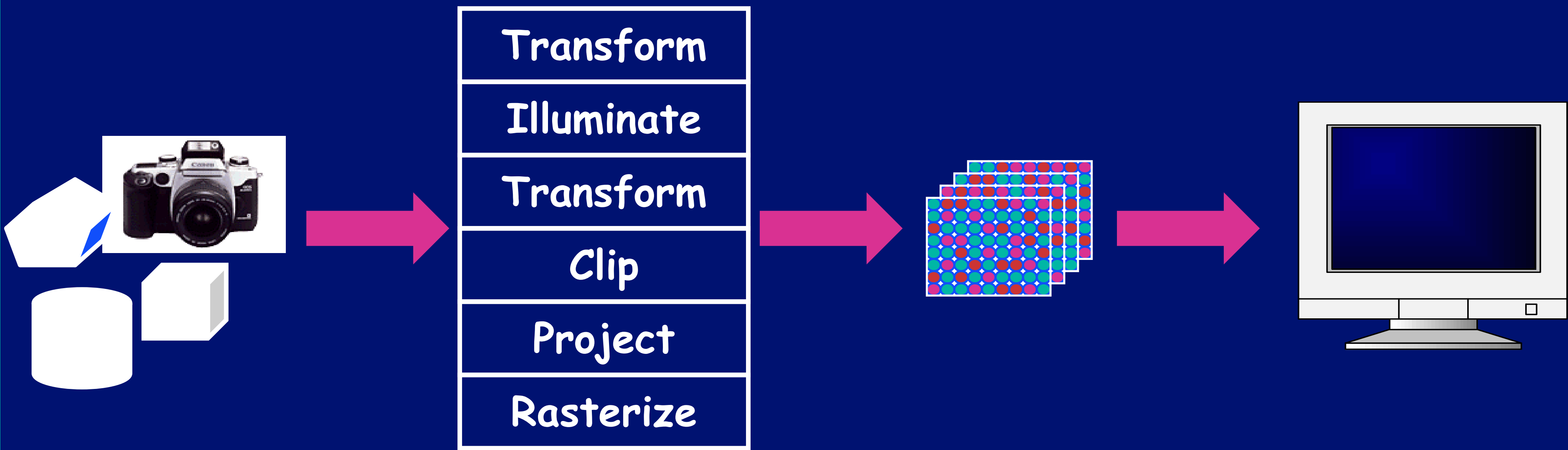
Rendering 3D Scenes



Model & Camera Parameters

Rendering Pipeline

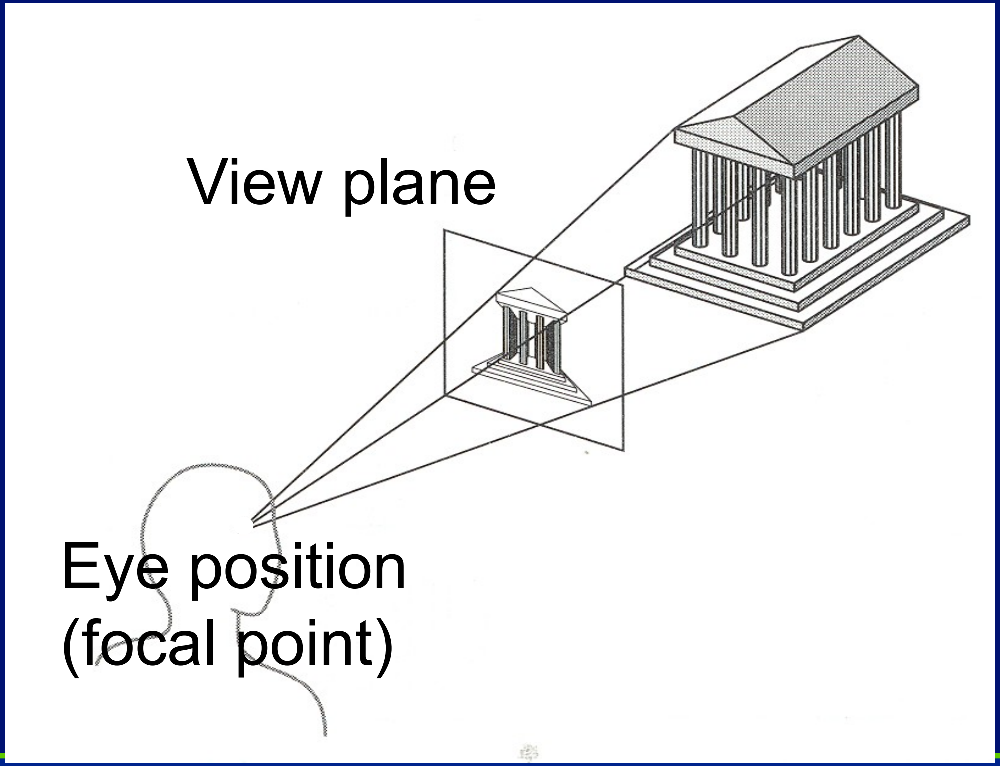
Framebuffer

Display

Camera Models

The most common model is pin-hole camera

- All captured light rays arrive along paths toward focal point without lens distortion (everything is in focus)
- Sensor response proportional to radiance



Other models consider ...

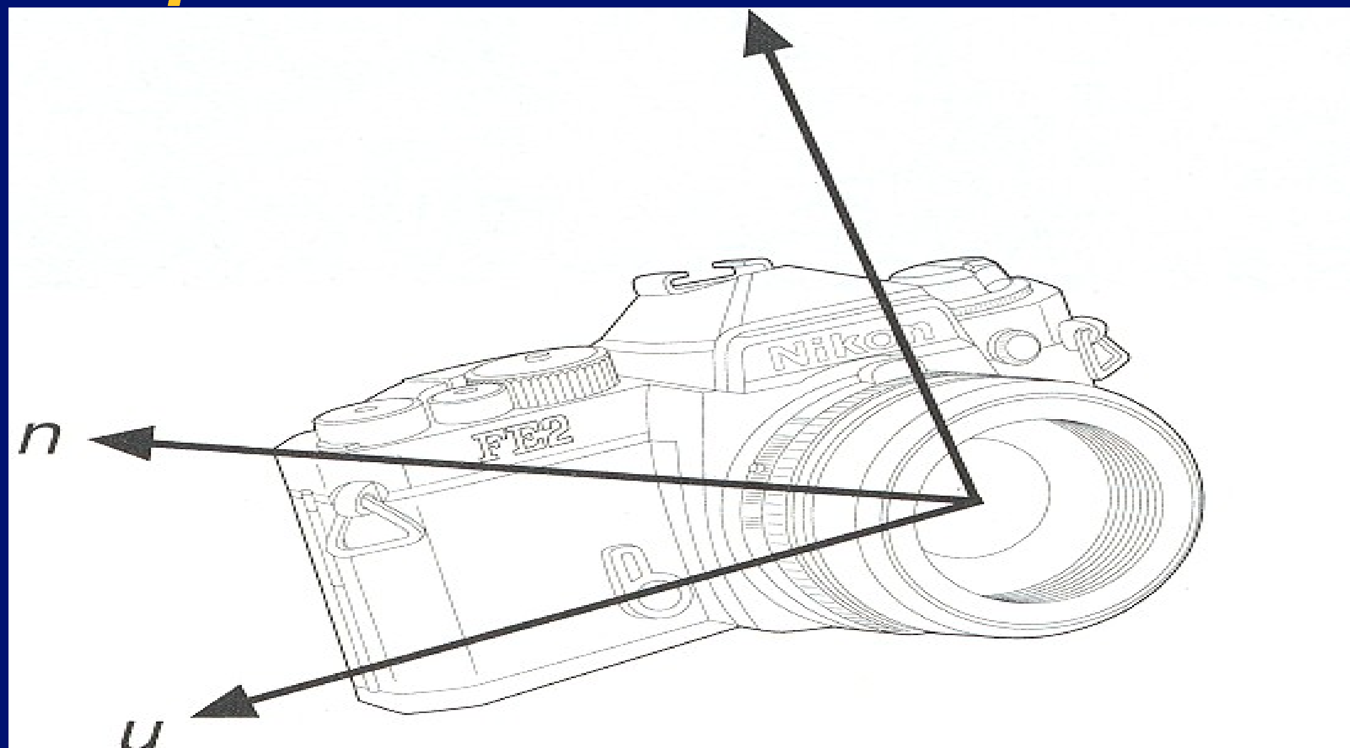
Depth of field

Motion blur

Lens distortion

Camera Parameters

What are the parameters of a camera?



Camera Parameters

Position

- Eye position (px, py, pz)

Orientation

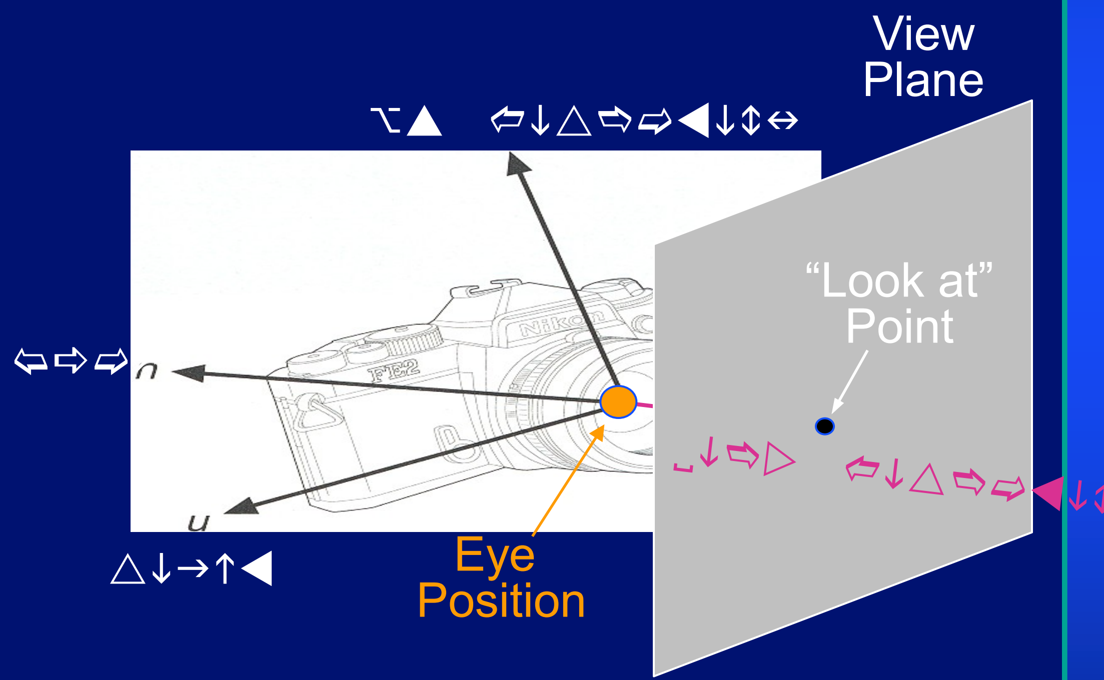
- View direction (dx, dy, dz)
- Up direction (ux, uy, uz)

Aperture

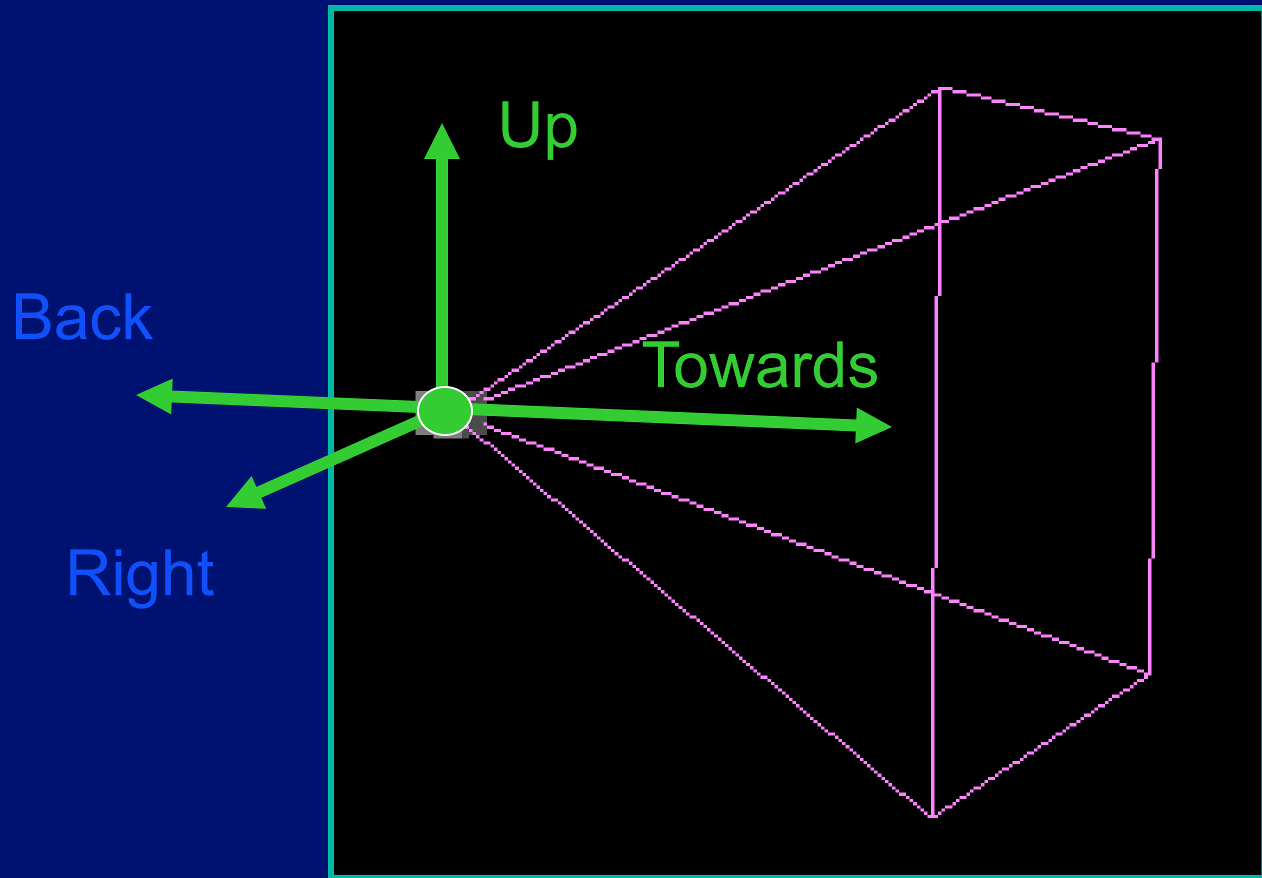
- Field of view (xfov, yfov)

Film plane

- “Look at” point
- View plane normal

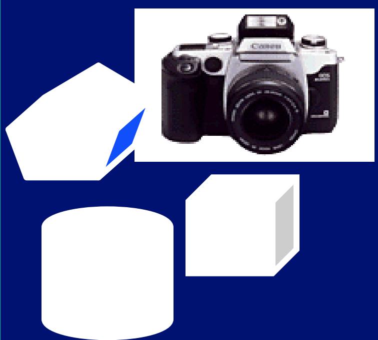


Moving the camera



View Frustum

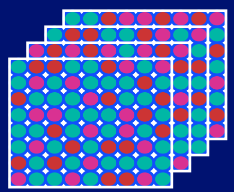
The Rendering Pipeline



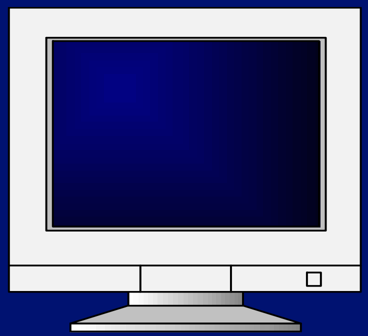
Model & Camera Parameters

Transform
Illuminate
Transform
Clip
Project
Rasterize

Rendering Pipeline



Framebuffer



Display

Rendering: Transformations

We've learned about transformations

But they are used in three ways:

- *Modeling transforms*
- *Viewing transforms (Move the camera)*
- *Projection transforms (Change the type of camera)*

The Rendering Pipeline: 3-D

Scene graph
Object geometry

Modeling Transforms

Lighting Calculations

Viewing Transform

Clipping

Projection Transform

The Rendering Pipeline: 3-D

Scene graph
Object geometry

Modeling Transforms

Lighting Calculations

Viewing Transform

Clipping

Projection Transform

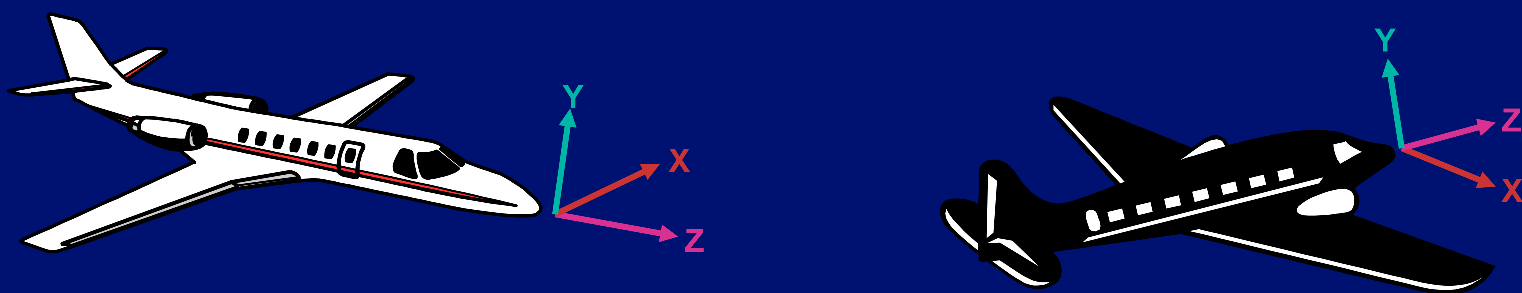
<u>Result:</u>

- All vertices of scene in shared 3-D “world” coordinate system

Rendering: Transformations

Modeling transforms

- Size, place, scale, and rotate objects and parts of the model w.r.t. each other
- Object coordinates -> world coordinates



The Rendering Pipeline: 3-D

Scene graph
Object geometry

Modeling Transforms

Lighting Calculations

Viewing Transform

Clipping

Projection Transform

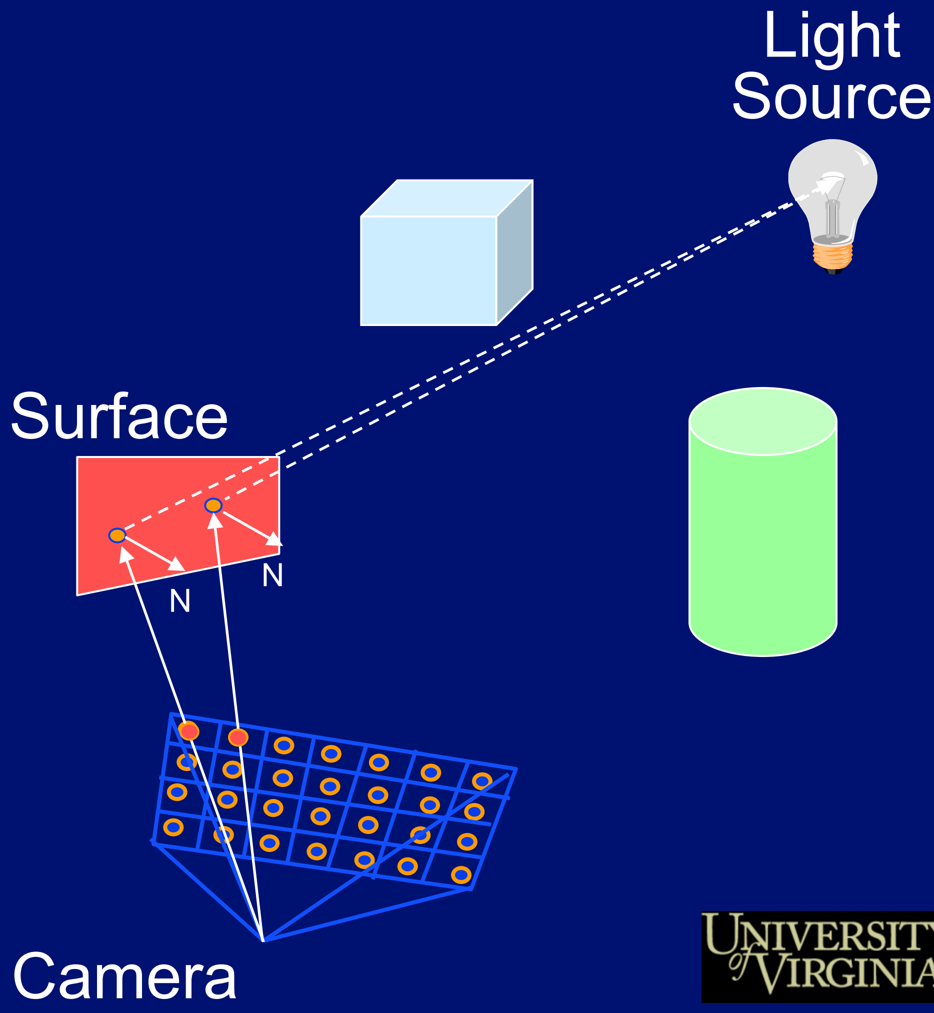
Result:

- All geometric primitives are illuminated

Lighting Simulation

Lighting parameters

- Light source emission
- Surface reflectance
- Atmospheric attenuation
- Camera response



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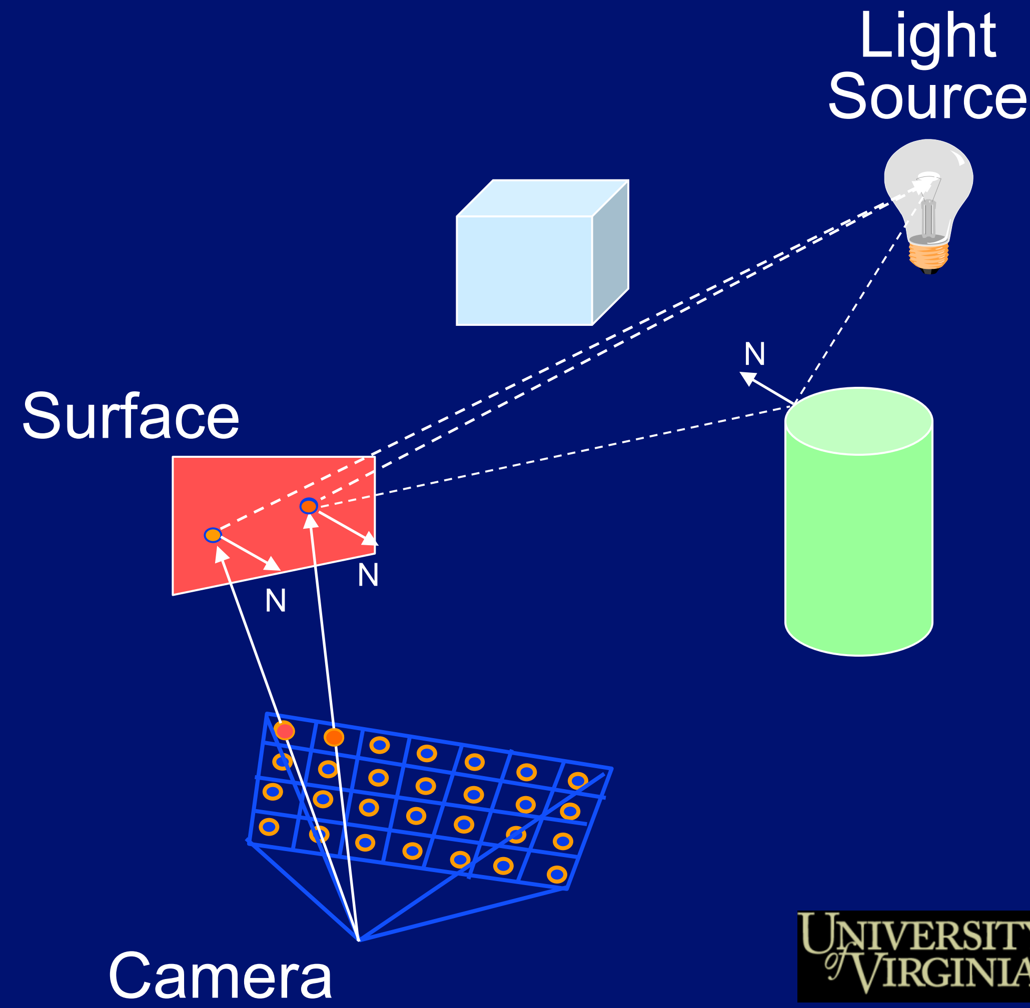
Lighting Simulation

Direct illumination

- Ray casting
- Polygon shading

Global illumination

- Ray tracing
- Monte Carlo methods
- Radiosity methods



More on these methods later!

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The Rendering Pipeline: 3-D

Scene graph
Object geometry

Modeling
Transforms

Lighting
Calculations

Viewing
Transform

Clipping

Projection
Transform

Result:

- Scene vertices in 3-D “view” or “camera” coordinate system

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Rendering: Transformations

Viewing transform

- Rotate & translate the world to lie directly in front of the camera
  - *Typically place camera at origin*
  - *Typically looking down -Z axis*
- **World coordinates ⇨ view coordinates**

The Rendering Pipeline: 3-D

Scene graph
Object geometry

Modeling Transforms

Lighting Calculations

Viewing Transform

Clipping

Projection Transform

Result:

- Remove geometry that is out of view

Assignment 2

Due two and a half weeks from today

- Project description available online
- We'll discuss details in class on Monday

The Rendering Pipeline: 3-D

Scene graph
Object geometry

Modeling
Transforms

Lighting
Calculations

Viewing
Transform

Clipping

Projection
Transform

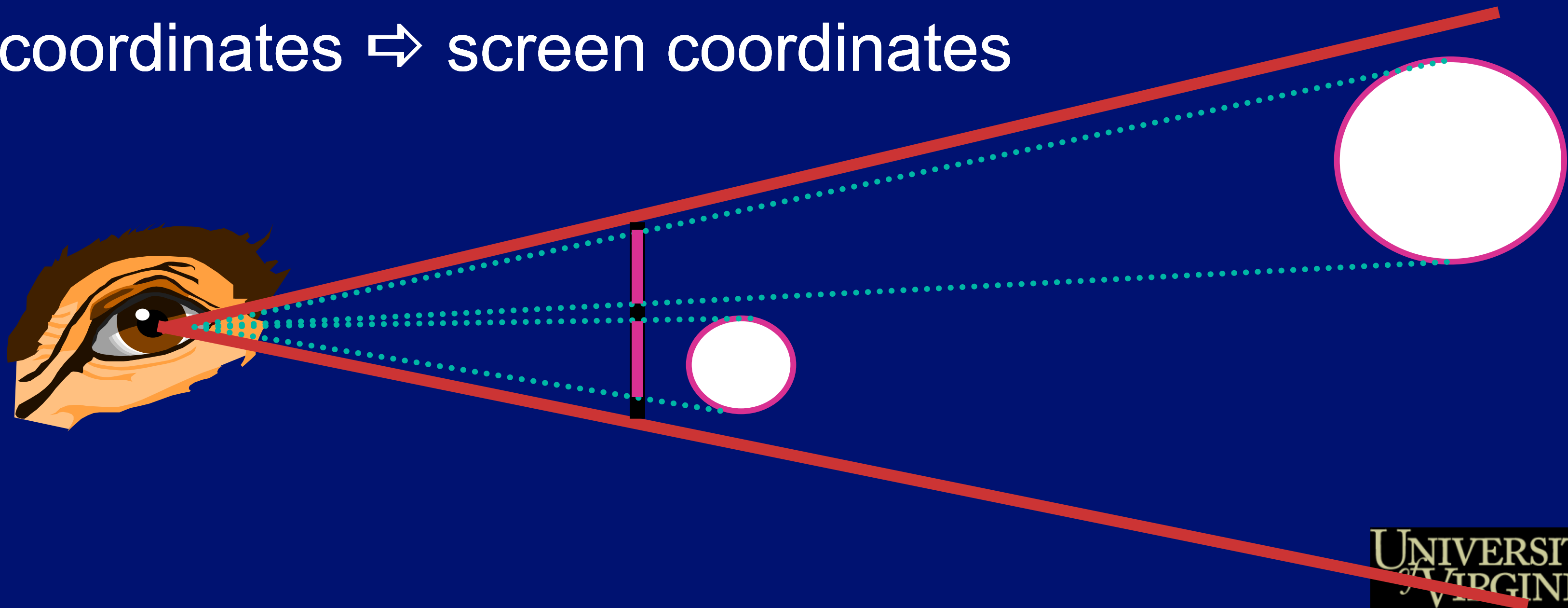
Result:

- 2-D screen coordinates of clipped vertices

Rendering: Transformations

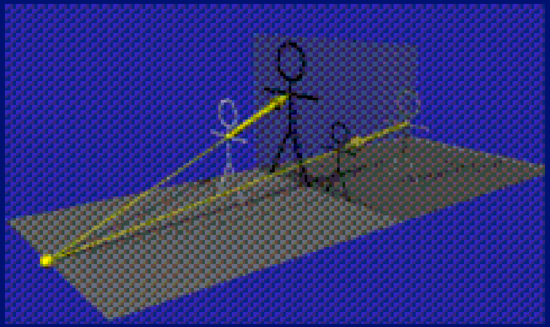
Projection transform

- Apply perspective foreshortening
  - *Distant = small: the* pinhole camera *model*
- View coordinates ⇨ screen coordinates

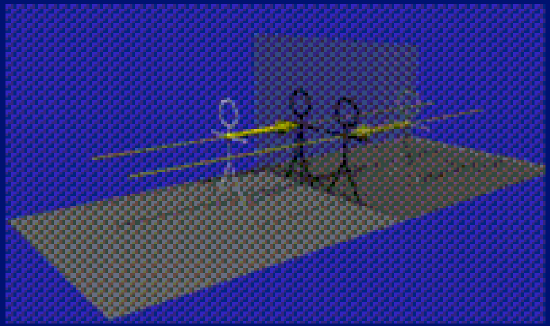


Rendering: Transformations

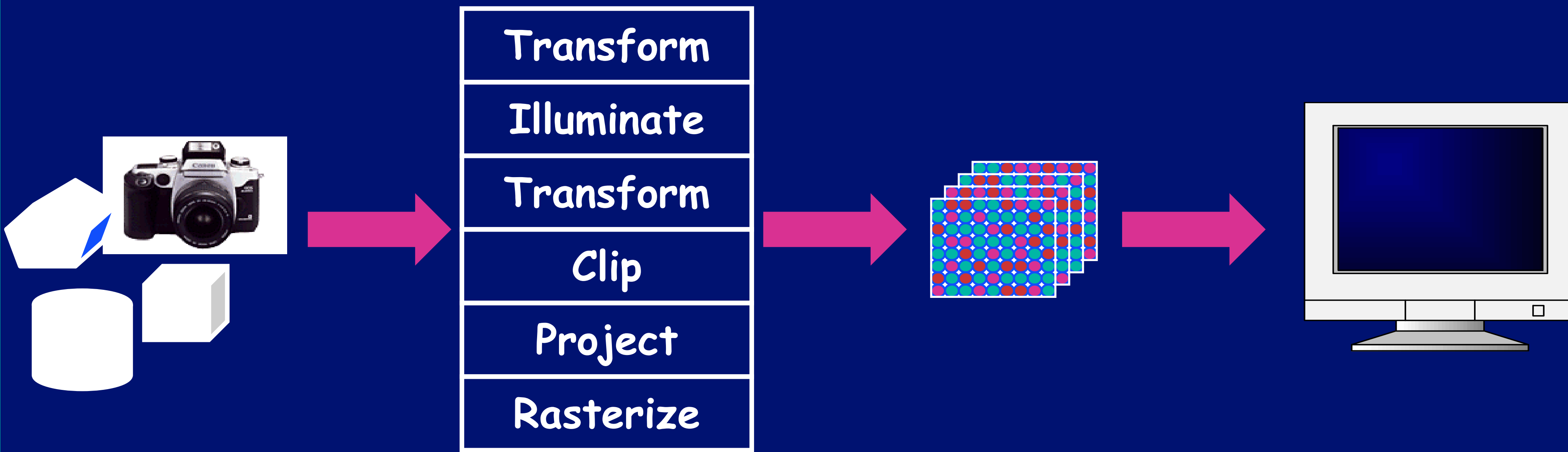
Perspective Camera



Orthographic Camera



Rendering 3D Scenes



Model & Camera Parameters

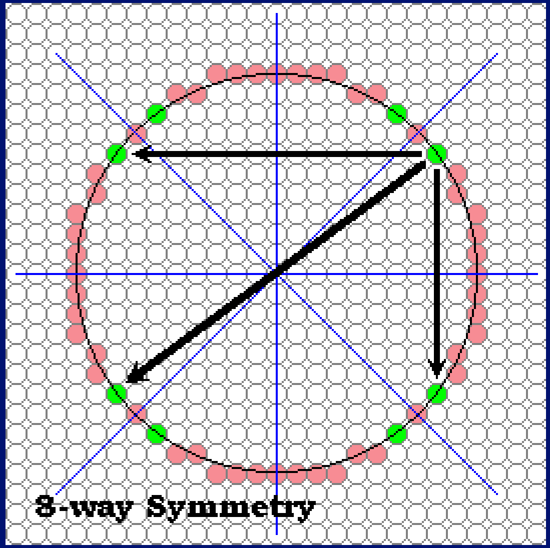
Rendering Pipeline

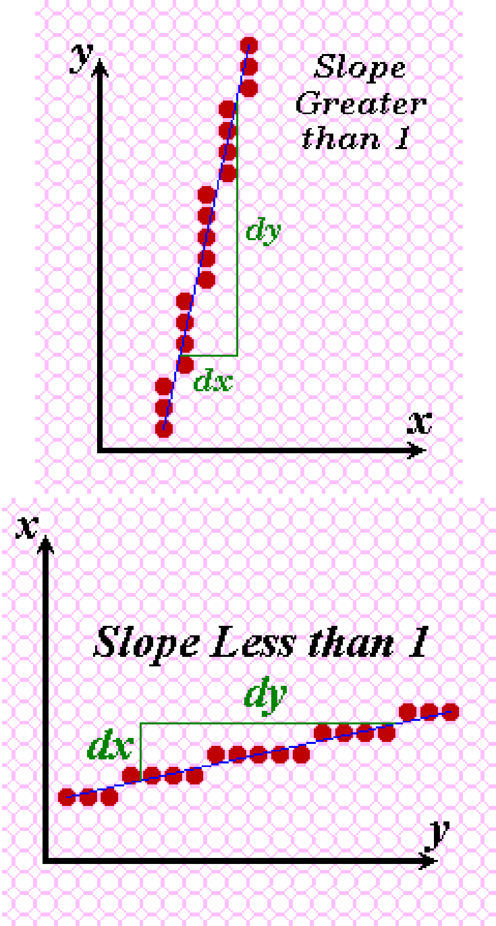
Framebuffer

Display

Rasterize

Convert screen coordinates to pixel colors





Summary

Geometric primitives

- Points, vectors

Operators on these primitives

- Dot product, cross product, norm

The rendering pipeline

- Move models, illuminate, move camera, clip, project to display, rasterize