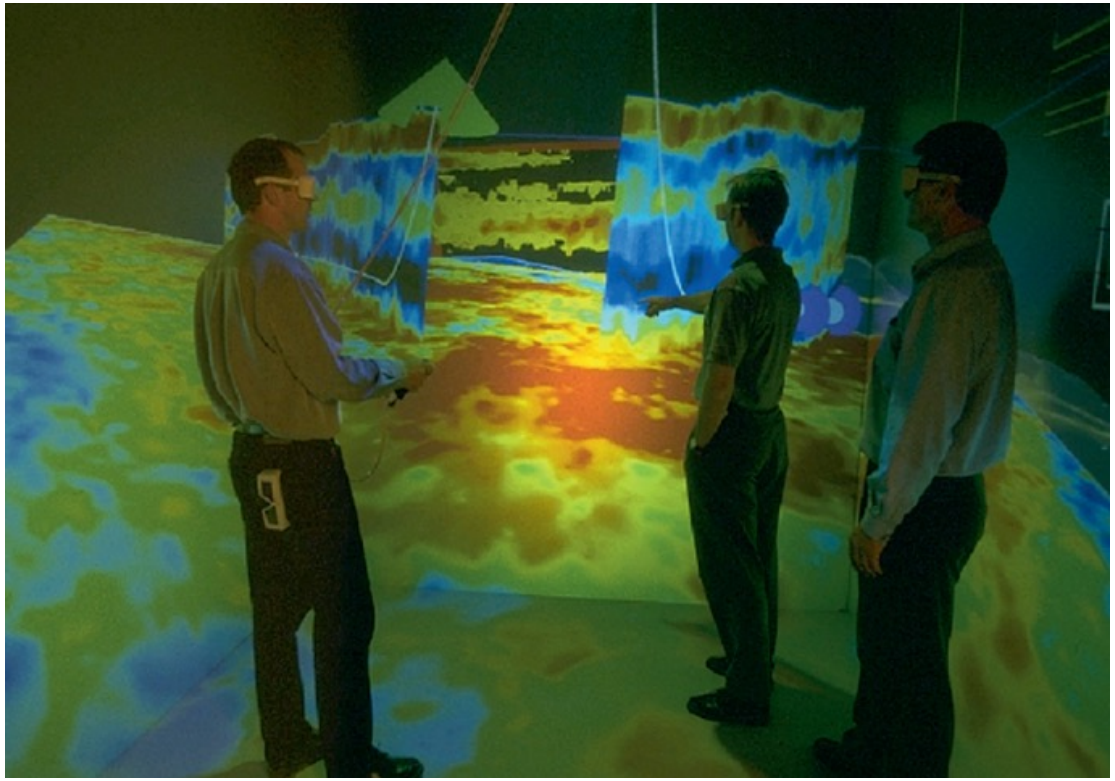


Major Applications of Computer Graphics

- Medical Imaging and Visualization

Major Applications of Computer Graphics

- Virtual Reality



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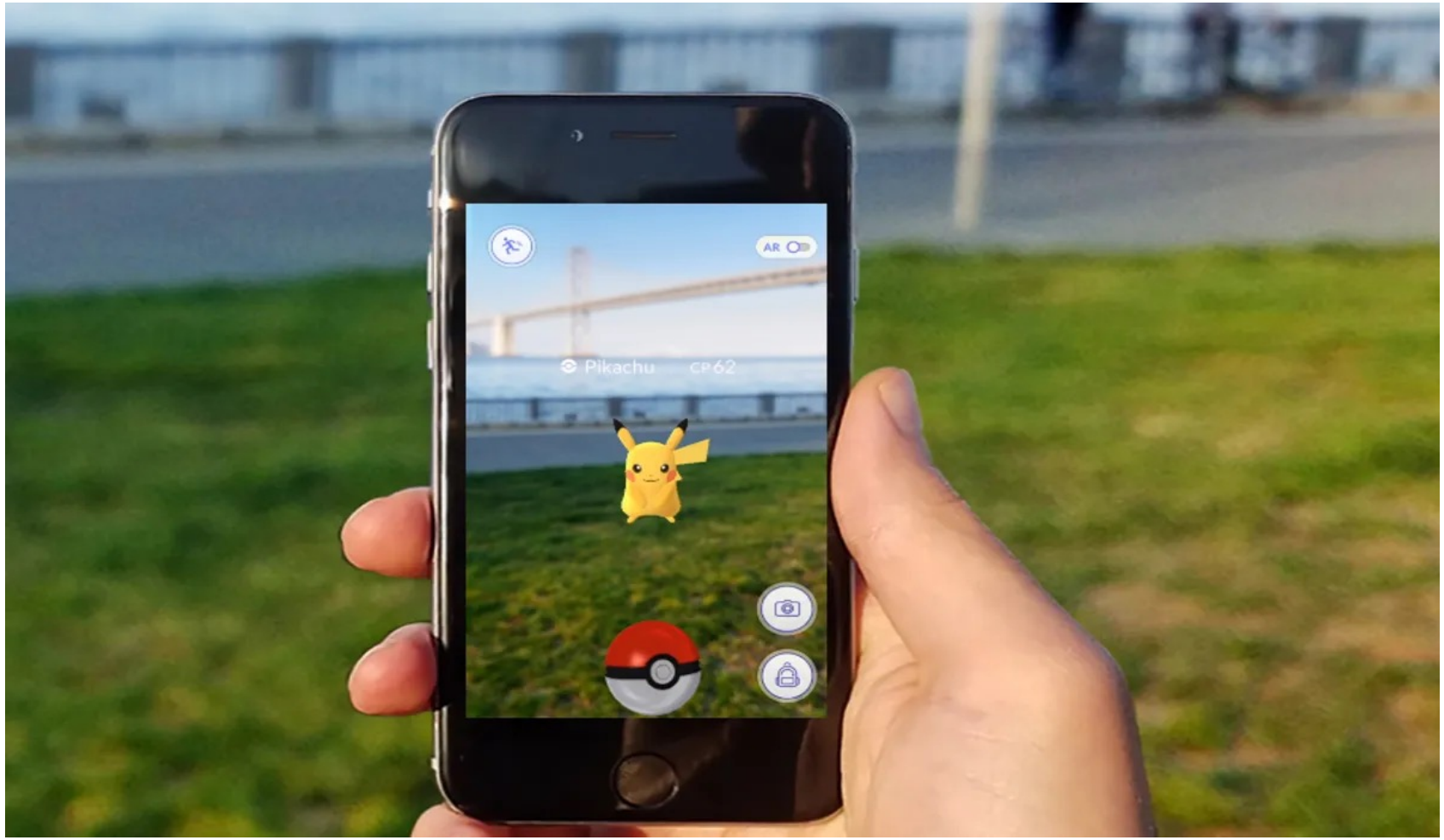
Major Applications of Computer Graphics

- Augmented Reality



Source: Google

Major Applications of Computer Graphics

- Computational Photography

Source: Google

Major Applications of Computer Graphics

- 3D Scanning

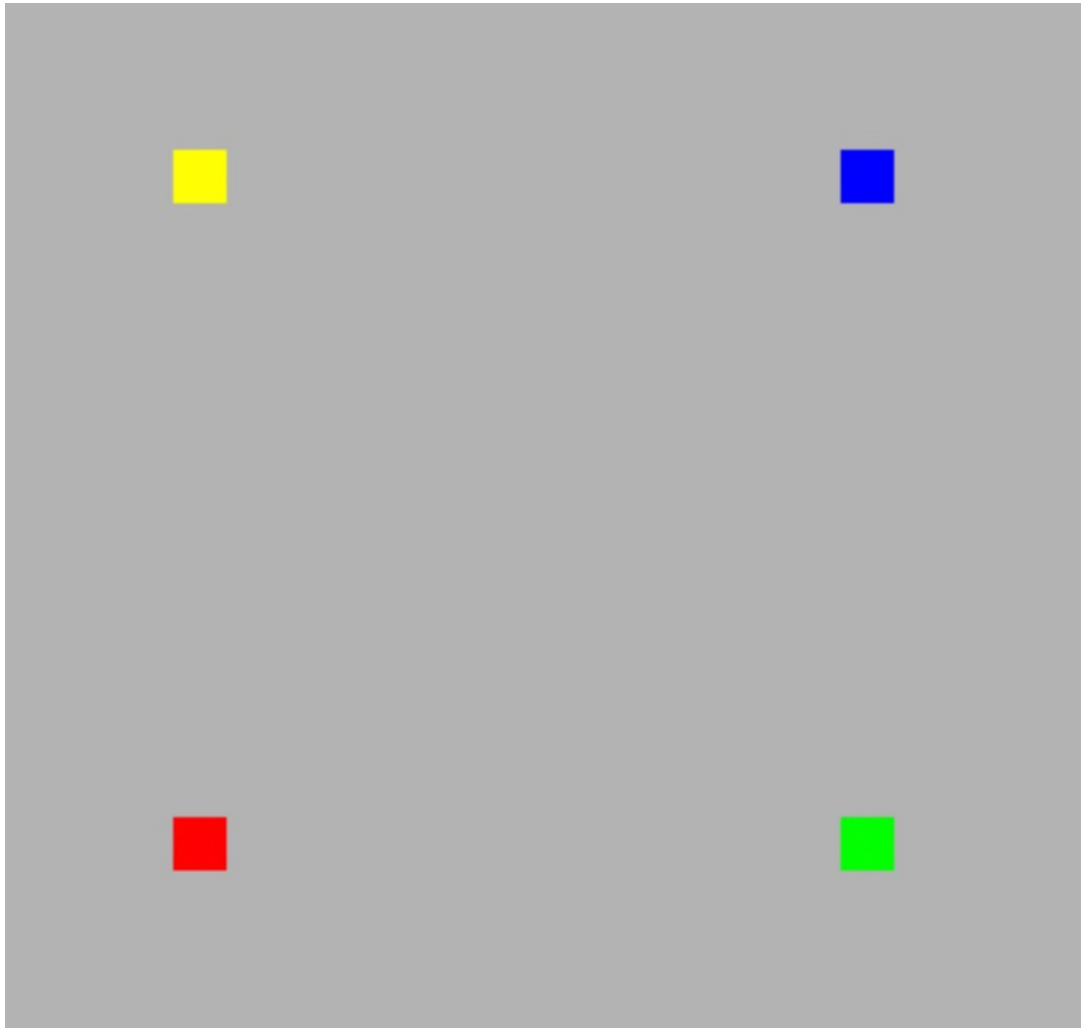
Source: Google

Major Applications of Computer Graphics

- User Interaction Interface

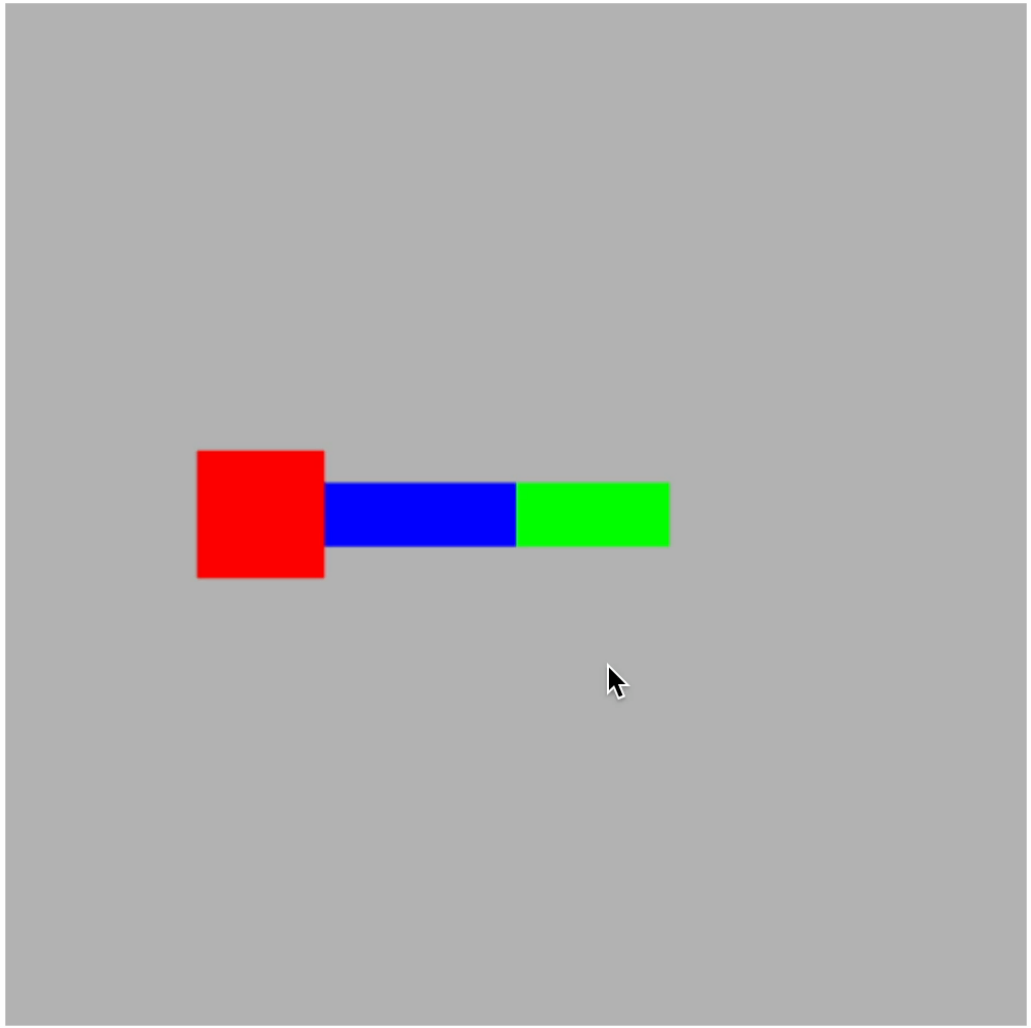
The Kind of Graphics You will Generate in This Course

Simple 2D Point Rendering

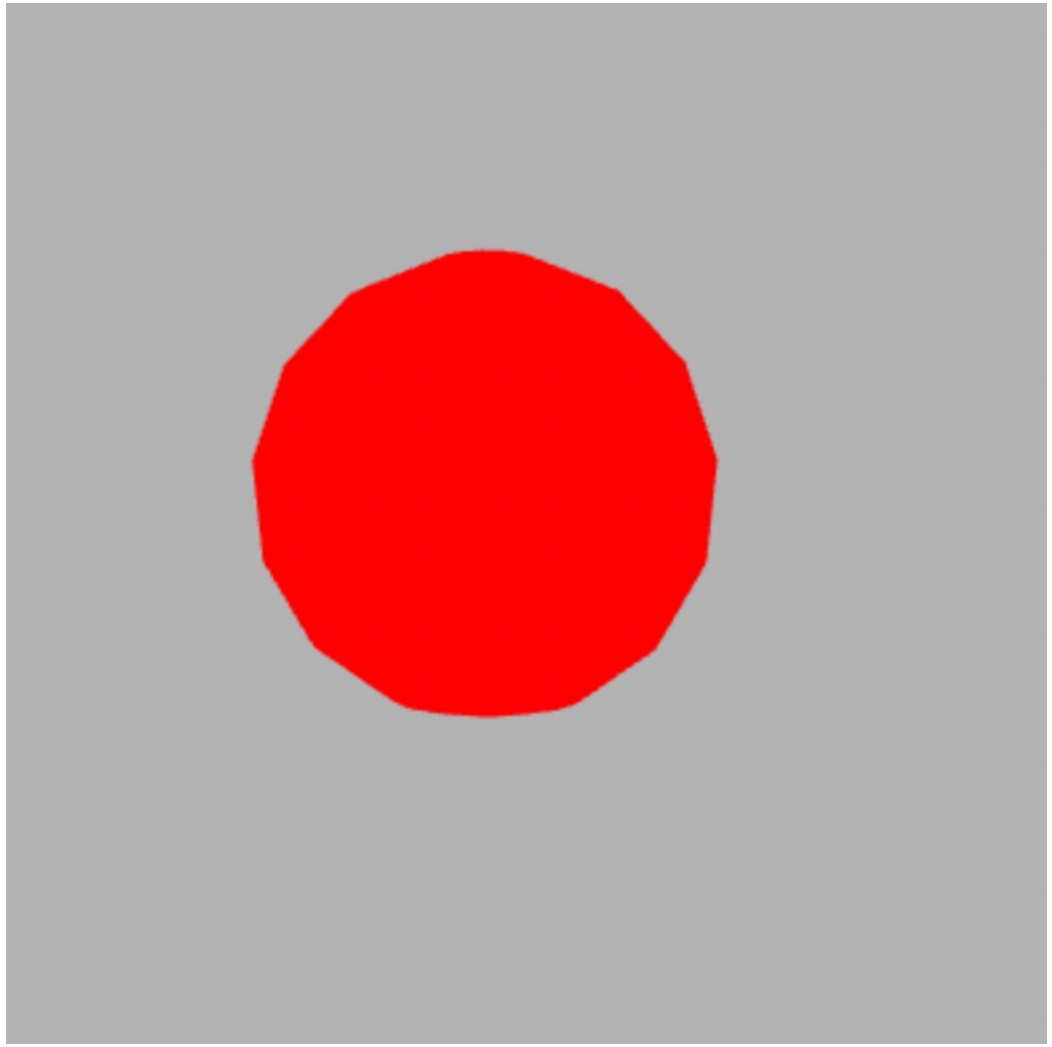


Simple 2D Primitive Rendering

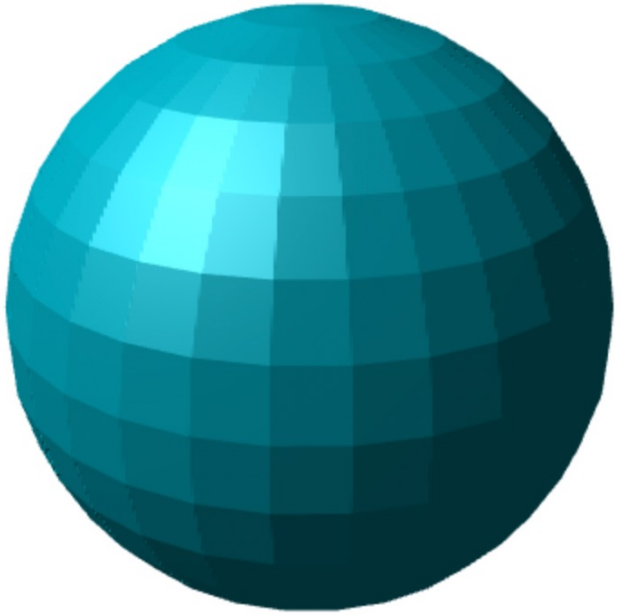
2D Transformation + Interaction

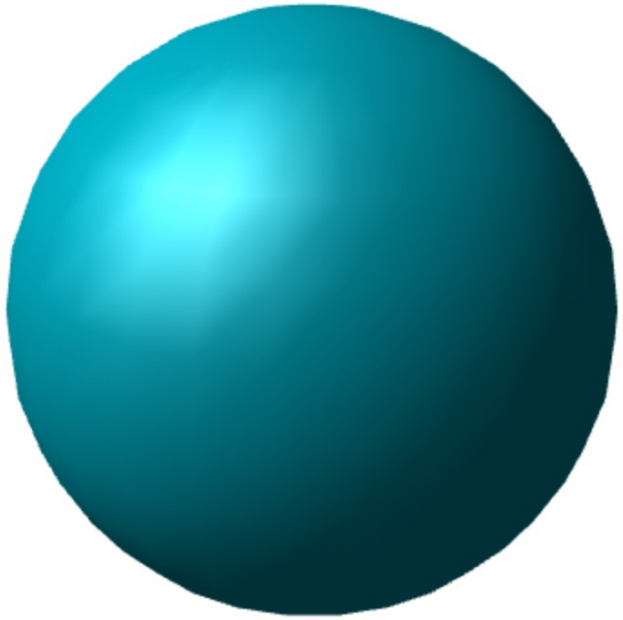


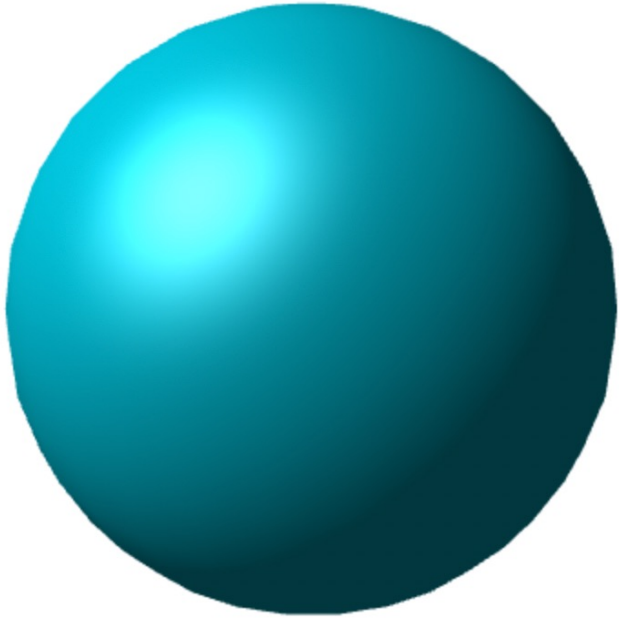
3D Primitive Rendering



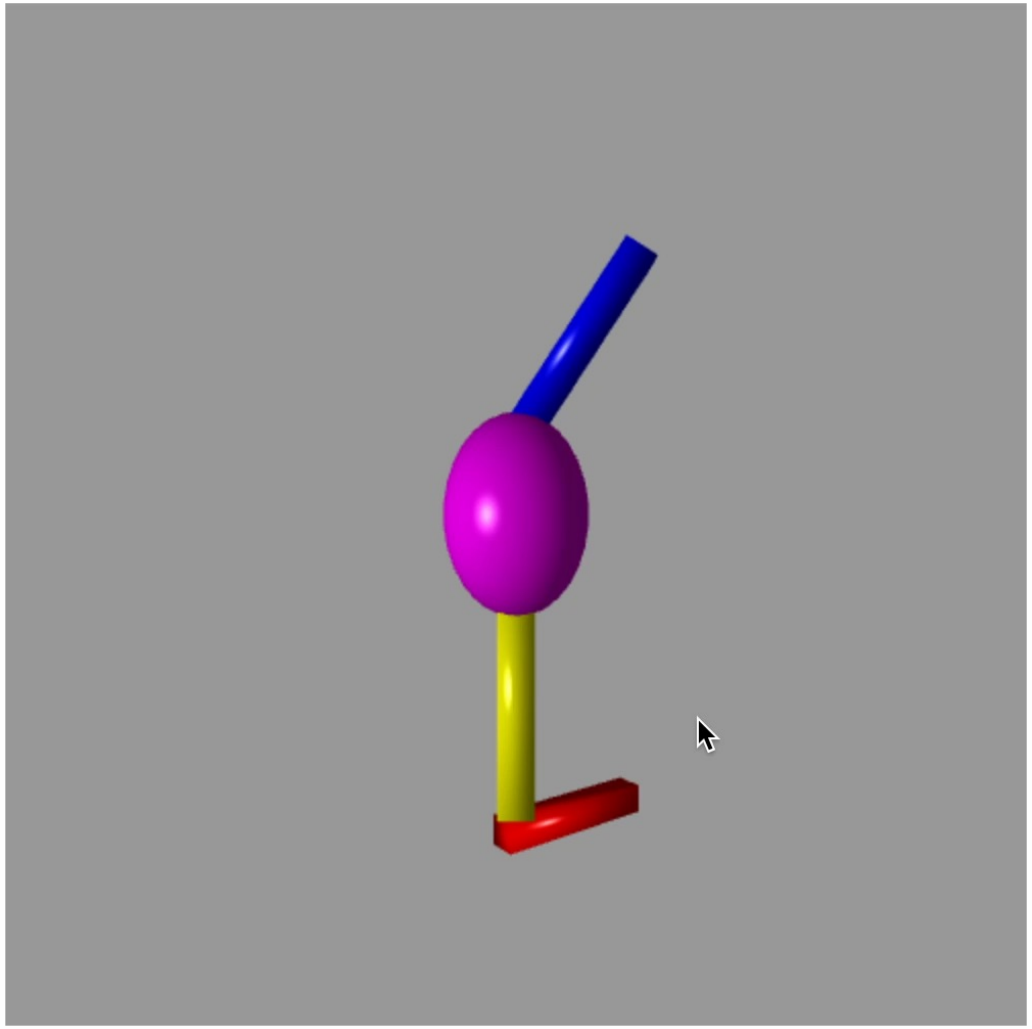
Realistic Lighting for 3D Rendering





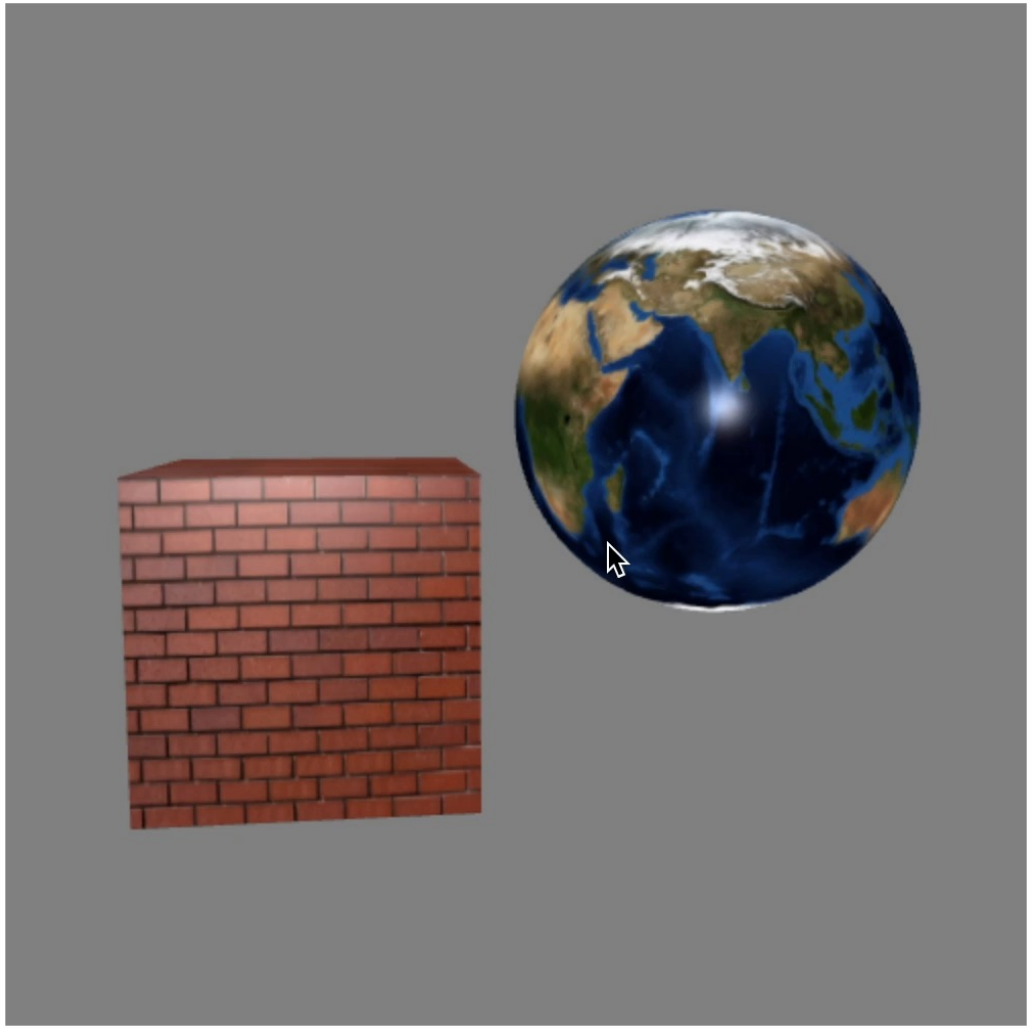


Hierarchical 3D Transformation + Animation + Interaction



2D Texture Mapping

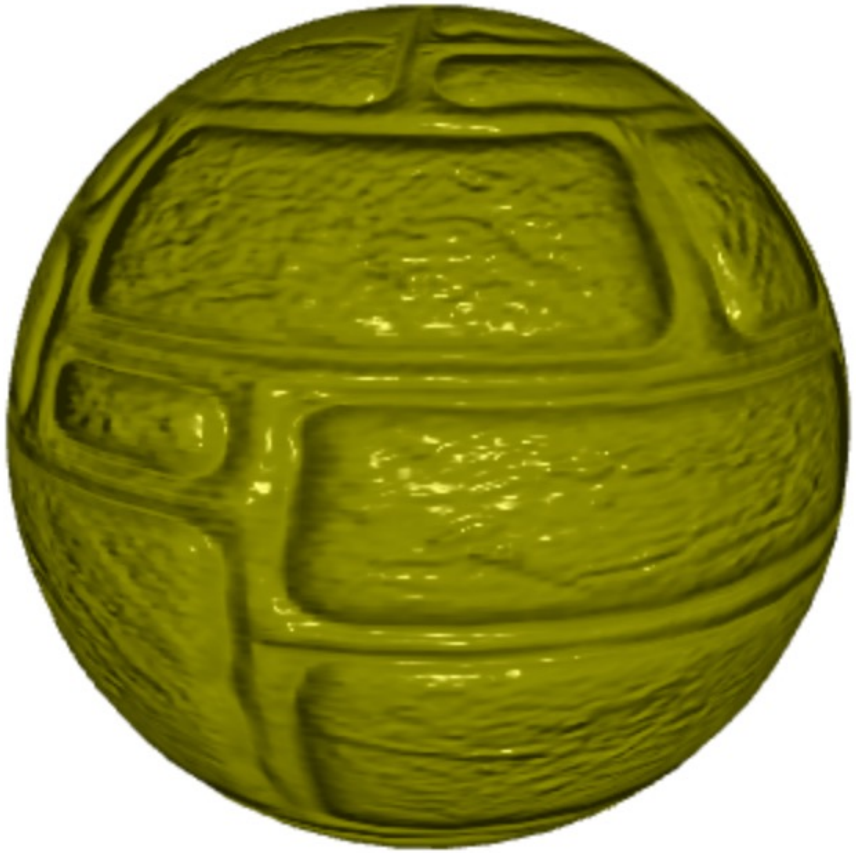
3D Texture Mapping



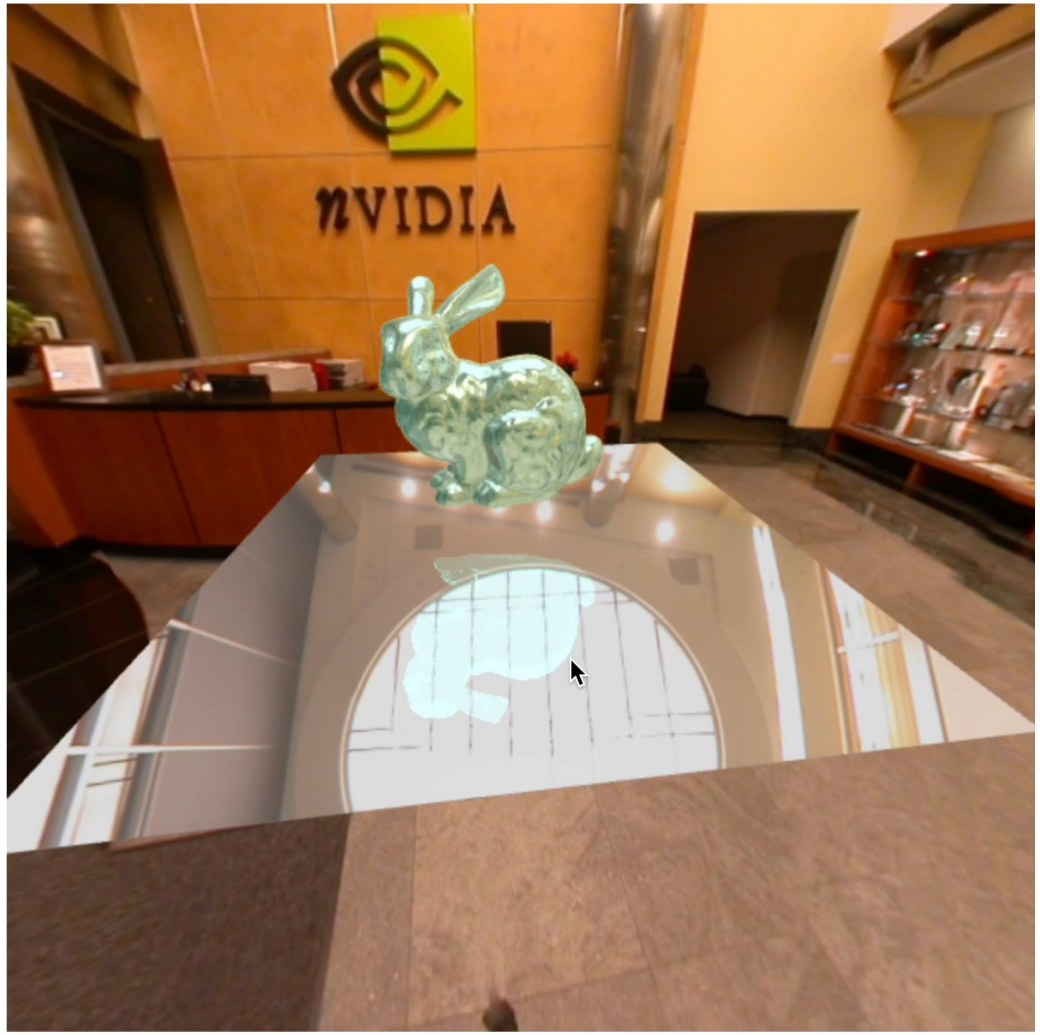
Loading Arbitrary Object Meshes

Advanced Rendering in GPU Shader + Skybox

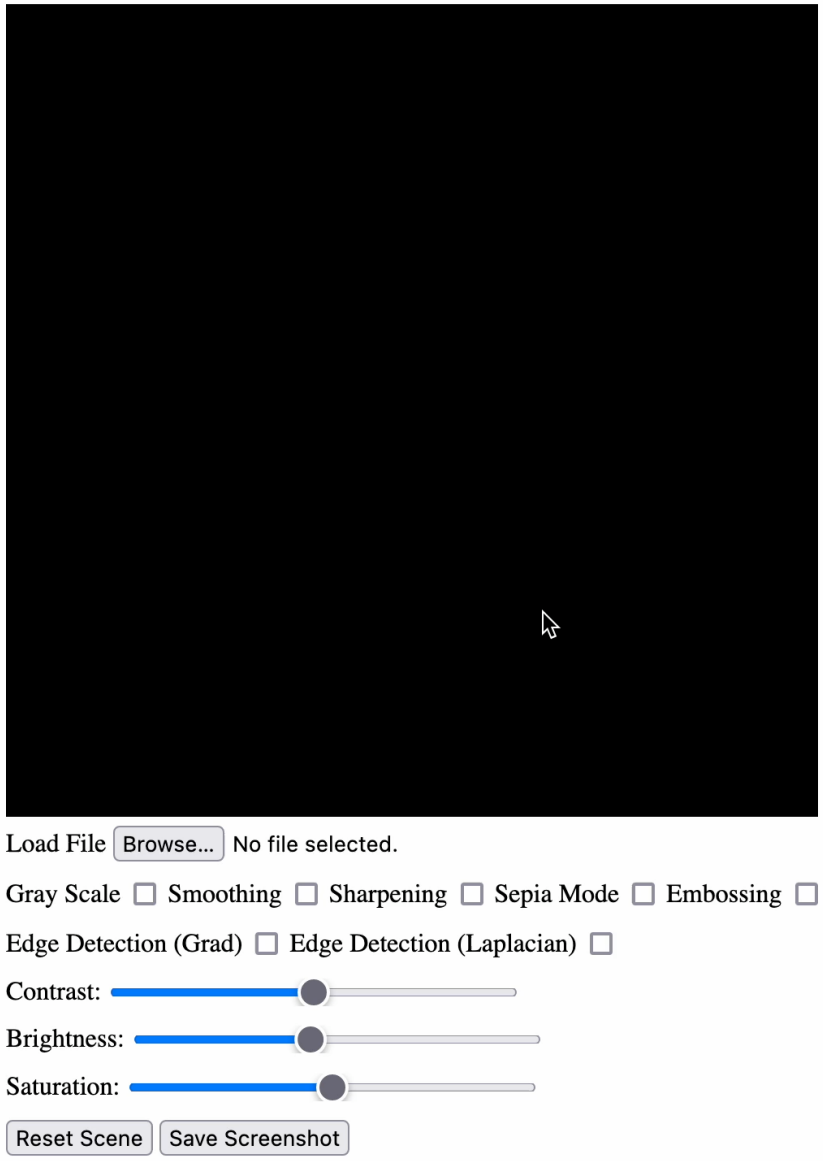
Bump Mapping



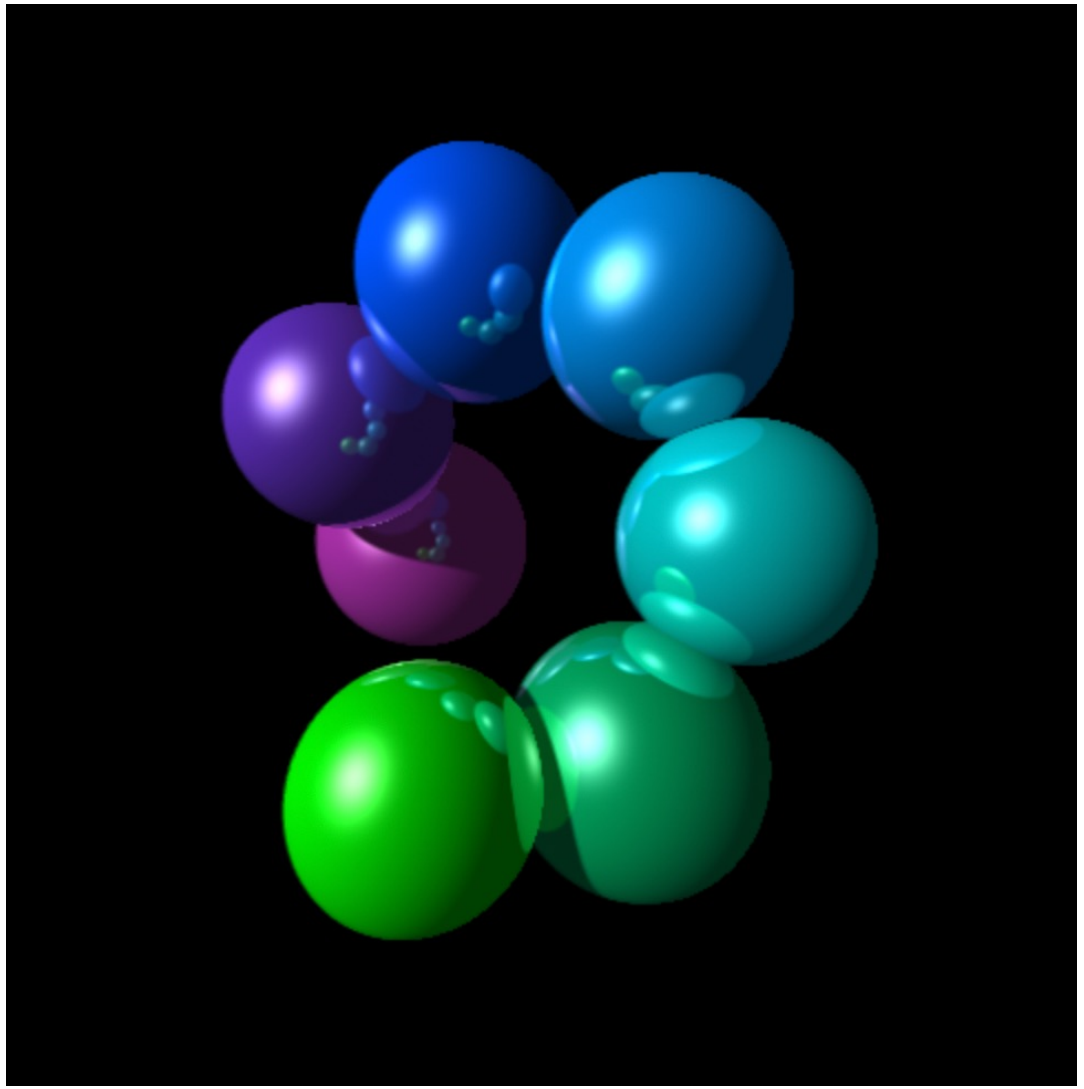
Real-time Planar Reflection



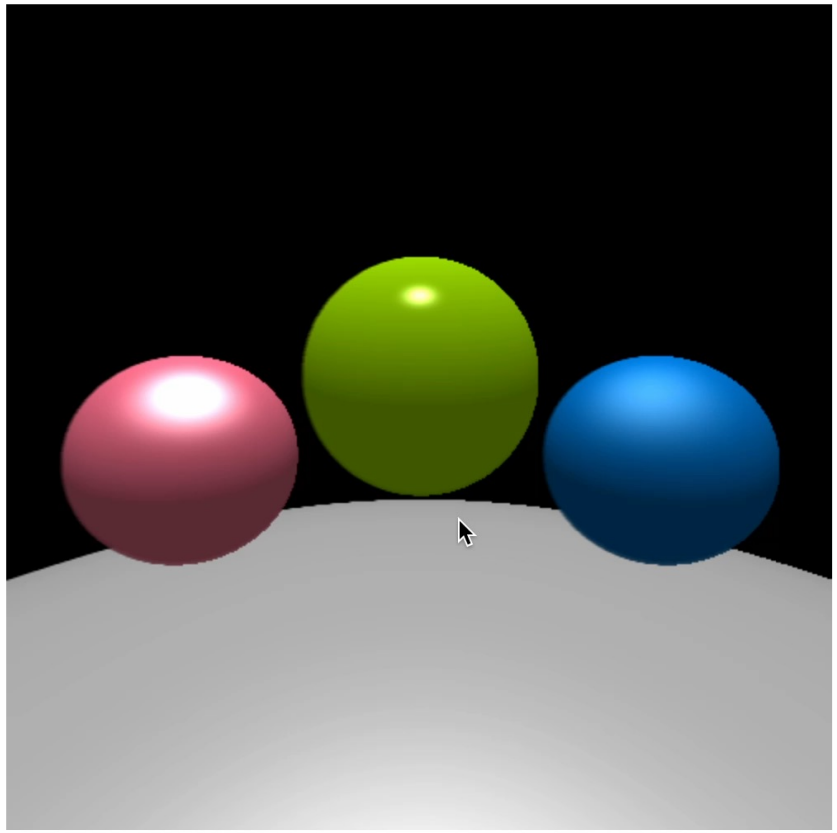
Real-time Image Post Processing in GPU Shader



Ray Tracing



Real-time Ray Tracing + Illumination + Reflection + Shadow



Shading Mode:

Phong | Phong+Shadow | Phong+Reflection | Phong+Shadow+Reflection

Anti Aliasing:

No AntiAliasing | With AntiAliasing

Move Light: