3D Displays Using Integral Images

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What is an *Integral Image*?

– An image that consists of many small *imagelets*, each is a perspective view of the scene. It is typically captured through a *microlens* (a.k.a., fly's-eye lens) array.

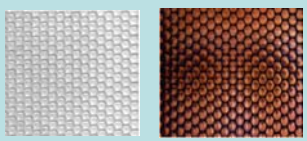
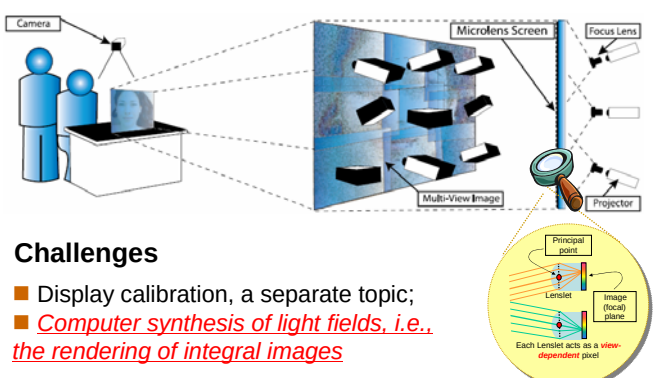


Figure 1: (left) A microlens array (right) An integral image that captured a woman's face [Roberts 2003]

Application of Integral Images: Auto-stereoscopic Display

- *3D without glasses!*
- Our vision: the ***light field display*** –synthesize the complete flow of light in all directions, using an array of projector and microlens arrays.



Challenges

- Display calibration, a separate topic;
- *Computer synthesis of light fields, i.e., the rendering of integral images*

[Roberts 2003] ROBERTS, D. E. 2003. History of lenticular and related autostereoscopic methods. White paper, Leap Technologies, LLC.)

Rendering of Integral Image

An easy way is to render each view independently and juxtapose the images, i.e., *viewporting*.

- number of rendering passes = the number of imagelets, $10^3 \sim 10^6$.
- *too slow for real-time rendering!*

Our Approach Assuming the imagelets are on a regular grid, render all the parallel rays at once (as shown below). Our *Parallel-Group Rendering* (**PGR**) algorithm can significantly reduce the number of rendering passes needed.

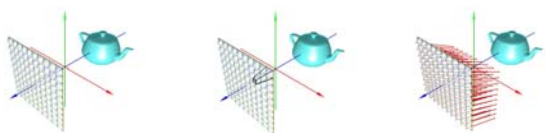


Figure 2: Parallel rays in a microlens array. **(Left)** A teapot scene is to be visualized. **(Middle)** A traditional way to produce an integral image is to render each imagelet one by one. **(Right)** Our novel rendering algorithm renders groups of parallel rays.

Advantages of PGR

- Over two orders faster than "viewporting"
- Easy to implement
- Directly accelerated by graphics hardware

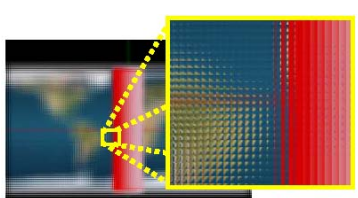


Figure 3: An integral image generated by PGR, the inset shows a zoom-in view.

[Halle 1998] HALLE, M. W. 1998. Multiple Viewpoint Rendering. In *Proceedings of SIGGRAPH 1998*, 243-254.

Prototypes

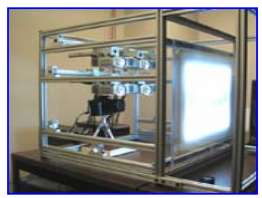


Figure 4: A prototype of our *light field display*, with four projectors.

View Dependent Effect of 3D Display

Figure 5: The view-dependent effect of our display. The red cylinder in front of the world map is blocking different parts of africa.

Flexible Pixel Router

Design FPGA-based hardware to perform the final composite through the DVI interface.

- Routes pixels from 4 Dvi Input ports (inputs from graphic cards) to 4 Dvi Output ports (output to projectors) based on a Lookup Table (LUT).

Inside the Pixel Router

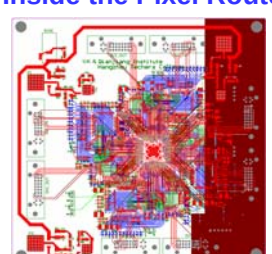


Figure 6: The Pixel router with 4 Dvi input, output ports and an array of SDRAM buffers.

DVI Hardware

Figure 7: The custom built hardware.

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