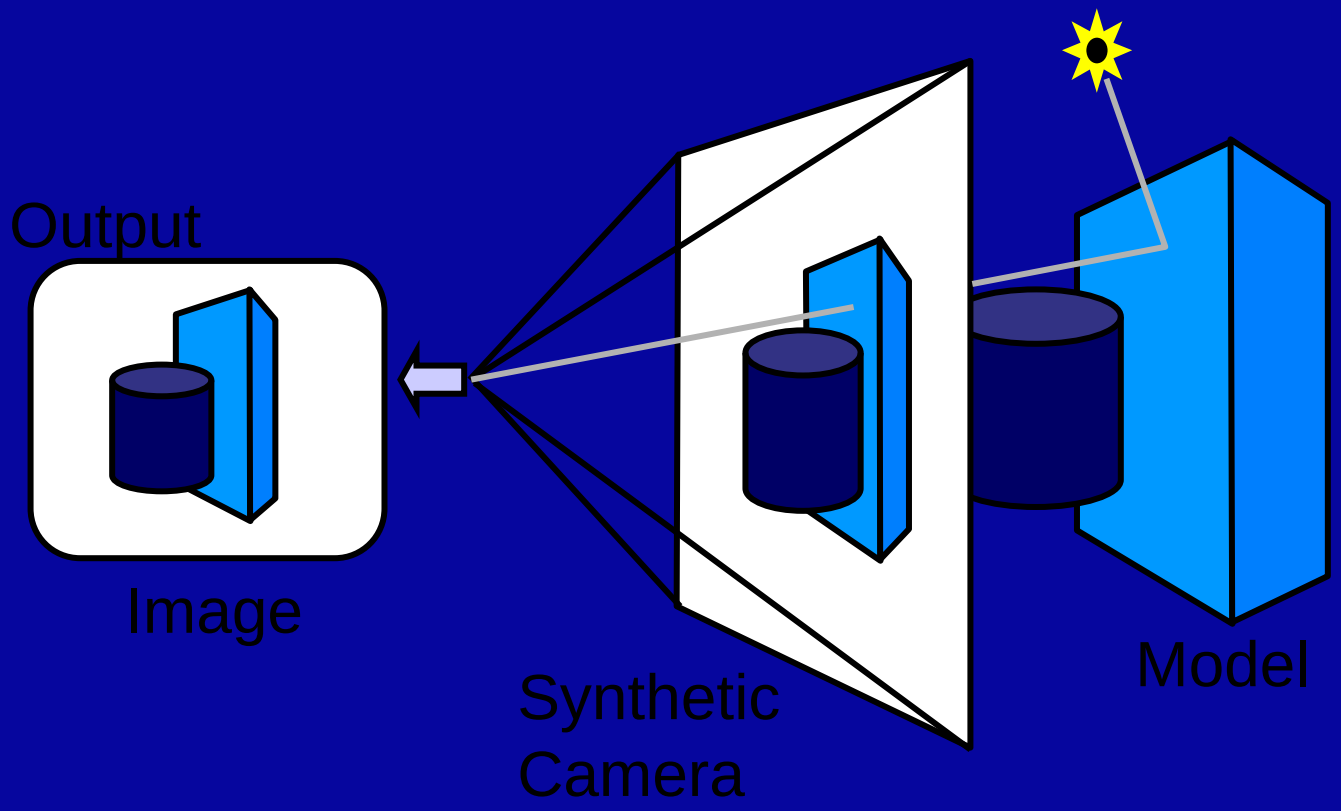
Image-Based Rendering

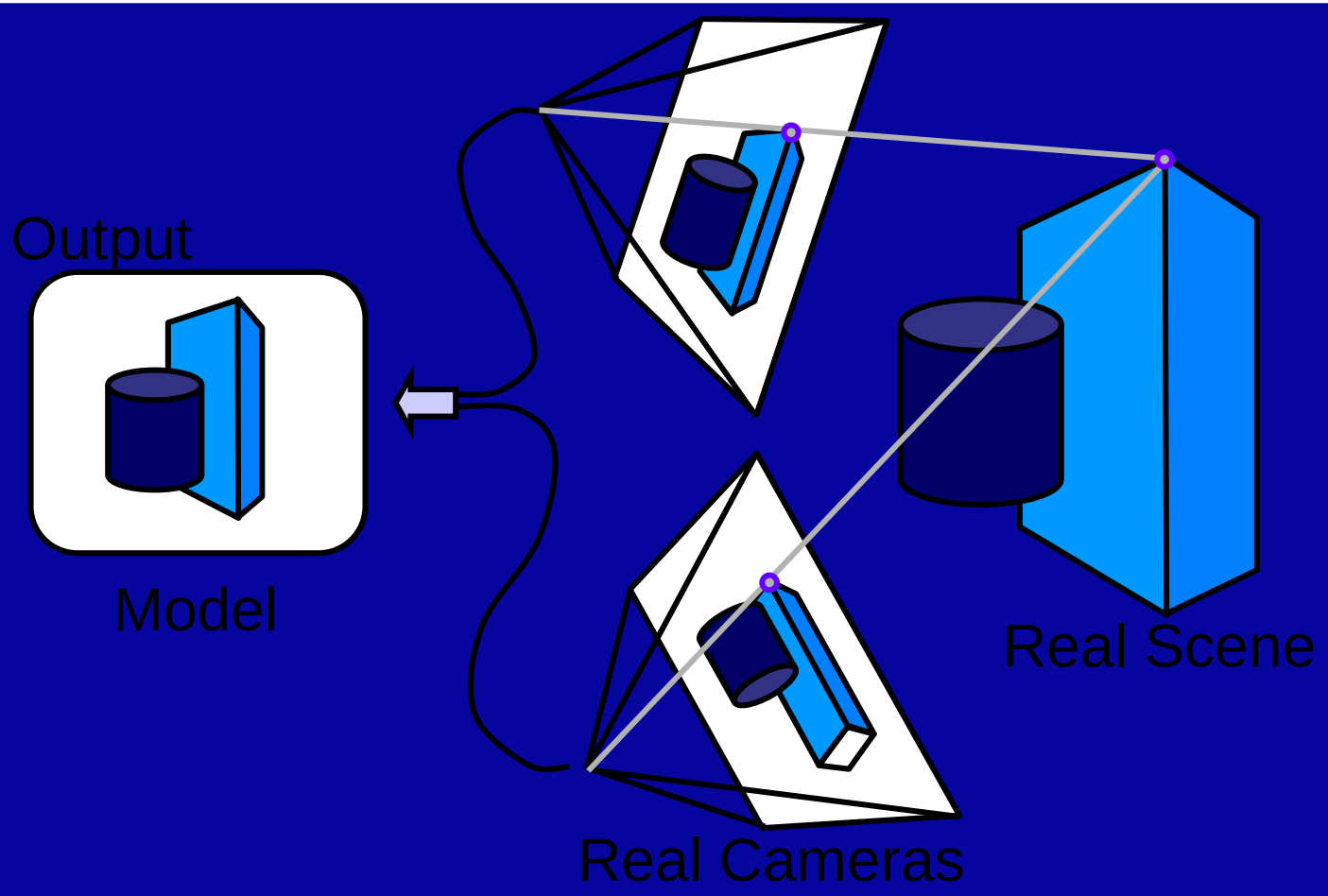
(with most of slides from Richard Szeliski and Michael Cohen)

Computer Graphics

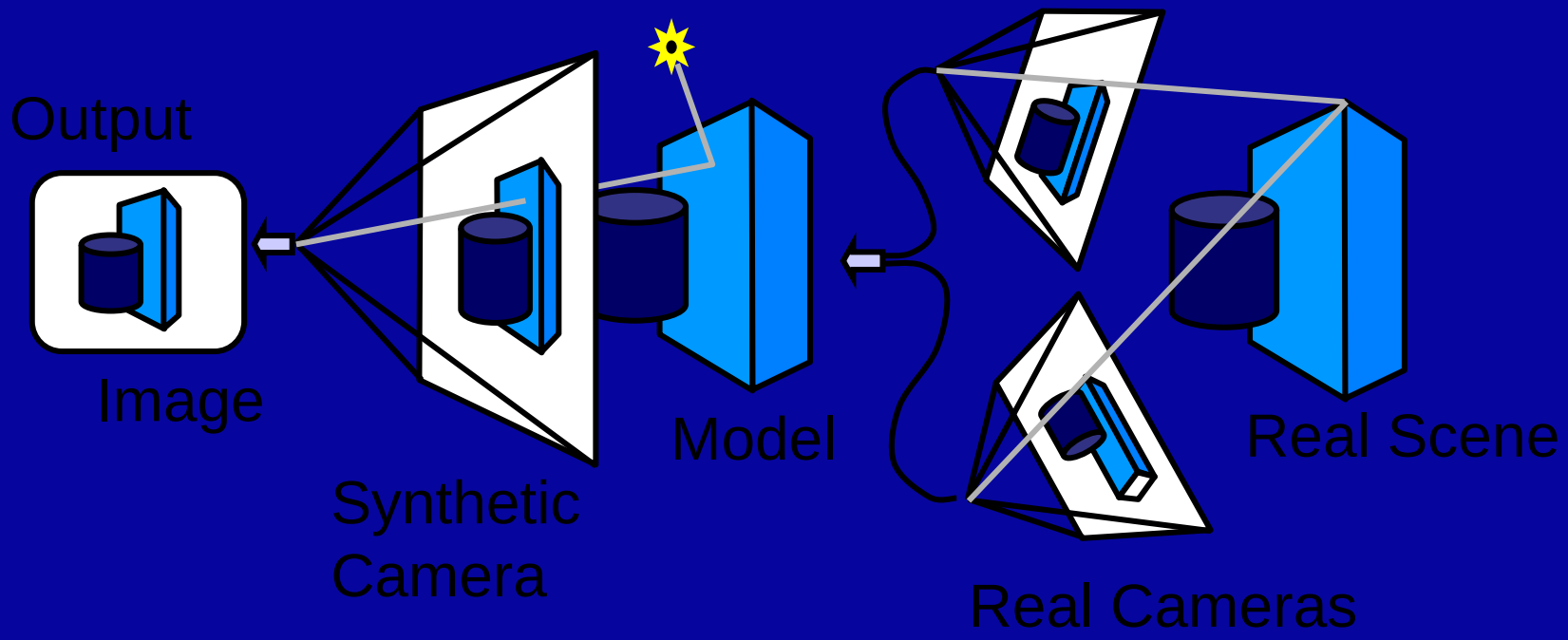


Geometry + Material attributes

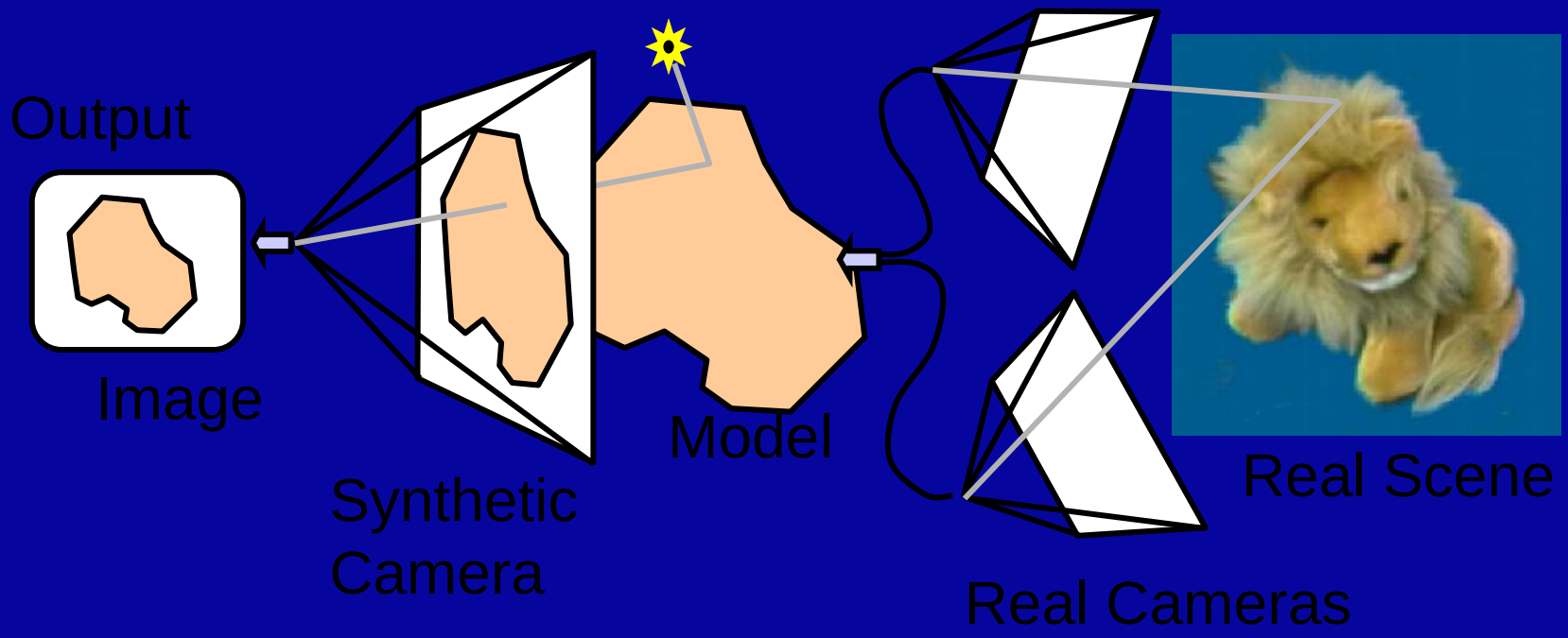
Computer Vision



Combined

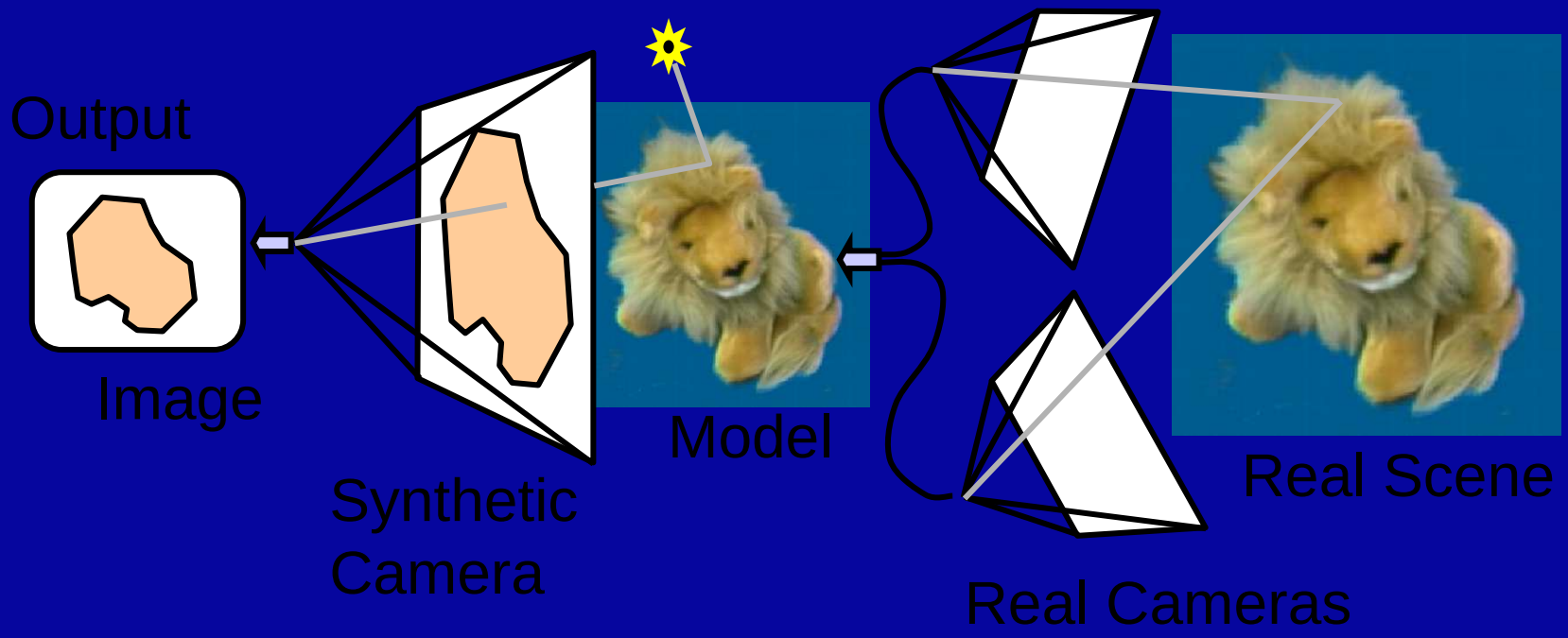

Output
Image
Synthetic Camera
Model
Real Scene
Real Cameras

But, vision technology falls short



Hard to re-create much of the complex geometry and lighting effects found in real world

… and so does graphics.



Hard to render world illumination

What is Image-Based Rendering?

All we usually care about in rendering is generating images from new viewpoints.

Image-Based Rendering

Geometry based

- Geometry + Material attributes

Skip traditional modeling/rendering process

Image based rendering seeks to replace geometry and surface properties with images

Quicktime VR

Skip traditional modeling/rendering process

Capture environment maps from given locations

Look around from a fixed point

Show Demo

Lightfields and Lumigraphs

Modeling light

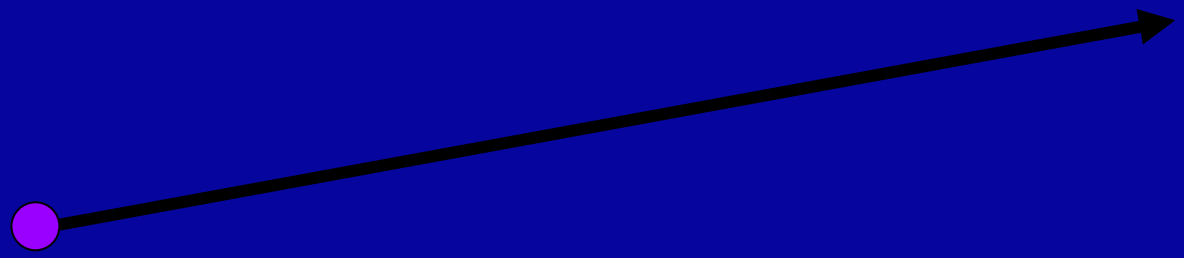
Capture flow of light in region of environment

Described by plenoptic function

Plenoptic Function

Describes the intensity of light:

- passing through a given point, $\boldsymbol{x}$
- in a given direction, (θ, ϕ)



5D

- 3D position
- 2D direction

All Rays

Plenoptic Function:

- all possible rays

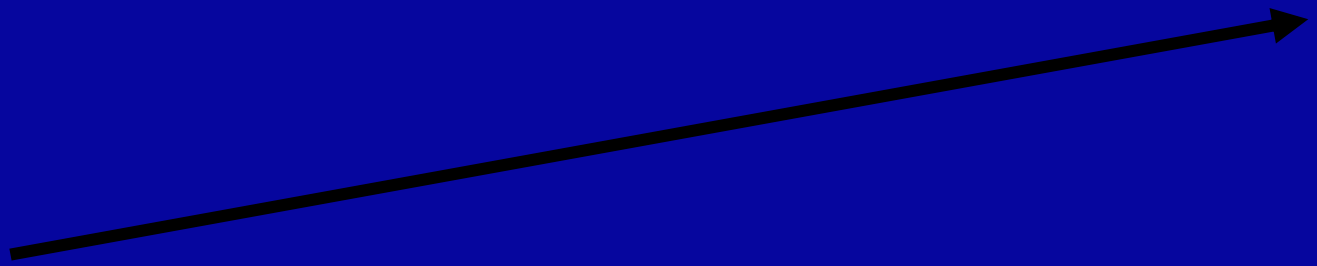
Plenoptic Function

Many image-based rendering approaches can be cast as sampling from and reconstructing the plenoptic function

Note, function is generally constant along segments of a line (assuming vacuum)

Line

Infinite line

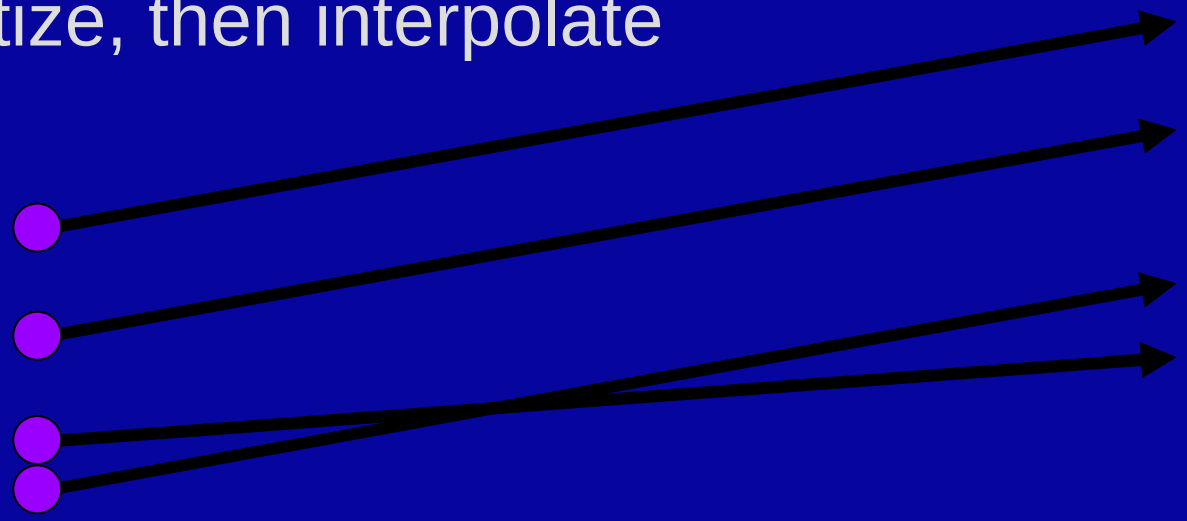


4D

- 2D direction
- 2D position
- Intensity does not change along the line

Ray

Discretize, then interpolate



Distance between 2 rays

- Which is closer together?

Panorama

What is an panorama?

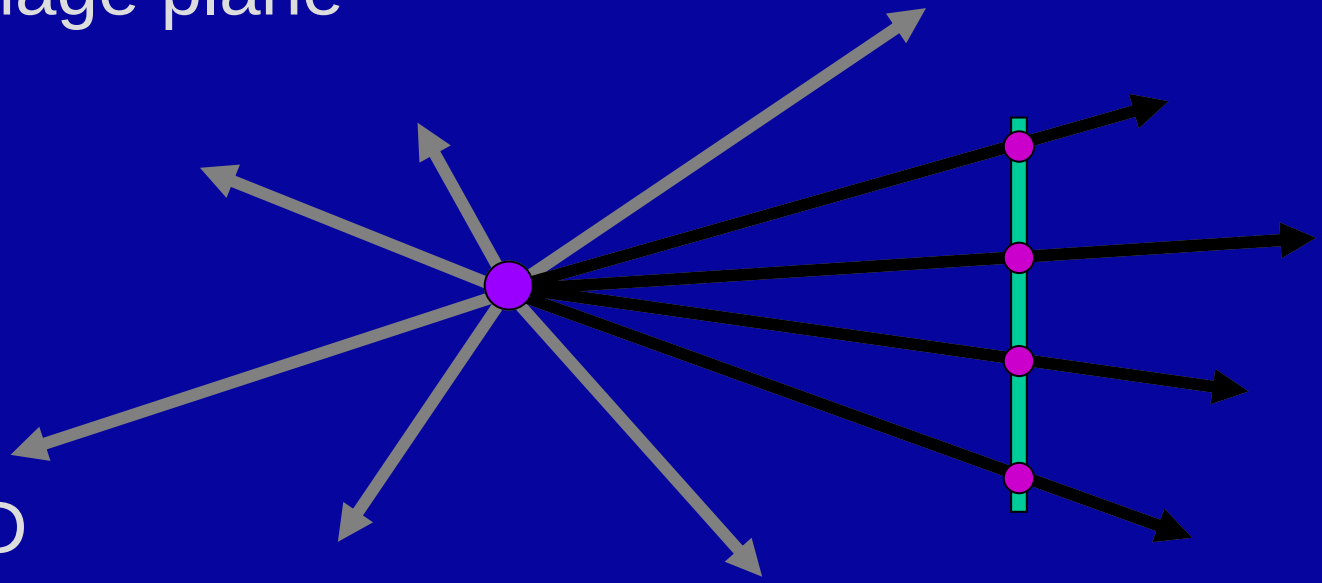
All rays through a point

Panoramic Mosaics

Convert panoramic image sequence into a cylindrical image

Image

Image plane

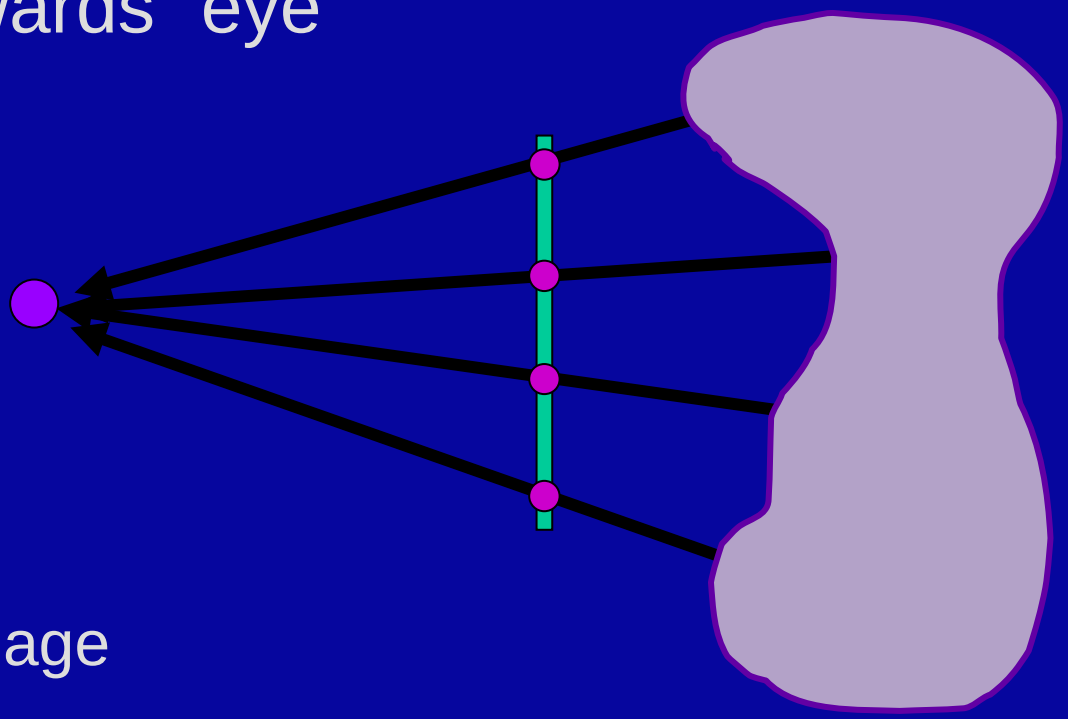


2D

- position in plane

Object

Light leaving towards “eye”

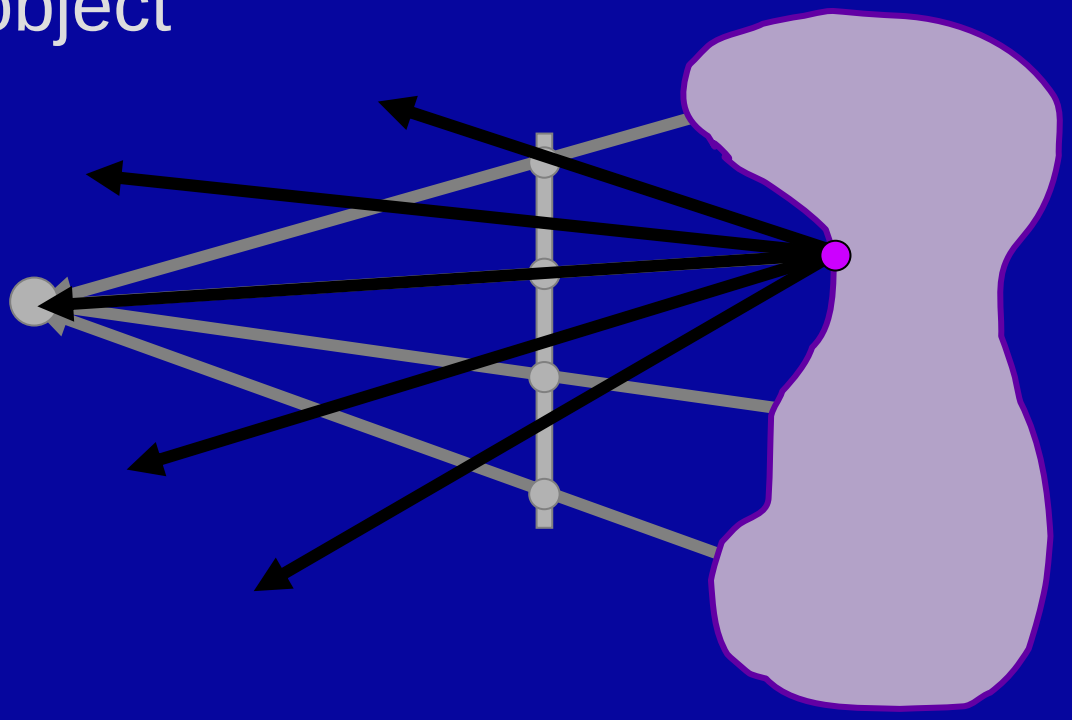


2D

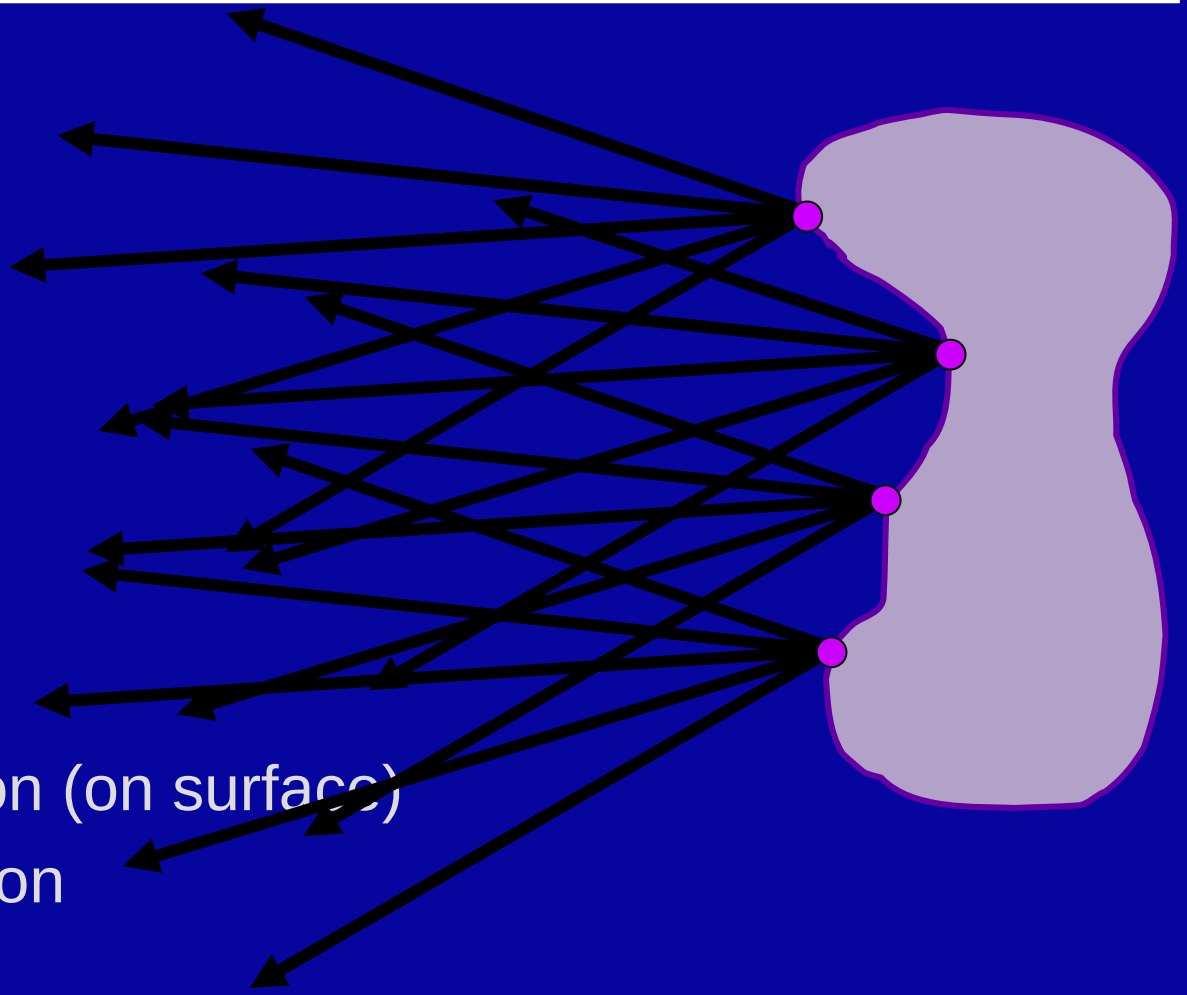
- just dual of image

Object

All light leaving object



Object

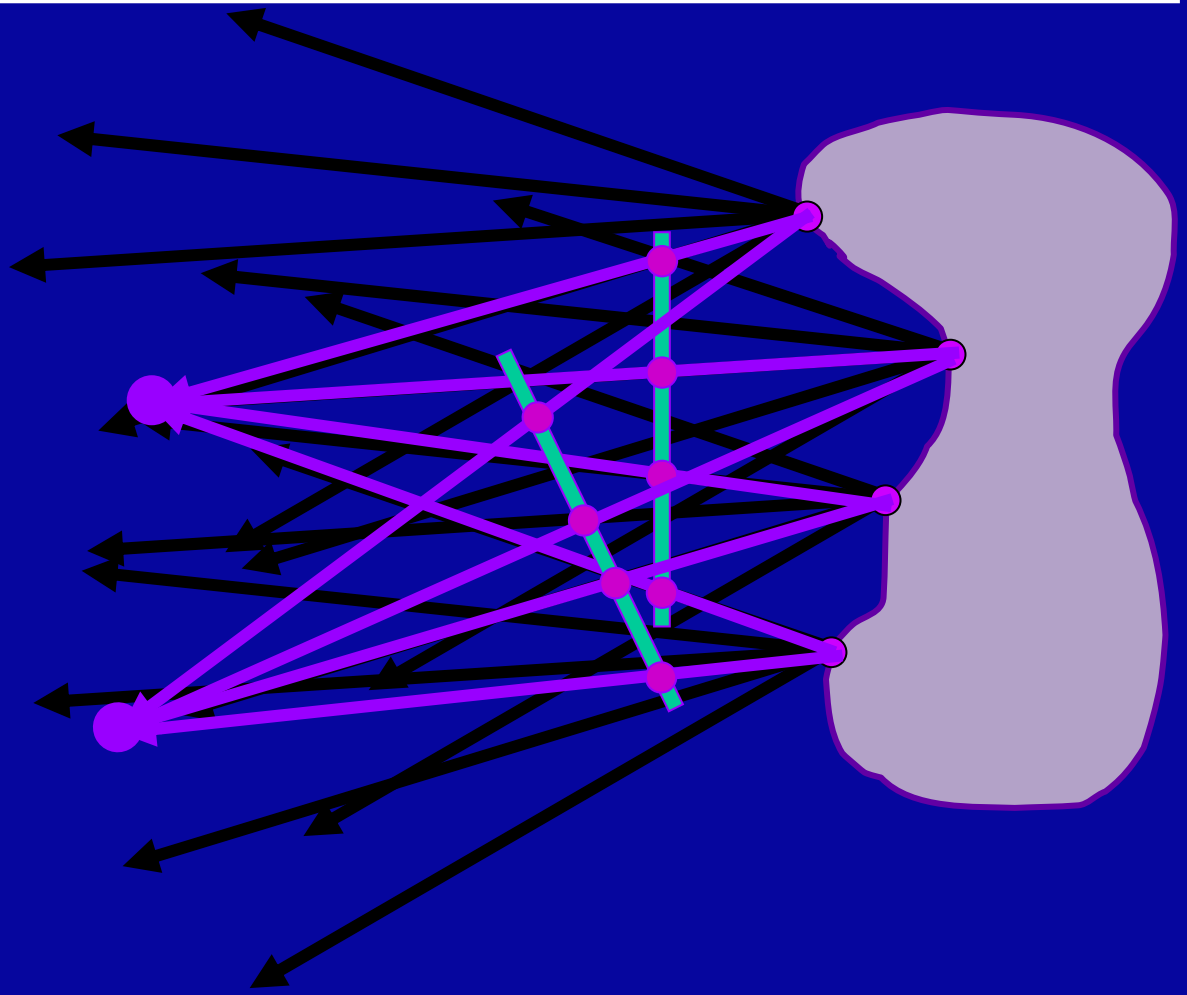


4D

- 2D position (on surface)
- 2D direction

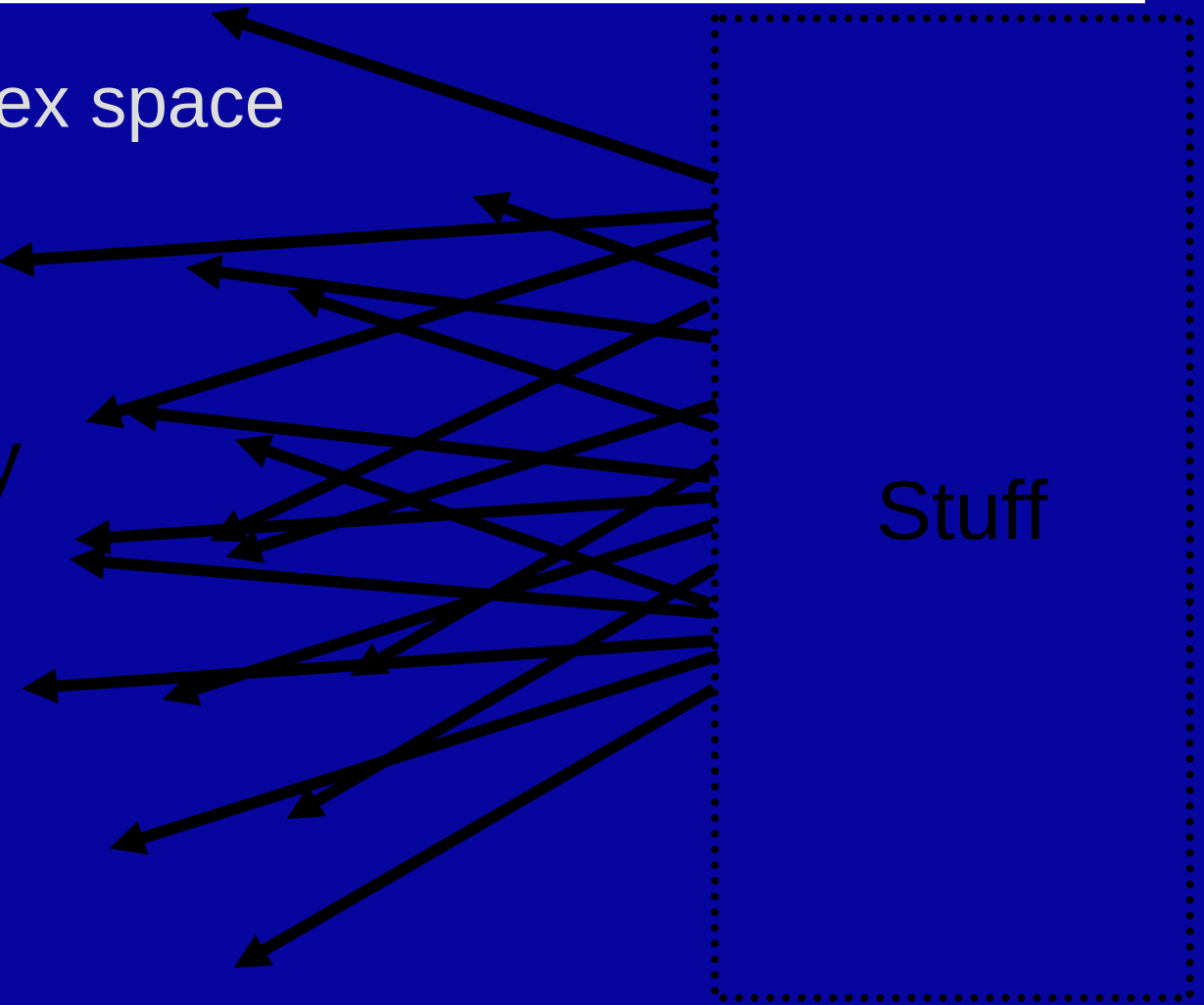
Object

All images



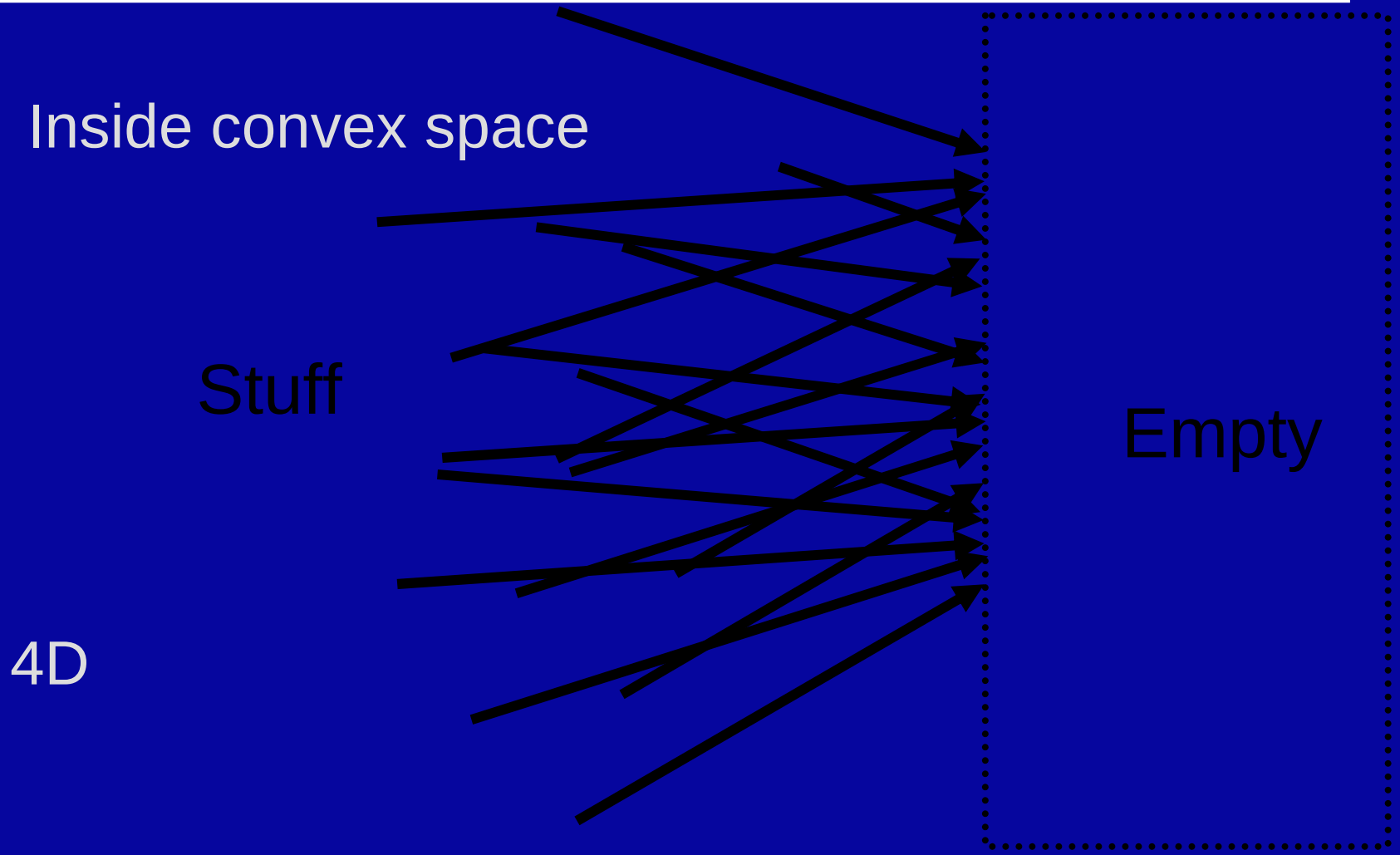
Lumigraph / Lightfield

Outside convex space



4D

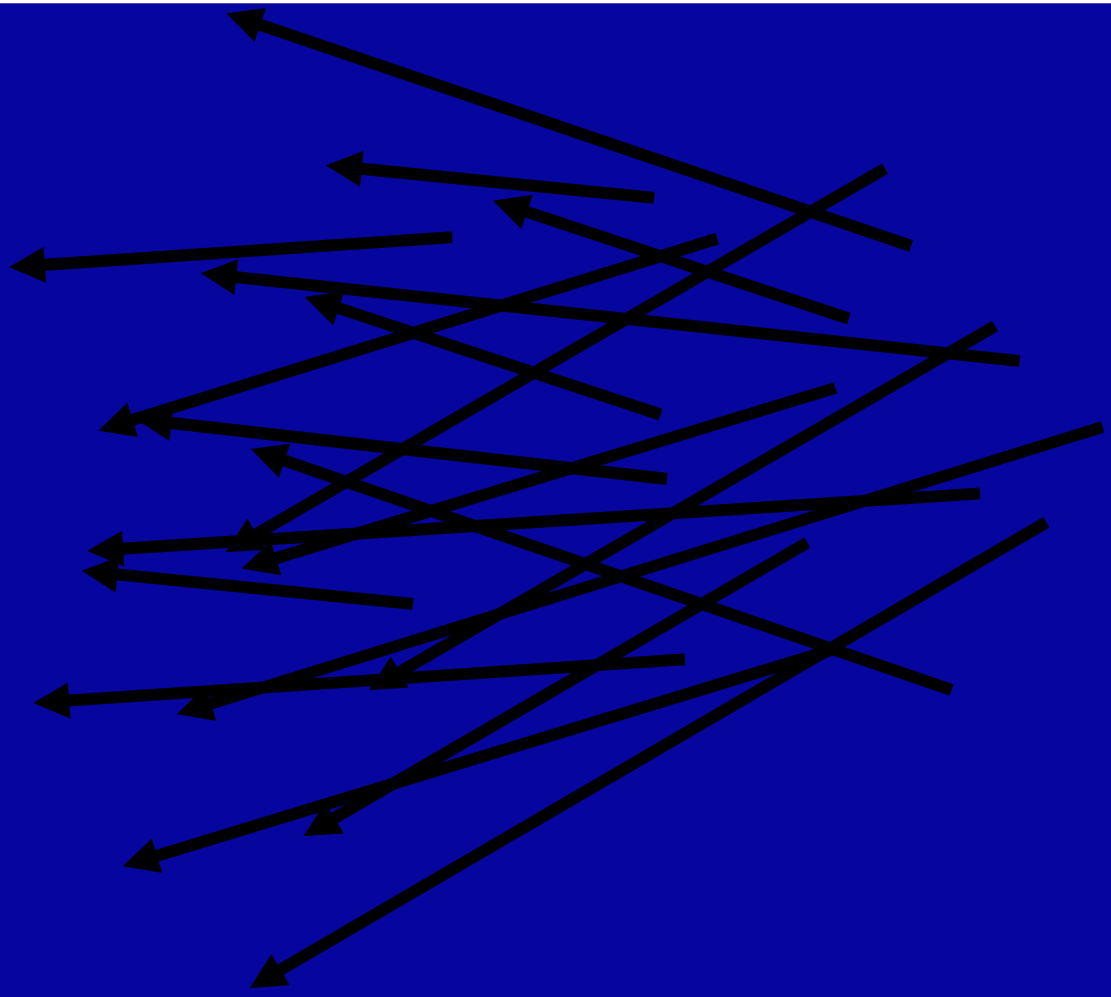
Lumigraph / Lightfield



Lumigraph / Lightfield

How to ?

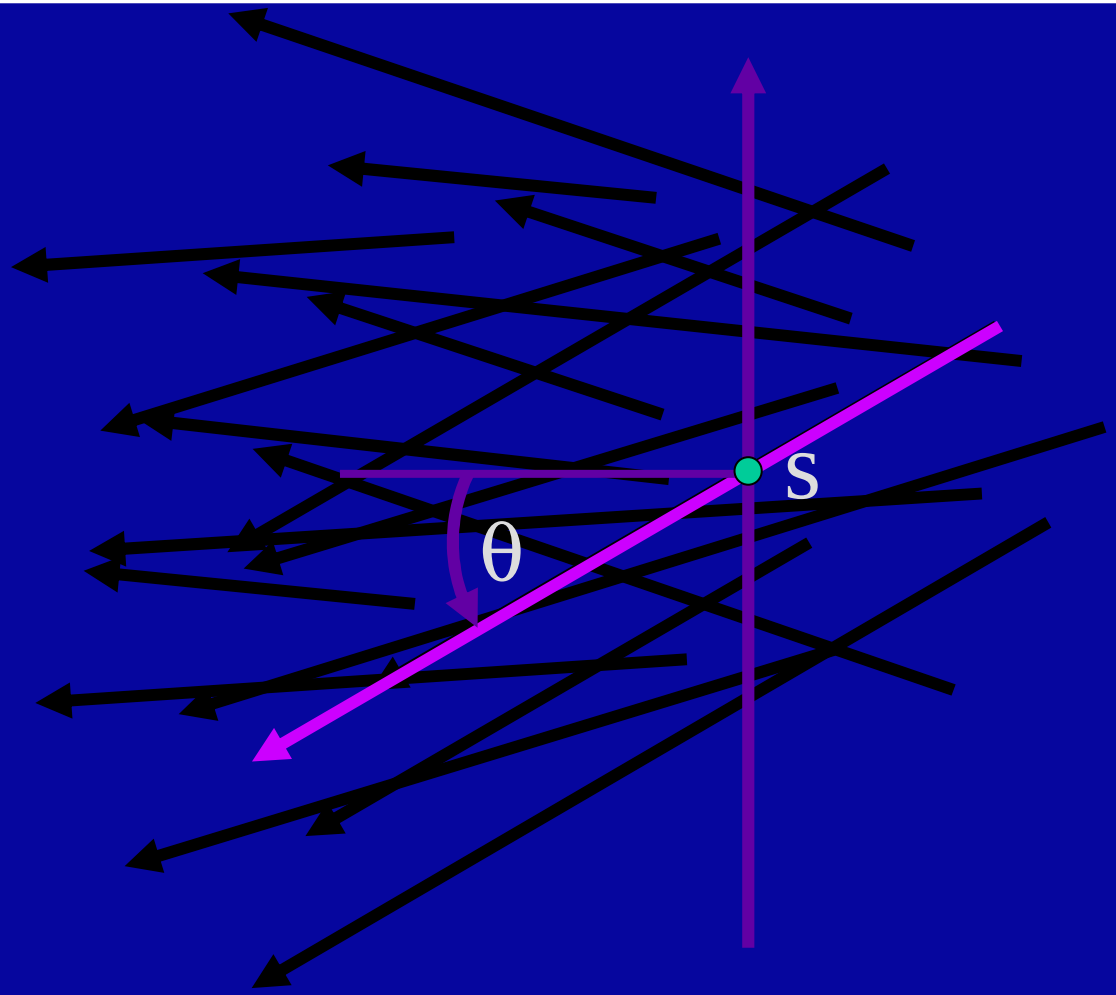
- organize
- capture
- render



Lumigraph - Organization

2D position

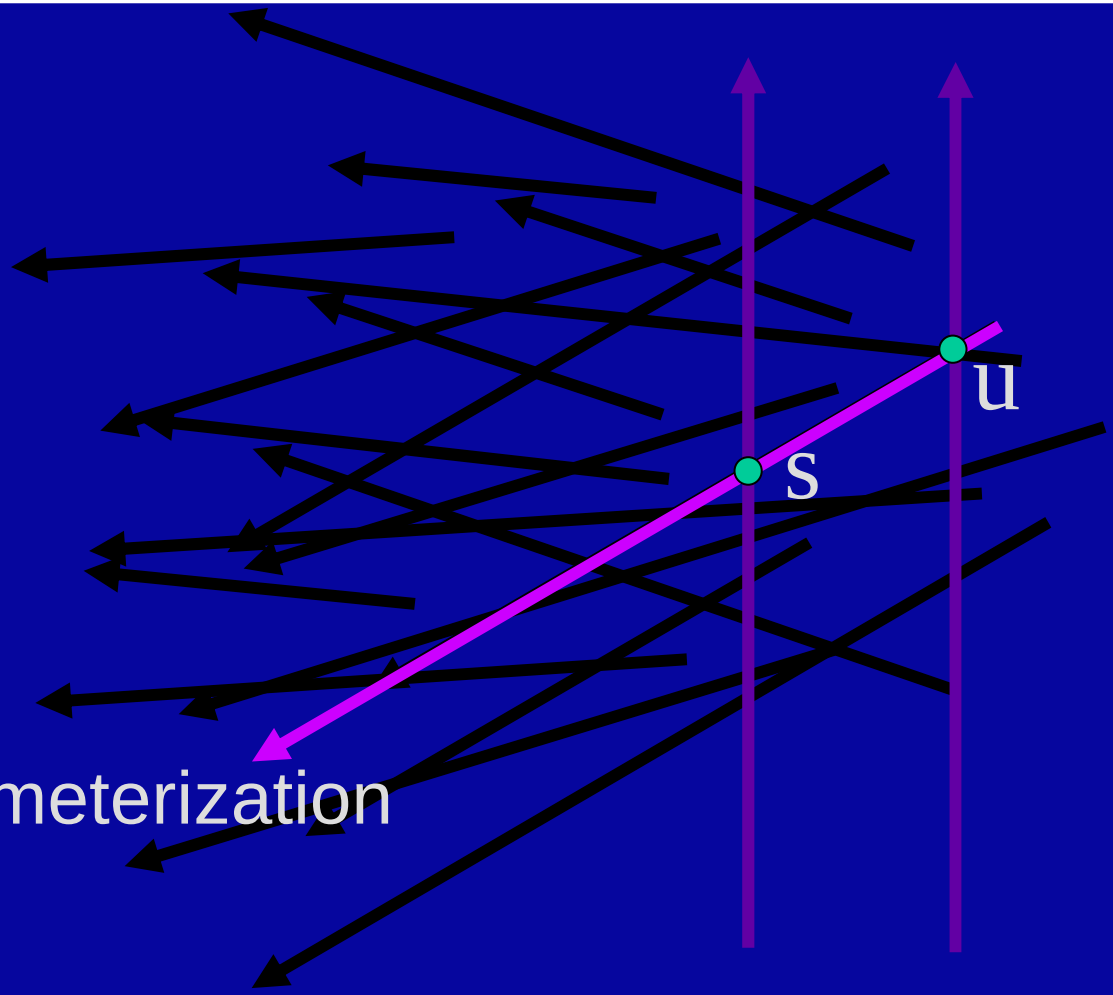
2D direction



Lumigraph - Organization

2D position

2D position

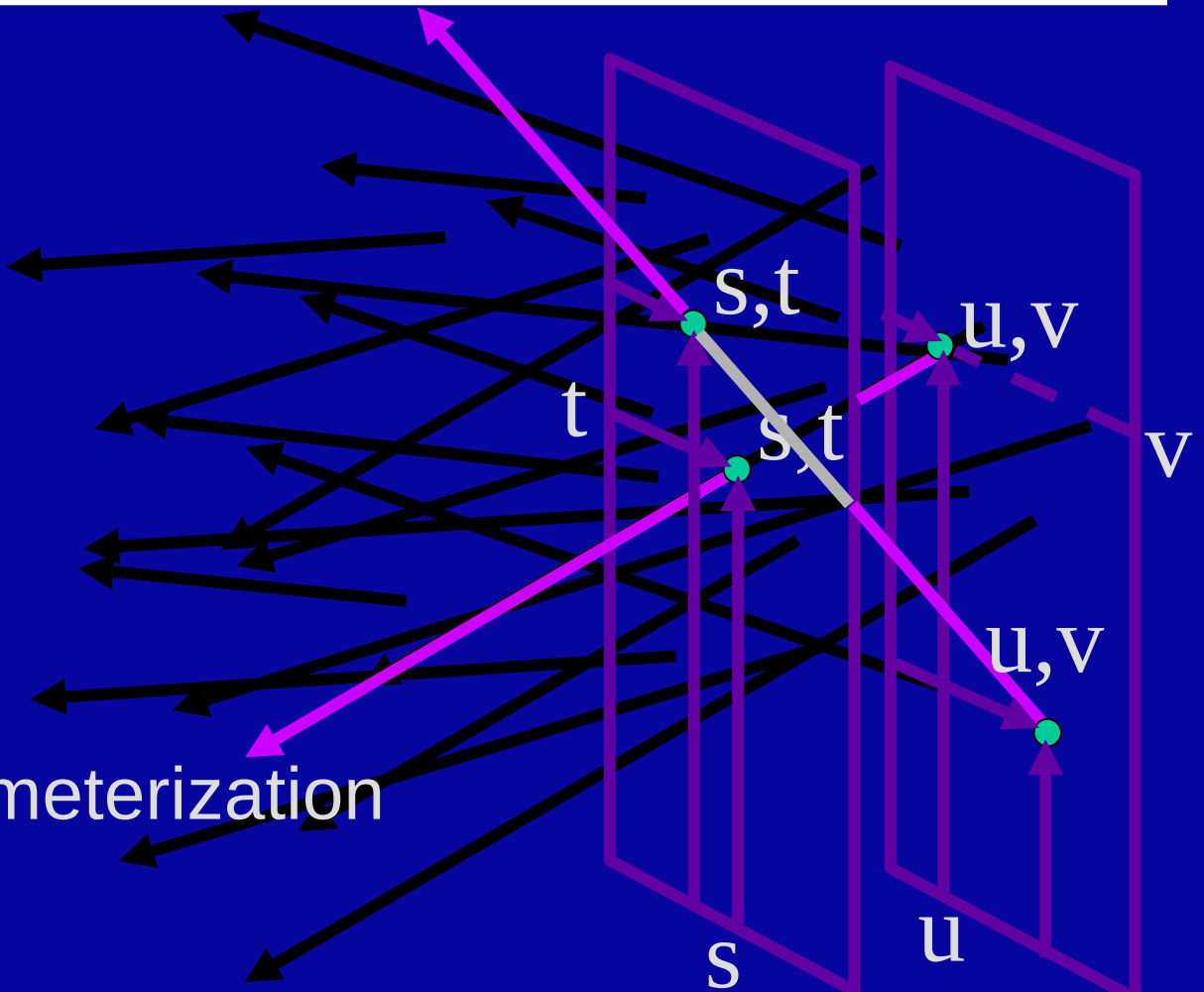


2 plane parameterization

Lumigraph - Organization

2D position

2D position



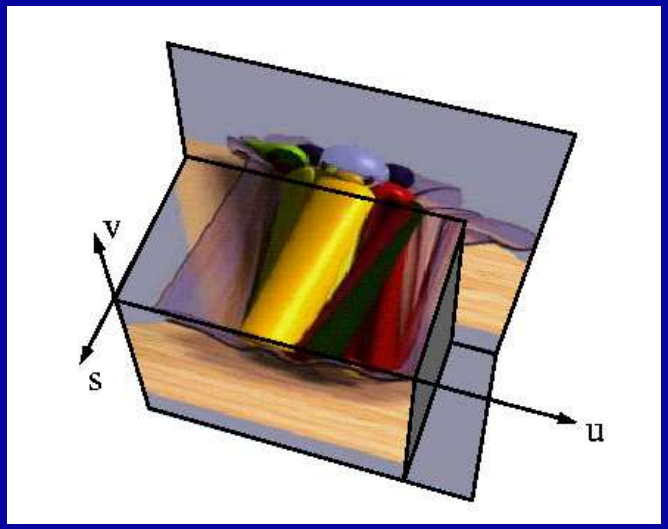
2 plane parameterization

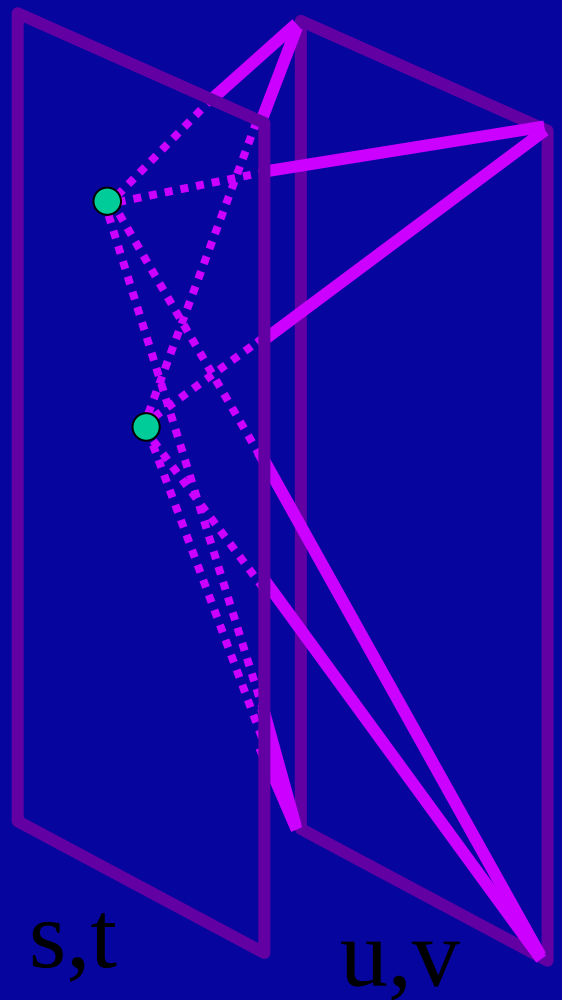
Lumigraph - Organization

Hold s,t constant

Let u,v vary

An image

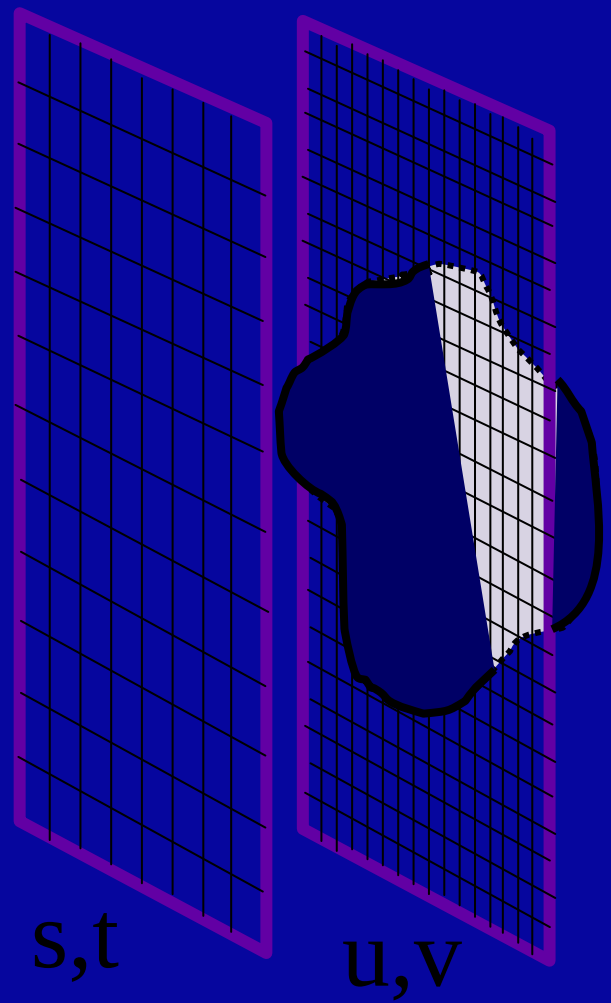




Lumigraph - Organization

Discretization

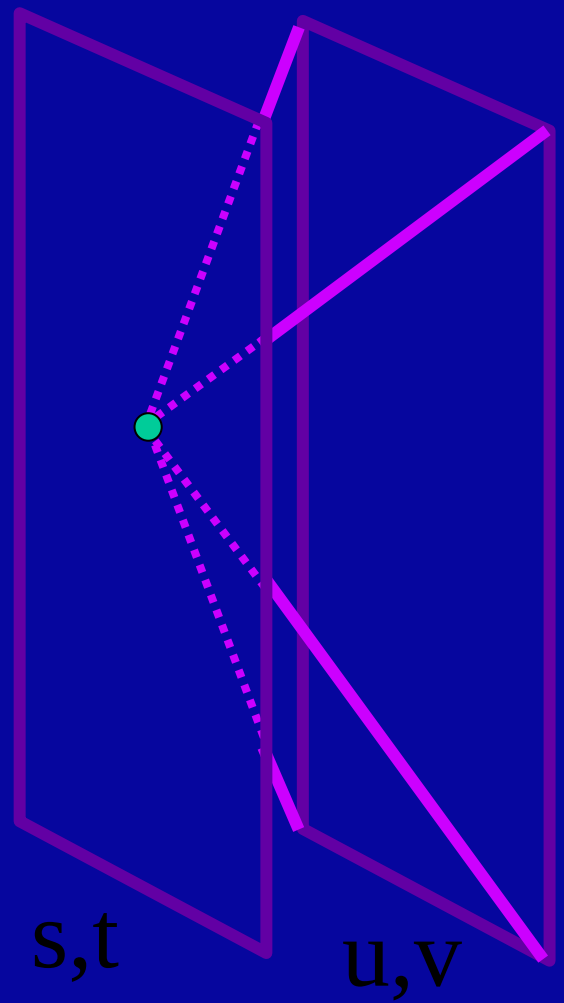
- higher res near object
  - if diffuse
  - captures texture
- lower res away
  - captures directions



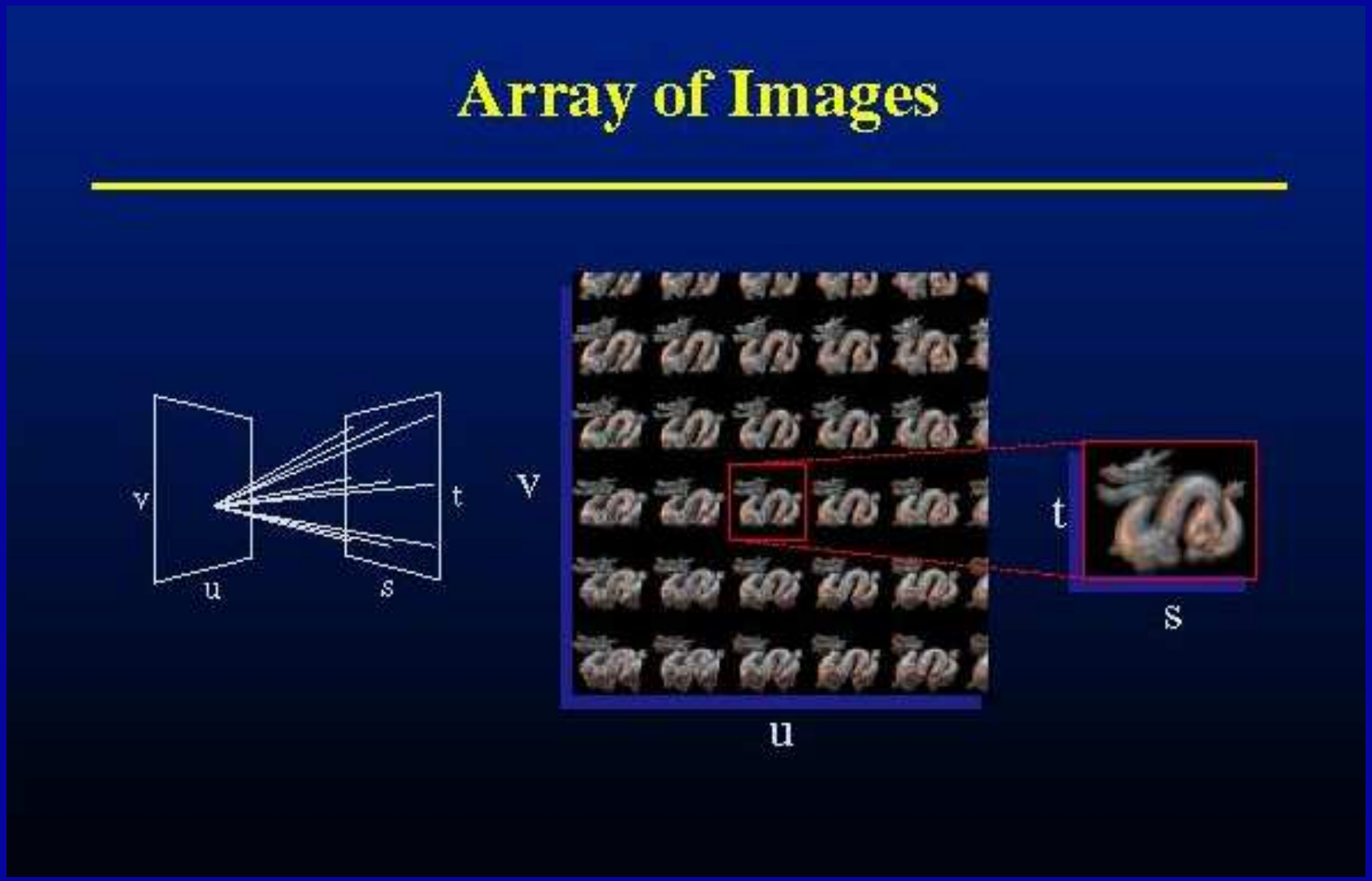
Lumigraph - Capture

Idea 1

- Move camera carefully over s,t plane
- Light Field



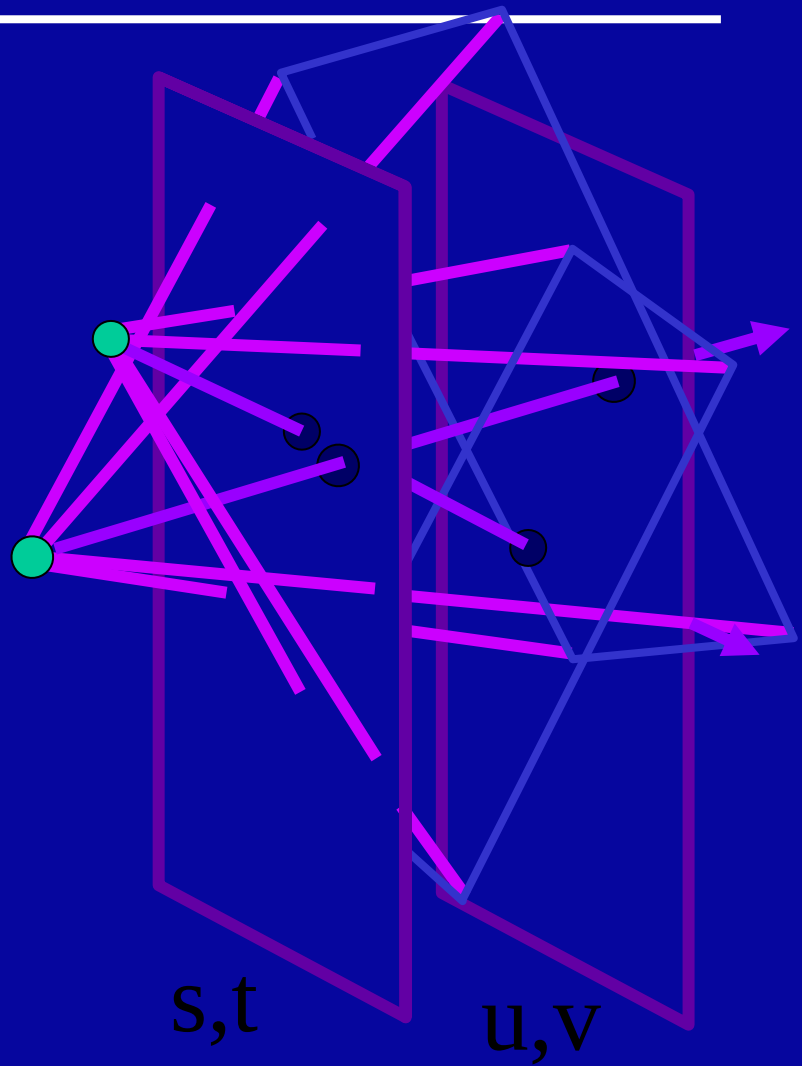
Lumigraph - Capture



Lumigraph - Capture

Idea 2

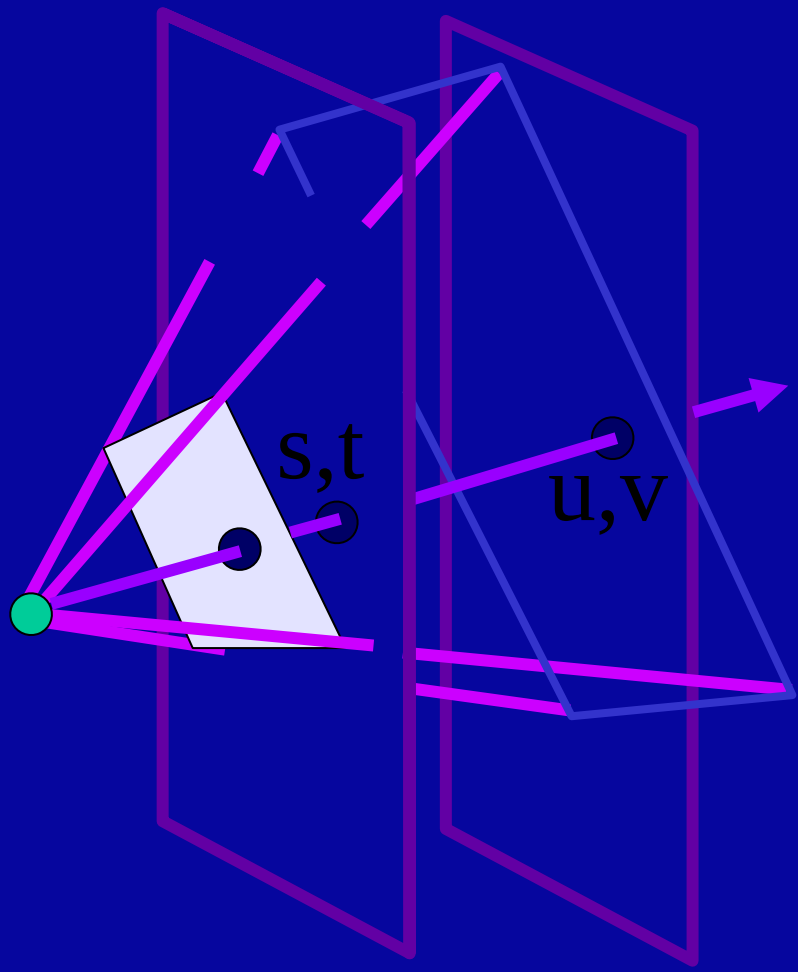
- Move camera anywhere
- Lumigraph paper



Lumigraph - Rendering

For each output pixel

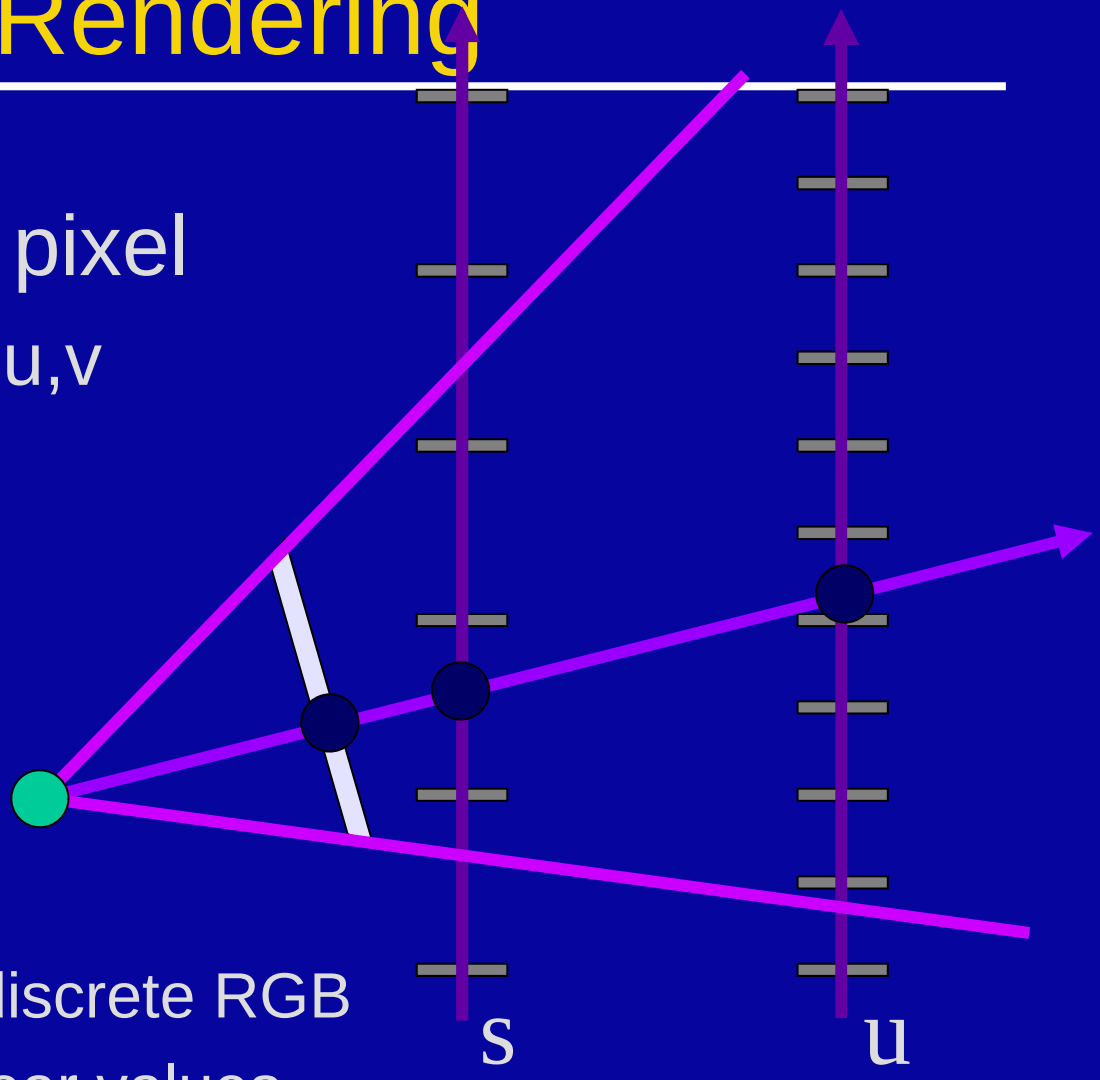
- determine s,t,u,v
- either
  - find closest discrete RGB
  - interpolate near values



Lumigraph - Rendering

For each output pixel

- determine s,t,u,v



- either
  - use closest discrete RGB
  - interpolate near values

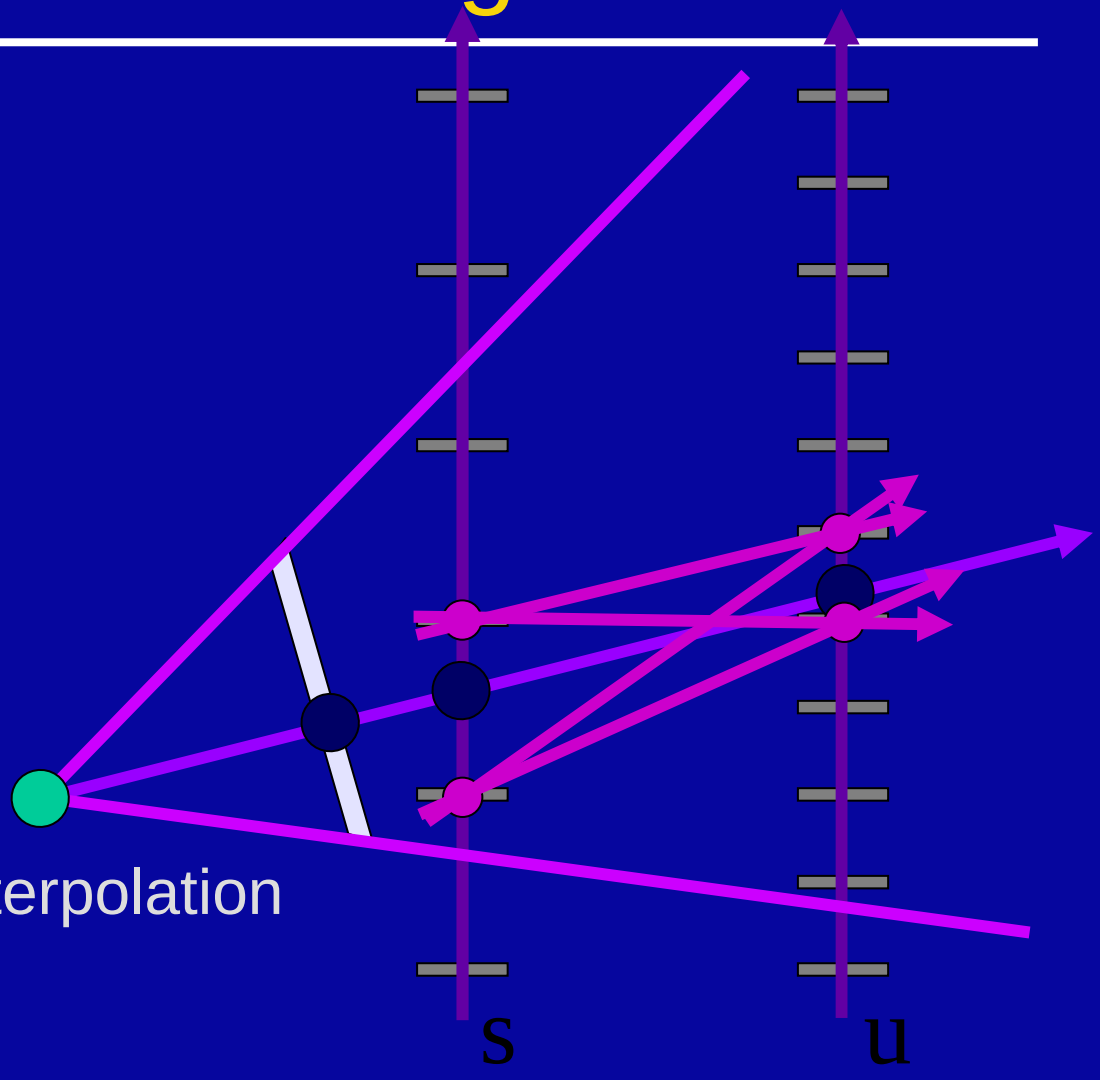
Lumigraph - Rendering

Nearest

- closest s
- closest u
- draw it

Blend 16 nearest

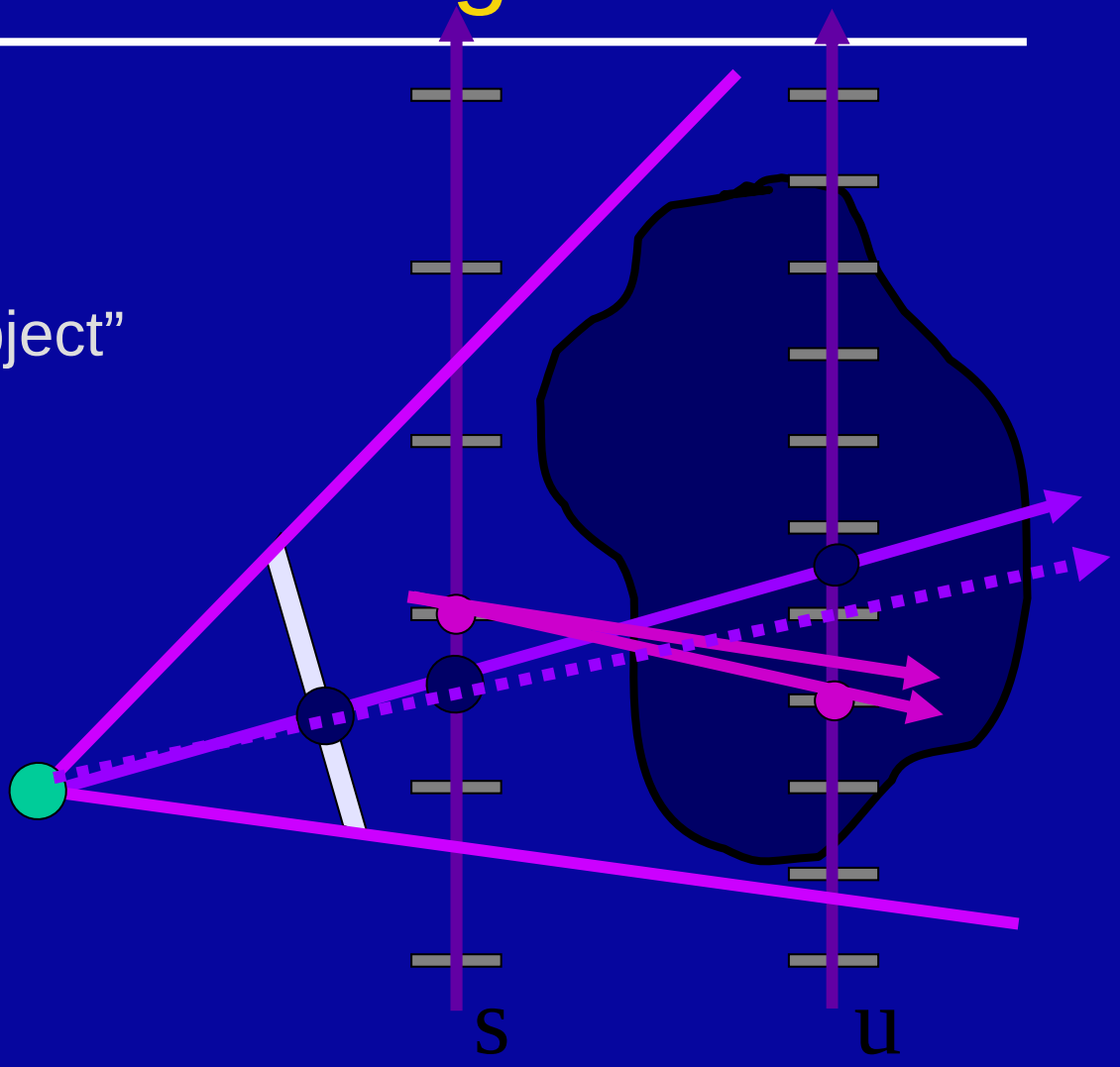
- quadrilinear interpolation



Lumigraph - Rendering

Depth Correction

- closest s
- intersection with “object”
- best u
- closest u

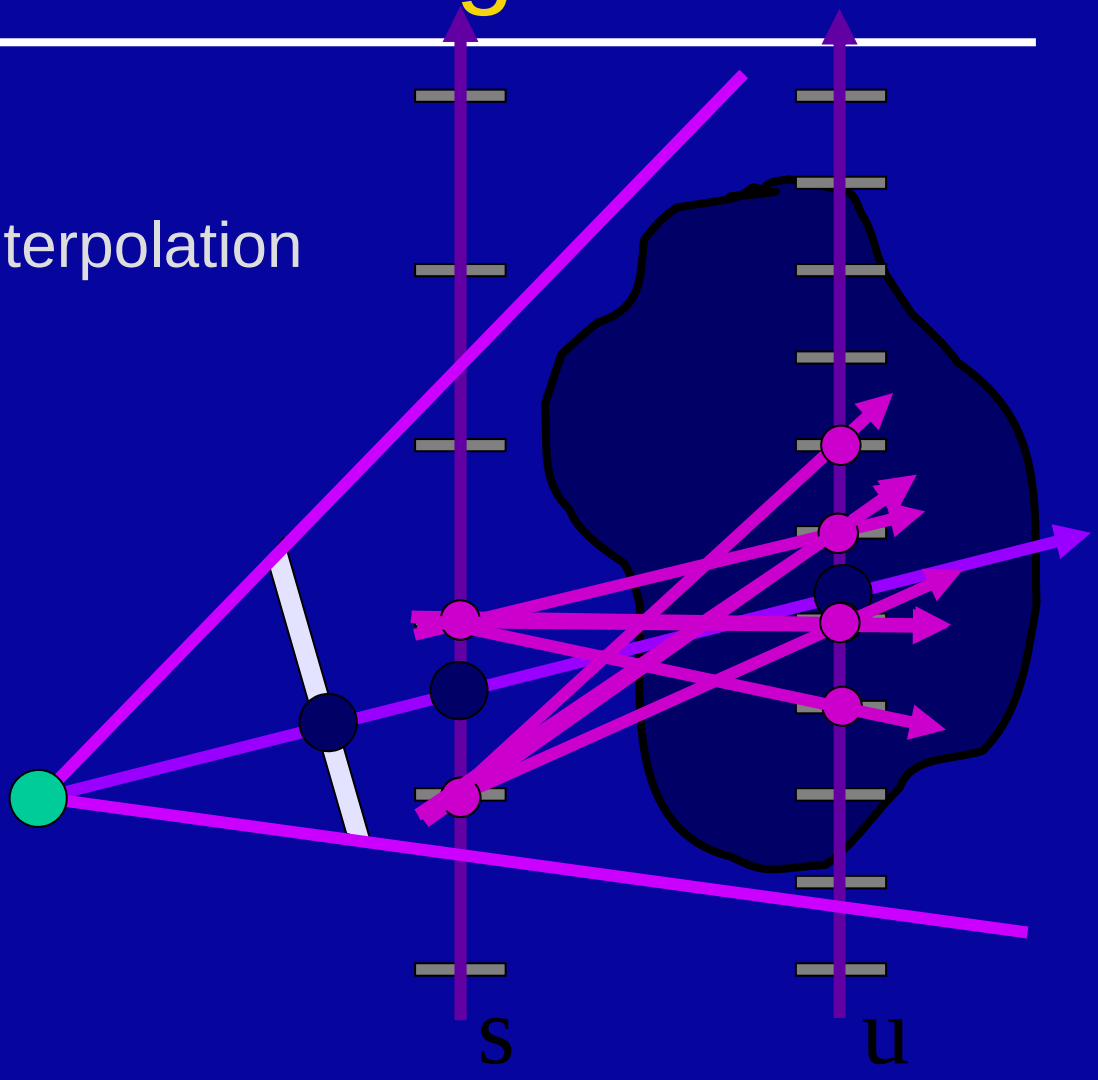


Lumigraph - Rendering

Depth Correction

- quadralinear interpolation
- new “closest”
- like focus

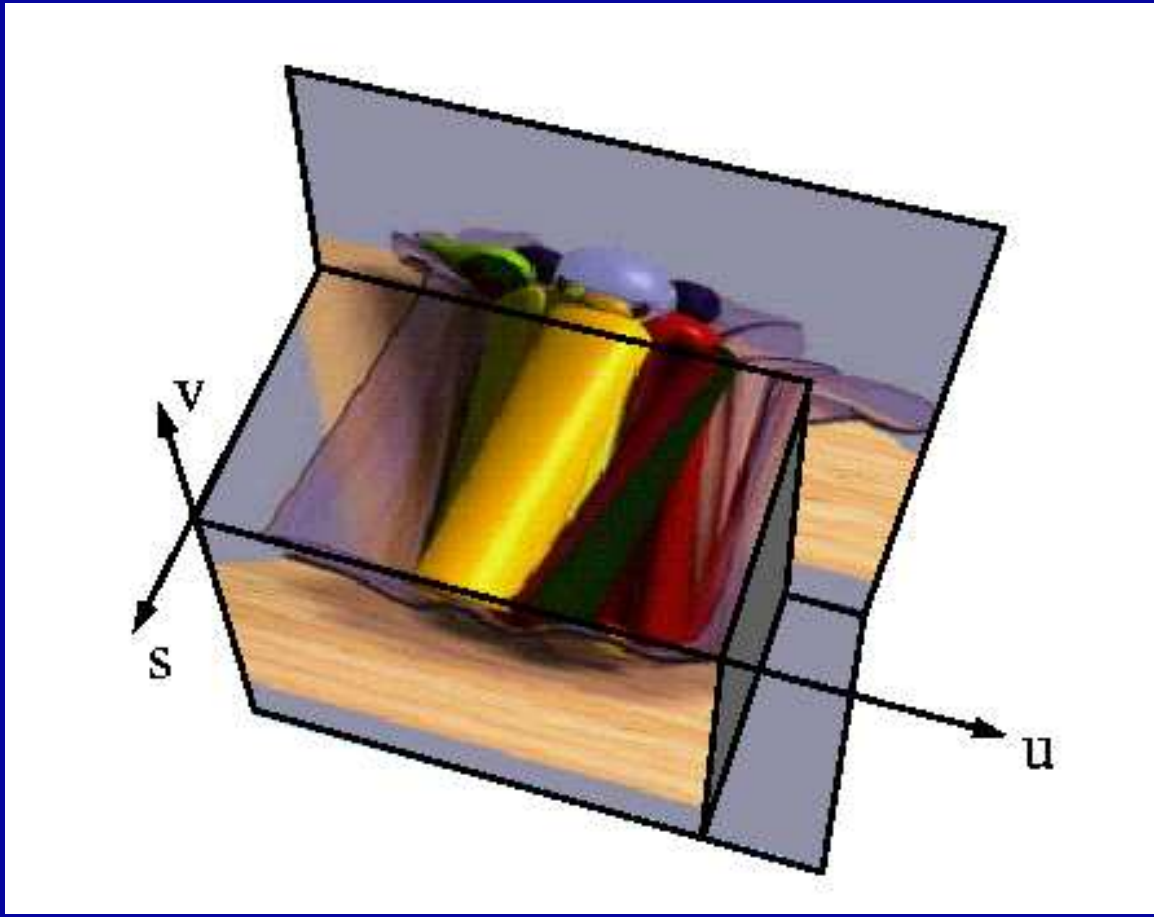
[Dynamically Reparameterized Light Fields, Isaksen, SG’2000]



Lumigraph - Ray Space

Image effects:

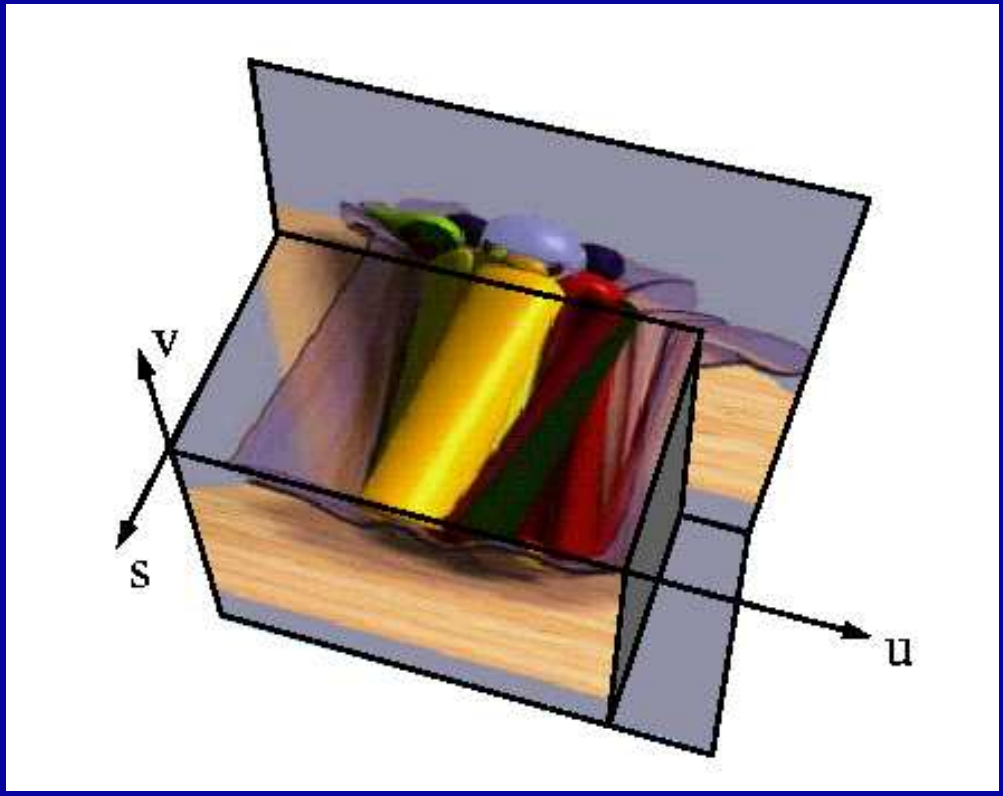
- parallax
- occlusion
- transparency
- highlights



Lumigraph - Demo

Lumigraph

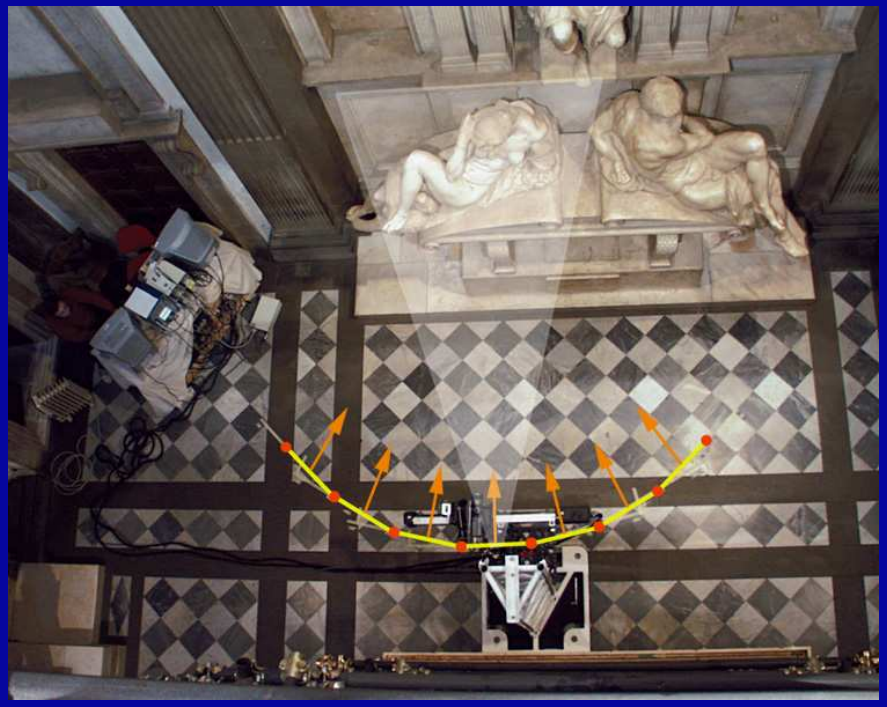
- Lion, Fruit Bowl



Complex Light Field acquisition

Digital Michelangelo Project

- Marc Levoy, Stanford University
- Lightfield (“night”) assembled by Jon Shade



Unstructured Lumigraph

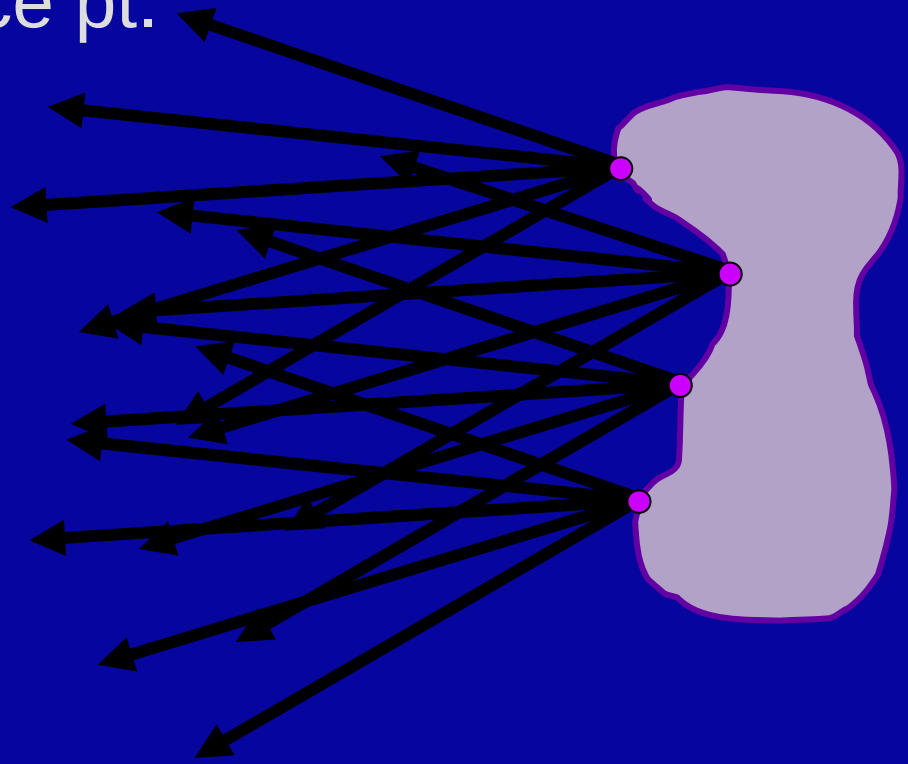
What if the images aren't sampled on a regular 2D grid?

- can still re-sample rays
- ray weighting becomes more complex
  [Buehler *et al.*, SIGGRAPH'2000]

Surface Light Fields

Turn 4D parameterization around:

image @ every surface pt.



Leverage coherence:

compress radiance fn (BRDF * illumination) after rotation by ***n***

Surface Light Fields

[Wood et al, SIGGRAPH 2000]

3D Representations

Image (and panoramas) are 2D

Lumigraph is 4D

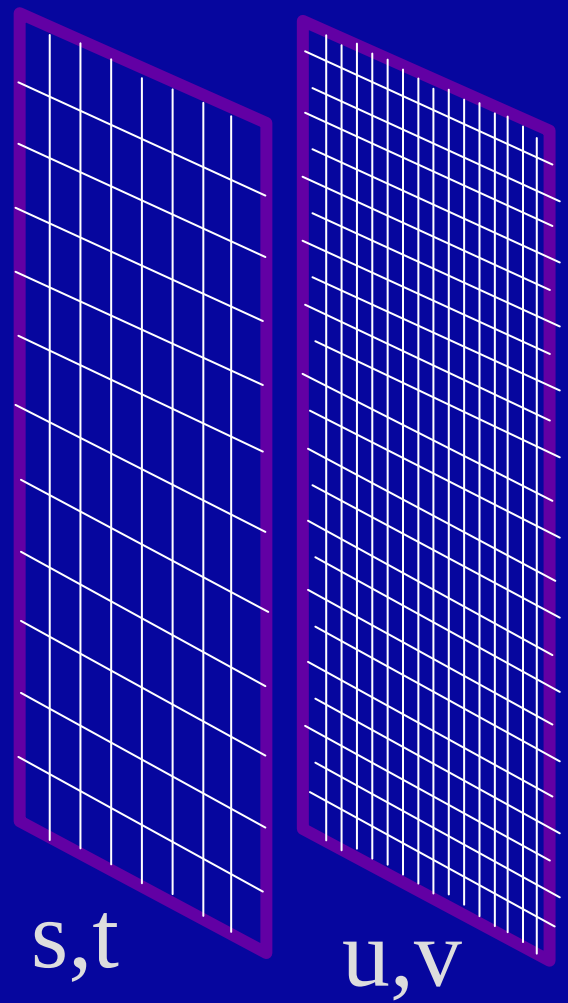
What happened to 3D?

- 3D Lumigraph subset
- Concentric mosaics

3D Lumigraph

One row of s,t plane

- i.e., hold t constant

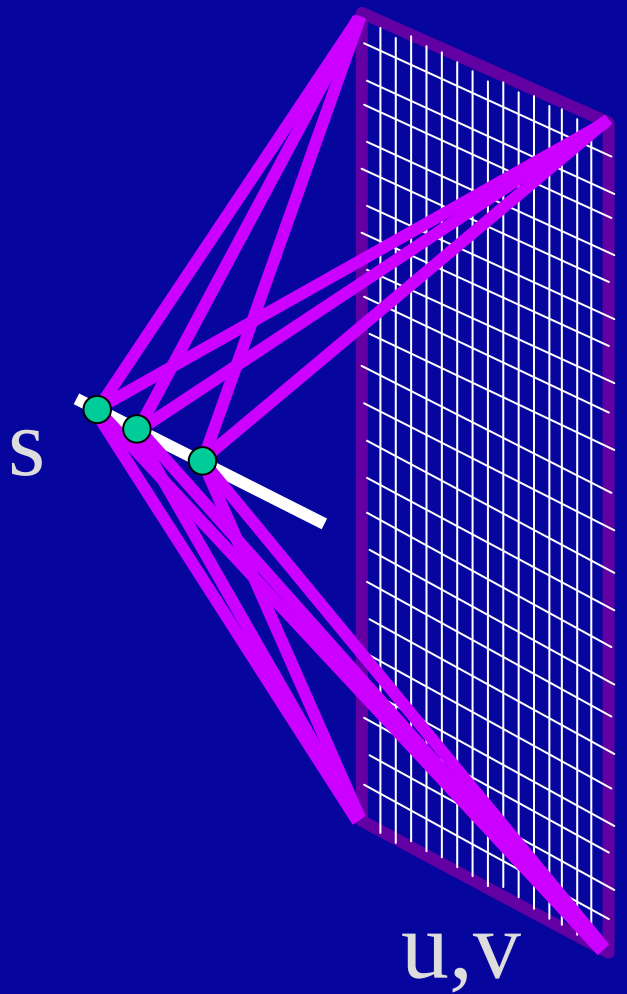


3D Lumigraph

One row of s,t plane

- i.e., hold t constant
- thus s,u,v
- a “row of images”

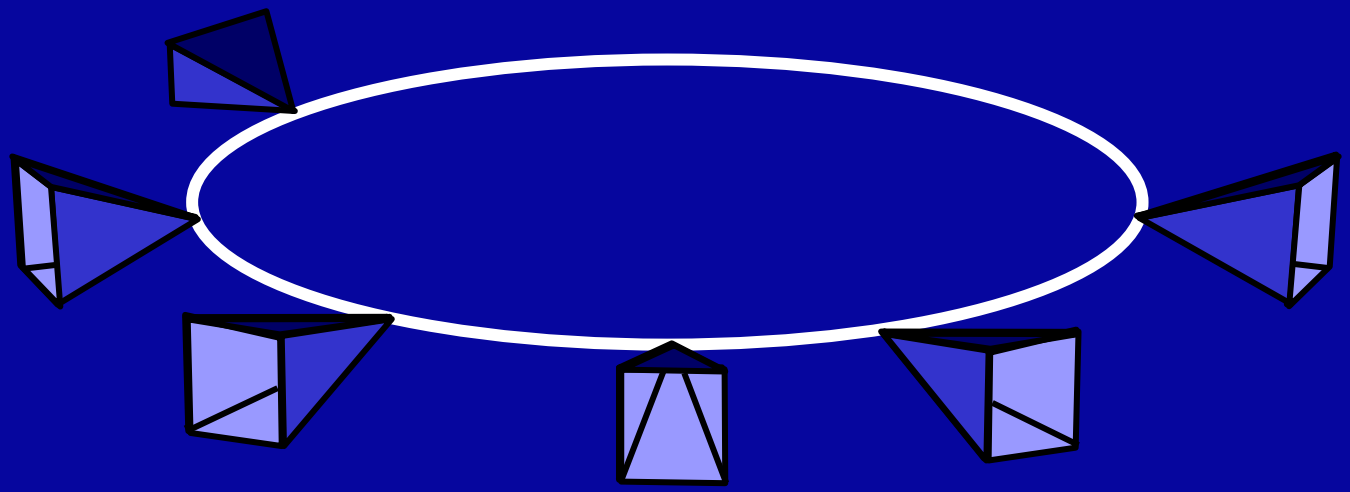
[Sloan *et al.*, Symp. I3DG 97]



Concentric Mosaics

Replace “row” with “circle” of images

[Shum & He, SIGGRAPH’97]

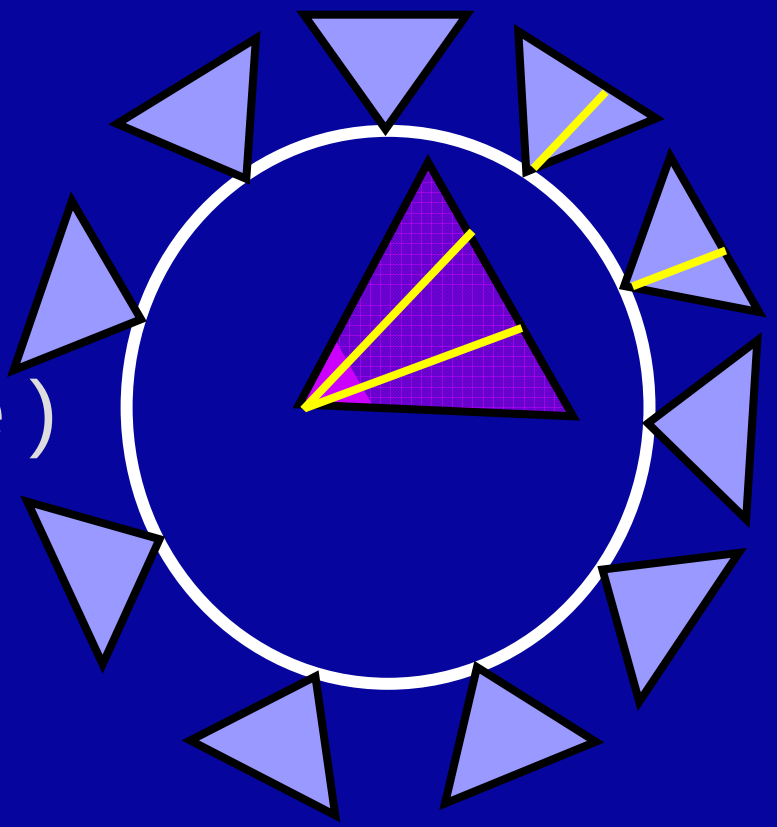


Concentric Mosaics

Concentric Mosaics

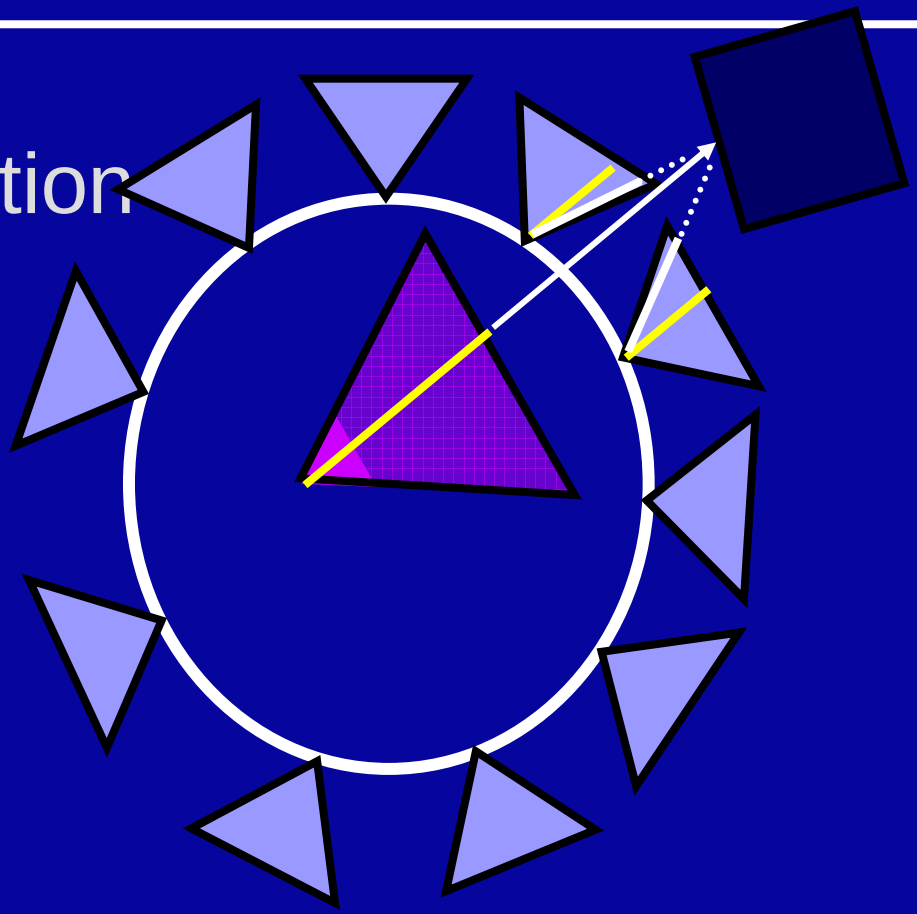
Rendering

(as seen
from above)



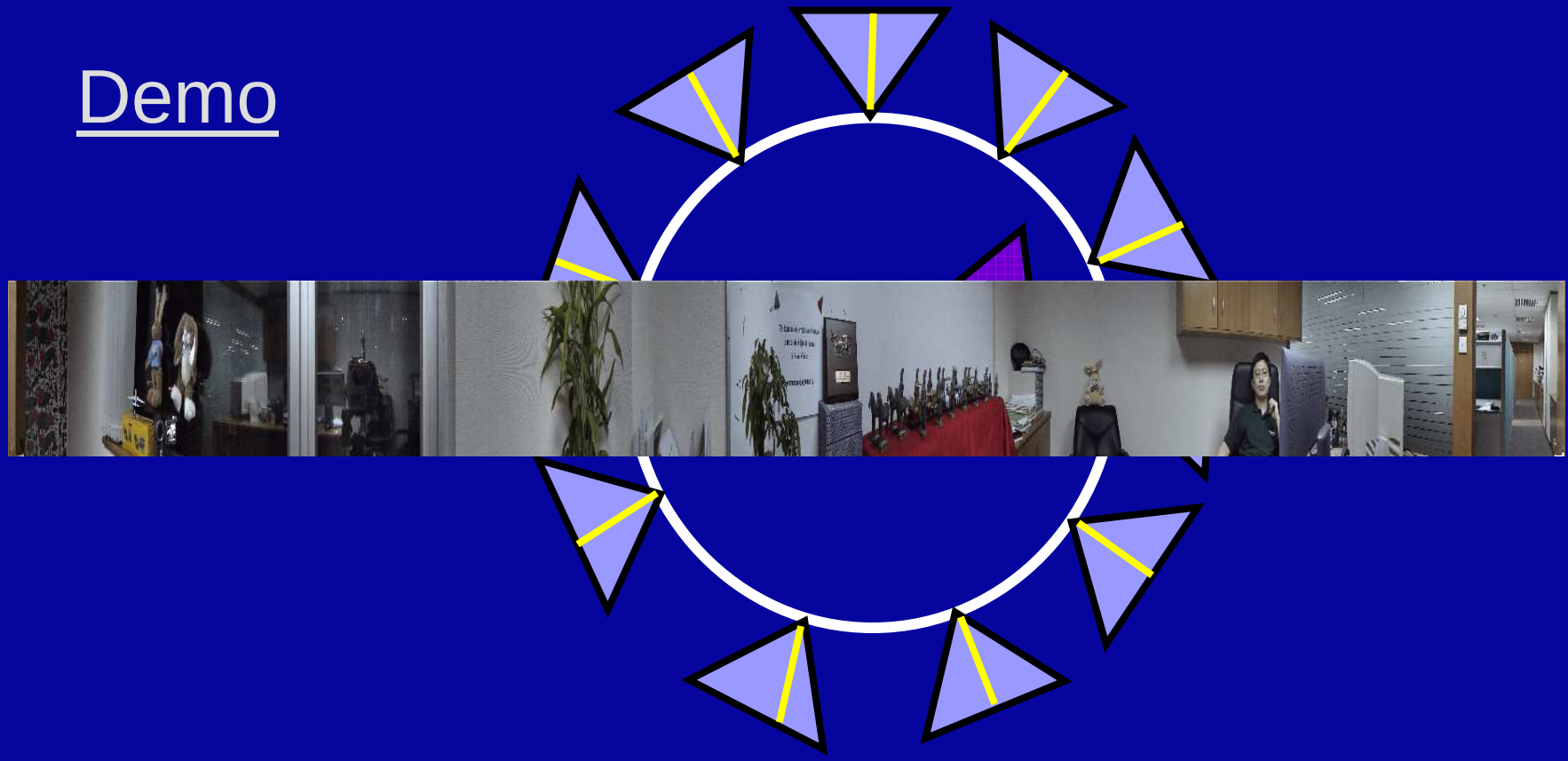
Concentric Mosaics

Depth correction



Concentric Mosaics

Demo



2.5D Representations

Image is 2D

Lumigraph is 4D

3D

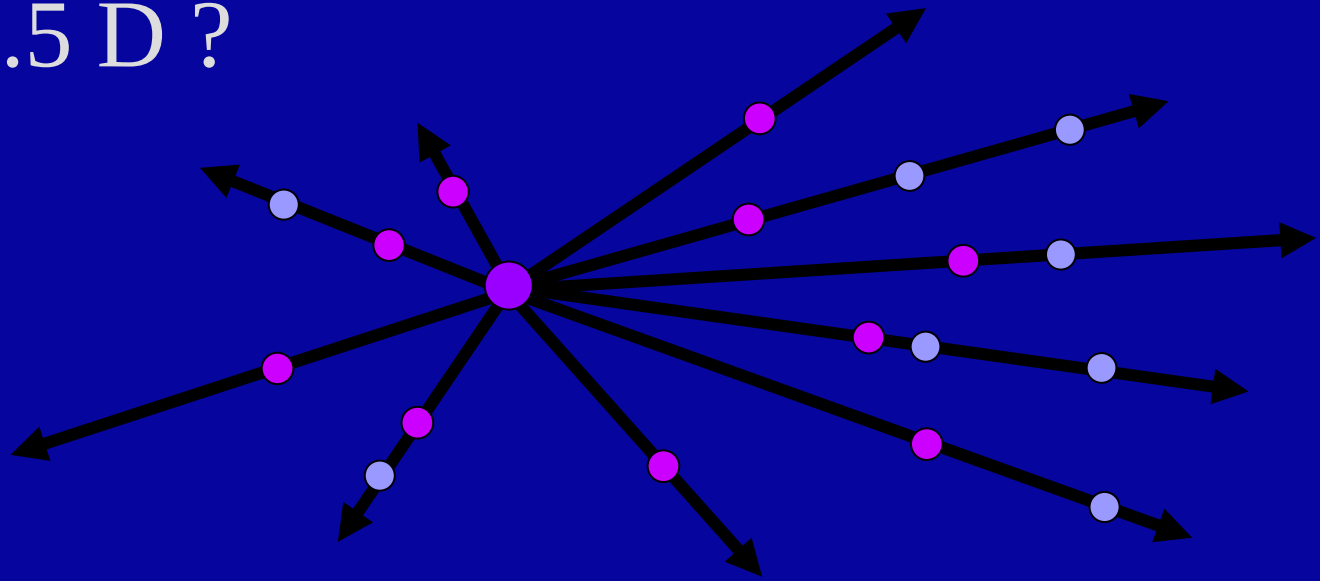
- 3D Lumigraph subset
- Concentric mosaics

2.5D

- Layered Depth Images
- Sprites with Depth (impostors)
- View Dependent Surfaces (see Façade)

Layered Depth Image

2.5 D ?

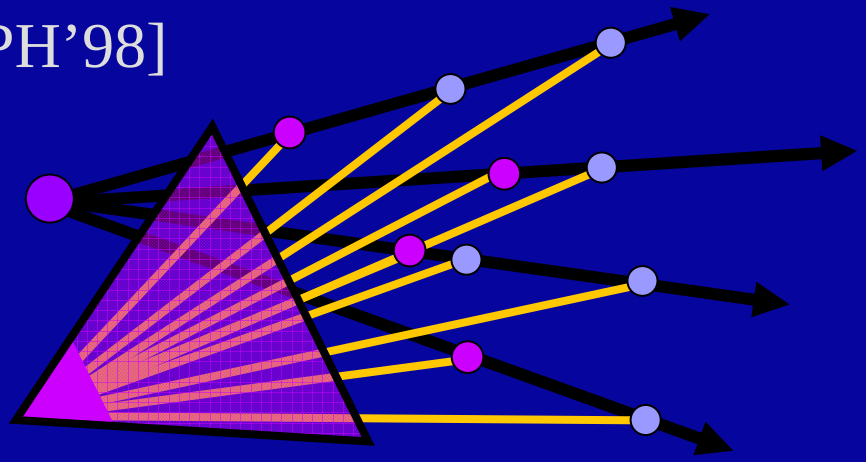


Layered Depth Image

Layered Depth Image

Rendering from LDI

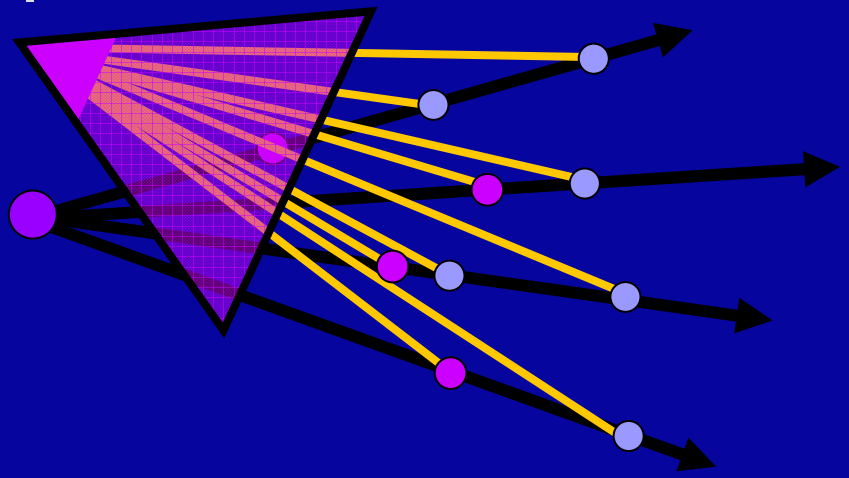
[Shade *et al.*, SIGGRAPH'98]



- Incremental in LDI X and Y
- Guaranteed to be in back-to-front order

Layered Depth Image

Rendering from LDI



- Incremental in LDI X and Y
- Guaranteed to be in back-to-front order

Hierarchy of Light Fields [Levoy]

5D: Plenoptic Function (Ray)
4D: Lumigraph / Lightfield
4D*: Environment Matte (single view)
3D: Lumigraph Subset
3D: Concentric Mosaics
2.5D: Layered Depth Image
2.5D: Image Based Models
2D: Images and Panoramas

Announcements

Course Evaluation is now open

Until Monday, May 7th

Please complete the evaluation