

Image Based Virtual Reality

Ladislav Čmólik

Czech Technical University in Prague
Faculty of Computer Science and Engineering



Outline

- Introduction to Image Based Rendering (IBR)
- Plenoptic function
- Where is the image and how it is created?
- Panoramic Imaging
- Layered Depth Images
- Concentric Mosaic
- Lightfield / Lumigraph
- Conclusion

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Introduction to IBR

- Image Based Rendering
 - Uses real or synthetic images in the rendering process
 - It is often somewhere between computer vision and computer graphics

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Introduction to IBR

- Rendering complexity is **not dependent** on geometric complexity
 - Often there is no geometry at all
- Note that
 - Usage of textures is image based rendering

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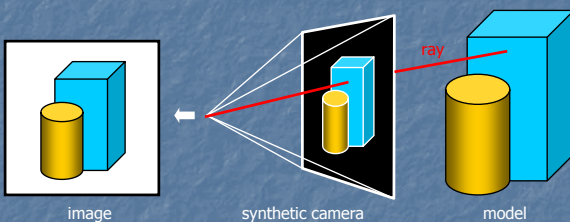


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Computer Graphics



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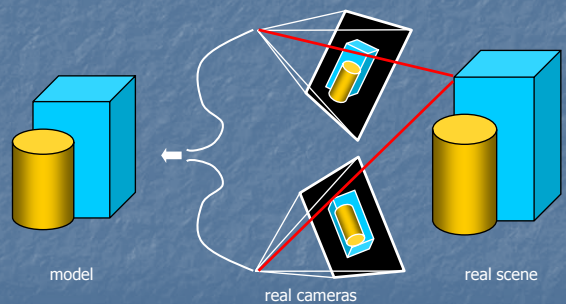


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Computer Vision



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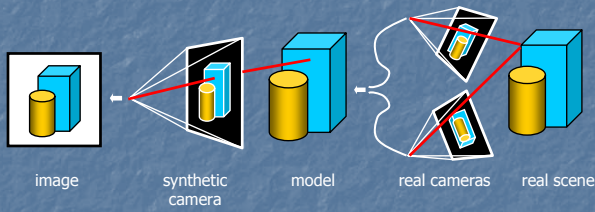


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Computer Graphics and Vision Combined



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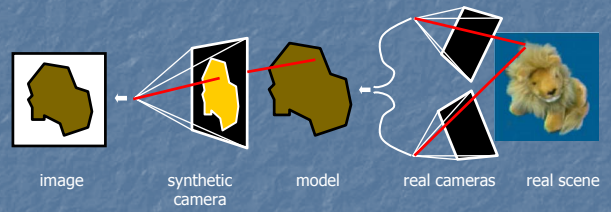


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Computer Vision Fails



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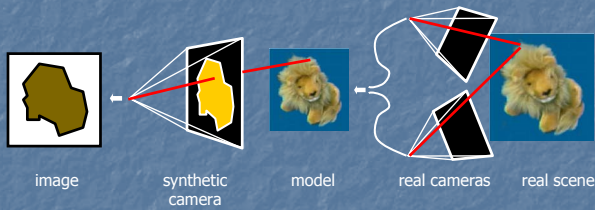


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Computer Graphics Fails



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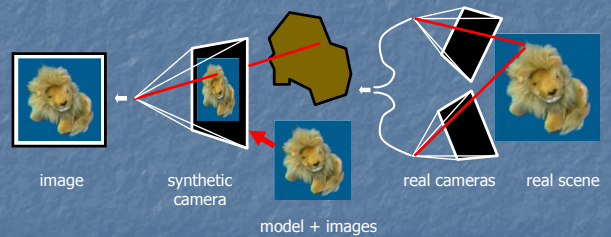


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Image Based Rendering



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Plenoptic Function

- Introduced by Adelson and Bergen [1]
- *Plenus* = full, *Optic* = vision
- Function in 7D
- Theoretically continuous, in praxis is discrete

$$p = P(\theta, \phi, \lambda, x, y, z, t)$$

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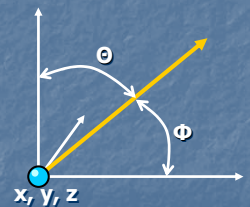


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Plenoptic Function

- x, y, z – coordinates in 3D space
- Θ – azimuth
- Φ – elevation angle
- λ – wavelength
- t - time

$$p = P(\theta, \phi, \lambda, x, y, z, t)$$



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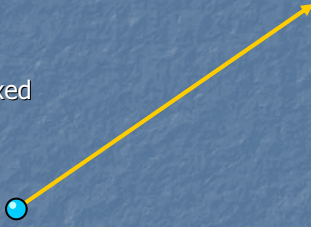
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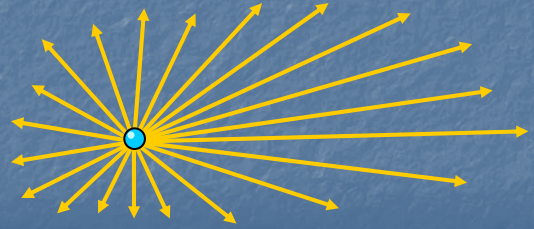
Plenoptic Function

- Ray (5D)
 - Time is fixed
 - Wavelength is fixed
 - Position (3D)
 - Direction (2D)



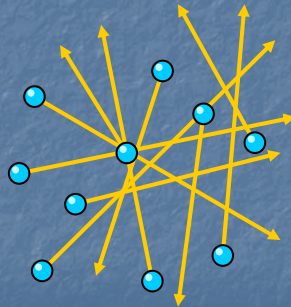
Penoptic Function

- All rays through a point (2D for simplicity)



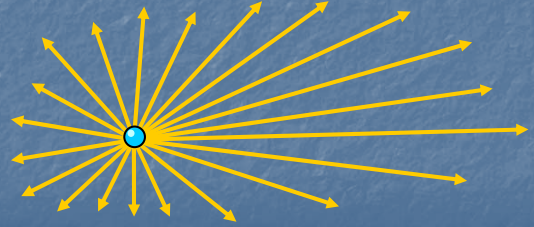
Plenoptic Function

- All Rays
 - **Too complex**
 - **Too hard**
 - Data structure to arrange rays is needed



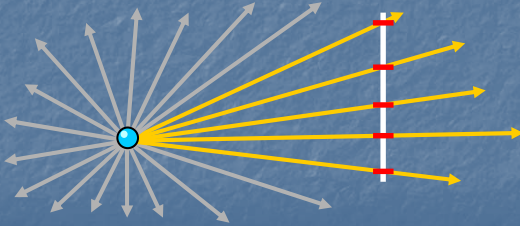
Where Is the Image?

- All rays through a point (2D for simplicity)



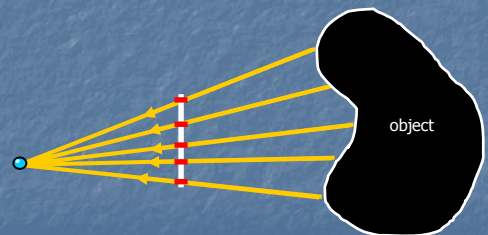
Where Is the Image?

- Intersections with image plane



How Is the Image Created?

- Light towards a camera (2D for simplicity)



Panoramic Imaging

- Panoramic image
 - 2D plenoptic function (θ, ϕ)
- Panoramic video
 - Panoramic image + time
 - Panoramic image + position
- Plenoptic modeling [2]
 - Interpolation of panoramic images

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Panoramic Images

- Panorama is 2D plenoptic function
 - Full
 - Partial
- Position is constant
- Only azimuth and elevation angles changes

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Panoramic Images Types

- Full 2D plenoptic function



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Panoramic Images Types

- Partial 2D plenoptic function



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Use of Panoramic Images

- QuickTime
- VRML 97 & X3D
 - Does **not** support spherical and cylindrical panoramas
 - Supports only cubical panoramas

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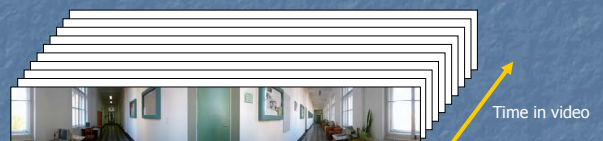


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Panoramic Video



- One frame is panoramic image
- Time in video represents:
 - Time (3D plenoptic function)
 - Position (3D plenoptic function)

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Use of Panoramic Video

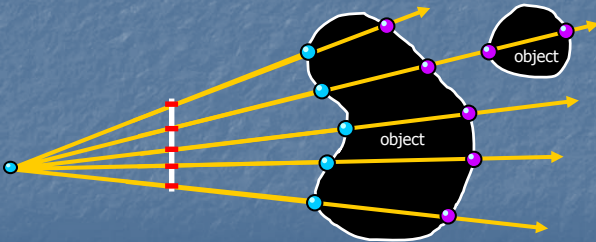
- Security – panoramic cameras
- Virtual reality
 - Dynamic panoramas (e.g. sky)
- Image Based Virtual Reality

Panoramic Video Demo



Layered Depth Images (LDI)

- LDI is 2.5D plenoptic function
- Introduced by J. Shade et al. in [3]

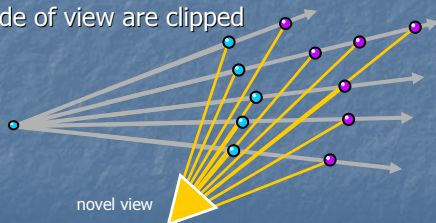


Layered Depth Images Capturing

- Synthetic scenes
 - Depth sprites from various angles
 - Modified ray-tracer
 - Modified z-buffer
- Real scenes
 - Plenty of photographs from nearby views
 - Positions and directions of camera
- The position of camera is part of LDI

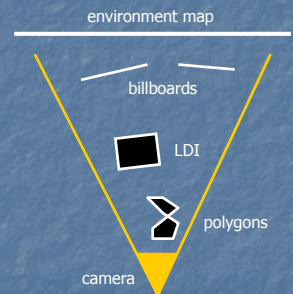
Layered Depth Images Rendering

- Splating
- Pixel size is estimated from distance
- Pixels outside of view are clipped



Use of Layered Depth Images

- LOD
 - Between polygons and billboards
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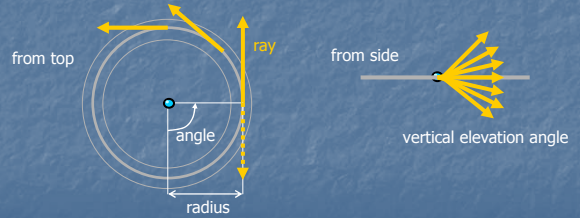


Layered Depth Images Demo

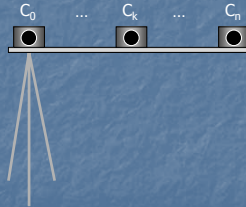


Concentric mosaic

- Concentric mosaic is 3D plenoptic function
- Introduced by H.-Y. Shum and L.-W. He in [4]

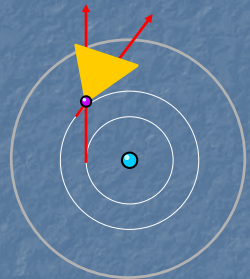


Concentric Mosaic Capturing



Concentric Mosaic Rendering

- Rendering of a novel view
- Interpolation from near samples is possible
- Perspective correction of interpolated slices is needed



Concentric Mosaic Demo



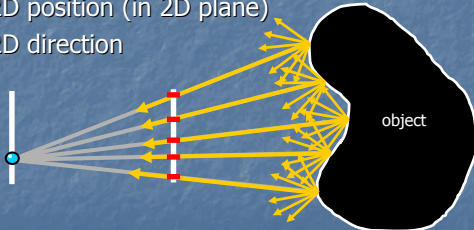
Lightfield / Lumigraph

- Lightfield / Lumigraph is 4D plenoptic function
- Lightfield introduced by M. Levoy at al. [5]
- Lumigraph introduced by S. J. Gortler at al. [6]
- Papers published in the same year and are very similar



Lightfield / Lumigraph

- All light leaving object (4D)
 - 2D position (in 2D plane)
 - 2D direction



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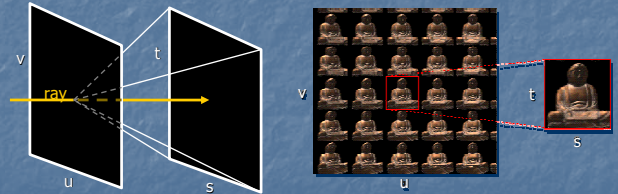
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Lightfield / Lumigraph

- 4D organization
- 6 uv planes on cube



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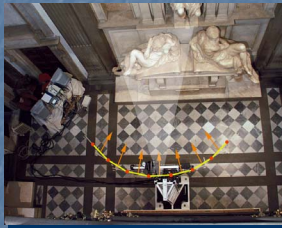
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Lightfield / Lumigraph Capturing

- Synthetic scenes
 - Rendered images from uv grid for all 6 planes of cube
 - Direction of camera points to centre of the cube
- Real scenes
 - Photographs with the same properties



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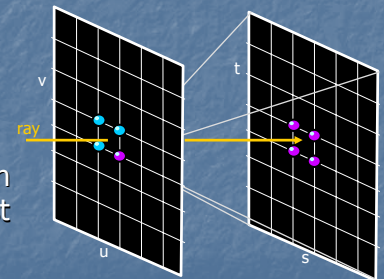
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Lightfield / Lumigraph Rendering

- Possible to render by ray-tracer
- Interpolation from nearest 16 samples



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Lightfield / Lumigraph Demo



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Conclusion

- Image based rendering does not depend on geometrical complexity
- The size of data files is quite big
- Nowadays used in praxis only panoramic images (and concentric mosaics)
- No support from VRML (X3D) viewers

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References

- [1] E. H. Adelson and J. Bergen. The plenoptic function and the elements of early vision. In *Computational Models of Visual Processing*, pages 3-20. MIT Press, Cambridge, MA, 1991
- [2] L. McMillan and G. Bishop. Plenoptic modeling: An image-based rendering system. In *Computer Graphics, Annual Conference Series*, pages 39-46, 1995
- [3] J. Shade, S. Gortler, L.-W. He, and R. Szeliski. Layered depth images. In *Computer Graphics (SIGGRAPH'98) Proceedings*, pages 231-242, ACM SIGGRAPH, Orlando, 1998



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- [4] Heung-Yeung Shum and Li-Wei He. Rendering with concentric mosaics. *SIGGRAPH 99*, pages 299-306, 1999
- [5] M. Levoy and P. Hanrahan. Light-field rendering. In *Computer Graphics, Annual Conference Series*, 1996
- [6] S. J. Gortler, R. Grzeszczuk, R. Szeliski, and M. F. Cohen. The lumigraph. In *Computer Graphics Proceedings, Annual Conference Series*, pages 43-54, ACM SIGGRAPH, New Orleans, 1996



Thank you

Questions?