The Epipolar Occlusion Camera

Paul Rosen
Voicu Popescu

Department of Computer Science
Motivation

- A traditional pinhole camera captures images from a single view point.
- We would like to capture all of samples along a view segment.
- This can be done by exploiting the epipolar geometry that exists when translating between 2 view points.
Example Reconstructions

One Depth Image

Two Depth Image

Epipolar Camera Image
Example Reconstructions

One Depth Image

Two Depth Image

Epipolar Camera Image
Previous Work

- **Depth Images**
  - Layered Depth Images (LDIs) [Shade 1998], and LDI Trees [Chang 1999]
  - Vacuum Buffer [Popescu 2001]

- **Non-pinhole cameras**
  - Pushbroom camera [Gupta 1997], Two-slit Camera [Pajdla 2002], General Linear Camera [Yu 2004]
  - Multiple-Center-of-Projection Camera (MCOP) [Rademacher 1998]

- **Occlusion cameras**
  - Single-Pole Occlusion Camera (SPOC) [Mei 2005]
  - Depth-Discontinuity Occlusion Camera (DDOC) [Popescu 2006]
Camera Model

- Epipolar geometry allows us to reduce search space to 1D
- We exploit this in our camera model
Camera Model

- The camera model requires 2 parts
  - Projection map
  - Ray map
- These maps are built from left to right
Camera Model

- For every ray on an epipolar segment
  - If has no depth discontinuity
    - Insert ray into ray map
  - Else
    - Calculate new ray set
    - Insert ray set into ray and projection maps
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model
Camera Model

- Ray Map
  - Stores the rays (of at most 2 segments)

- Projection Map
  - Stores a minimum and maximum offsets
  - $z_n$ and $z_f$ for the offsets
  - Does not provide a precise project for a point
    - Instead, provides a segment on which the point exists
Rendering

- CPU and GPU implementation
  - GPU implementation requires a card supporting DX 10

- Algorithm
  - Project a triangle with the Left PHC
    - For every epipolar span for the triangle
      - Project the end points with the EOC *Projection Map*
      - Rasterize by intersecting the EOC projected segment with the corresponding rays in the *Ray Map*
Examples
Picket Fence

picket.avi
Examples
Double Doors
Examples
Radial Sphere

PHC Projection
Radial Projection
Examples
Radial Sphere

EOCI Progressive Build
EOCI Reconstruction
Examples
Radial Armadillo
Examples
Crossing Segments of Projection

Depth Images
EOC Image
Examples
Crossing Segments of Projection

Depth Images

EOC Image
Examples
Complex Scene (Unity)
Applications

- Geometry Replacement
- Compression
- 3D Display Acceleration
Conclusions

- Novel non-pinhole camera model designed to gather samples visible along a segment
- Provide fast projection
  - Without redundant sampling
- Unlike previous occlusion cameras, the EOC does not place restrictions on the scene complexity
Future Work

- Accelerating the construction of the EOC model by off-loading it from CPU to GPU
- A rigorous study of the conservativeness of the EOC model
- Non-redundant light field
- Occlusion cameras models that can be constructed from sets of pinhole camera images, without the need of geometry.
- Apply the model to other computer graphics contexts, including motion blur, antialiasing, and soft shadows.
Thank you

- Questions?