CS 395/495-26: Spring 2002

IBMR: Week 7B

Applying P^2, P^3 Projections: Spherical Light Probes

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Reminders

- Project 2 overdue today (C^*_∞ part optional)
- **HW1 due Today, May 16**
- Proj3 Due Thurs May 23

  HW2 assign on Tues (I promise)
- HW2 due Thurs May 30

  Proj4 Assign Thurs May 23

  HW 3 Assign Tues May 28
- Proj4 Due Tues June 11
- HW3 Due Tues June 11

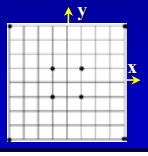
Image Warping: General Idea

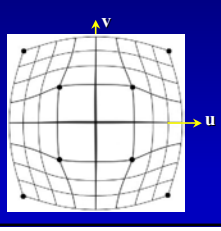
2D→2D continuous coordinate map, a 'rubber sheet'

- Notation: input(x,y)→output(u,v)
- **'Forward Mapping'** u = u(x,y), v = v(x,y) (x,y steps)
- **'Inverse Mapping'**: x = x(u,v), y = y(u,v) (u,v steps)
- **'Parameterized'**:

  u = u(s,t), v = v(s,t)

  x = x(s,t), y = y(s,t)



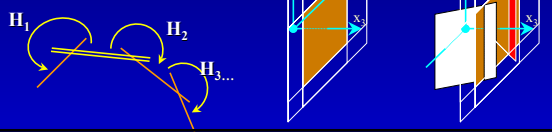


Panoramas: Planar 'Bow-Tie'

- For limited-size mosaics only (angle limits)
- Find all **H** from correspondence in overlapped regions
- Choose a (central) reference image (book pg. 196)
- Reproject, cross-dissolve in reference image plane

Recall: Planar Panoramas

- Choose a 'reference' image plane, extend it
- Add images: for each one,
  - find **H** from overlap correspondences (in P^2)
  - transform new image to reference plane
  - re-sample, 'blend' (weighted sum) to one image



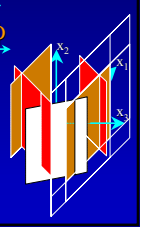
Non-Planar Panoramas

Can't use planar method beyond 180° FOV;

- Sphere or cylinder can 'wrap around' origin
- How? Spherical coords
  - write 3D sphere eqn in P^2 coords:

$x_1 = \sin(\theta)\cos(\phi)$
$x_3 = \sin(\theta)\cos(\phi)$
$x_2 = \sin(\phi)$

  - 'Inverse Map' warp:
    - Output pixel m,n: $\theta = 2\pi n/nmax$, $\phi = \pi(n/nmax - ½)$
    - Find $x' = H^{-1}\cdot[x_1, x_2, x_3]$ for each image
    - Blend color(s) found at x' for each image



Side Note: Camera Distortions

Correct many camera/lens errors in P^2

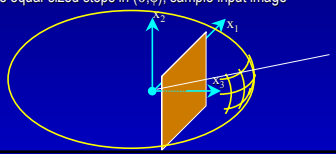
- Place raw camera input at (x,y,1) plane
- Write equations for 3D 'projection surface'

  Example: scaleable, offset sphere for spherical distortion

  $x_1 = a + b*\sin(\theta)\cos(\phi)$; $x_3 = c + d*\cos(\theta)\cos(\phi)$; $x_2 = e + f*\sin(\phi)$

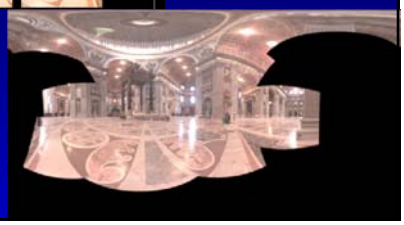
- Scan projection surface to find output pixels

  Example: take equal-sized steps in (θ,ϕ); sample input image



Example: Spherical Panorama

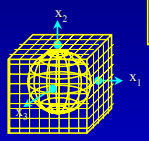
CAREFUL! EASY TO MISS SOMETHING!

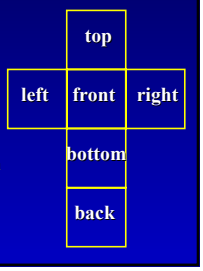


Paul Debevec, from SIGGRAPH2001 short course "Image-Based Lighting"

Practical Panoramas: 'Box Cross'

- Spherical maps oversample near poles;
- Cylindrical maps can't see floor, ceiling spot
- Nice solution: 'Box Cross'
  - 'unwrap' a cube around origin
  - 6 square planar images
  - Easy!
    - for each image,
    - for each box side,
    - find reprojection **H**
    - find pixels on box
    - rewarp as needed (cyl,sphere, etc.)





Panoramic Cameras

Panoramics without 'stitching':

- 'Fisheye' Lenses, conics,…
- Slit-scan: (WideLux, Noblex, PanoScan…)
  - cyl. or spherical image
  - slow! no action shots
- Multiple Planar Cams
  - Fast, flexible, expensive
  - can do panor. movies
- History: 1843…http://www.panoramicphoto.com/timeline.htm

Light Probes: What?

- Photograph a mirrored sphere
- warp image to find irradiance .vs. direction

1 picture==
half-sphere

High contrast?
Full sphere?
More Pictures!

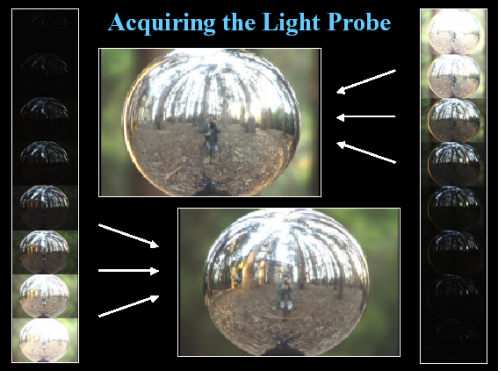
Light Probes

- Example images (see Debevec's site)

Paul Debevec, SIGGRAPH2001 course "Image Based Lighting"

High Contrasts too!

Paul Debevec, SIGGRAPH2001 short course "Image Based Lighting"



(Try it yourself—I'd like to…)

Paul Debevec, SIGGRAPH2001 short course "Image Based Lighting"

Sources of Mirrored Balls

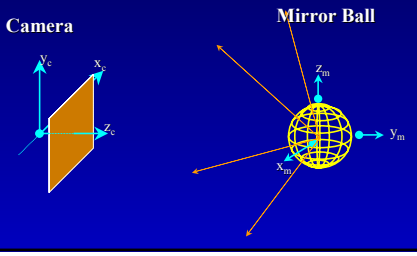
2-inch chrome balls < $20 ea.
King Bearing, Inc.
Applied Industrial Technologies
(many locations nationally, check www.bigbook.com)

6-12 inch large gazing balls (blown glass)
Baker's Lawn Ornaments
570 BERLIN PLANK ROAD
SOMERSET, PA 15501-2413
814-445-7028

Mirror Ball→Panorama Conversion

Makes an offset 'virtual' half-sphere camera located at mirror ball center:

- ? How can we write this in P^2 and/or P^3?



Light Probes: Daydreams

- Debevec: 'Light Stage 2.0'

- Go further!
  - Sphere of projectors set incoming light field
  - CAVE / Light Stage corrupted by interreflections
  - Probe(s) measure ACTUAL incoming light
  - Math: Remove interreflected amounts from computed display

Light Probes

- 'Two-shot' panoramic camera
- Clever, fast, simple, cheap, flexible
- Probe position != Camera position; telephotos…
  - allows small probes in tight, risky spaces
  - Little/no image alignment / mosaicing
- Drawbacks:
  - Highly non-uniform sampling
  - Camera ALWAYS in the image
- Daydreams: a better probe?
  - Huge: mirrored weather balloon?
  - Tiny, stochastic: bubbles in a liquid?
  - Dynamic shapes: whirling mirror on arm?
  - Other shapes: Nayyar, Carlbom, ?He(MSRchina) etc.

END