Light field photography

CS 178, Spring 2012

Marc Levoy
Computer Science Department
Stanford University
“Light field photography using a handheld plenoptic camera”

Ren Ng, Marc Levoy, Mathieu Brédif, Gene Duval, Mark Horowitz and Pat Hanrahan

(Proc. SIGGRAPH 2005 and TR 2005-02)
Conventional versus plenoptic camera
Conventional versus plenoptic camera
Prototype camera

Contax medium format camera

Kodak 16-megapixel sensor

Adaptive Optics microlens array

125 µ square-sided microlenses

\[ 4000 \times 4000 \text{ pixels} \div 292 \times 292 \text{ lenses} = 14 \times 14 \text{ pixels per lens} \]
Digital refocusing

- refocusing = summing windows extracted from several microlenses
Example of digital refocusing
Refocusing portraits
Refocusable sports photography
Extending the depth of field

conventional photograph, main lens at $f/4$

conventional photograph, main lens at $f/22$

light field, main lens at $f/4$, after all-focus algorithm [Agarwala 2004]
Macrophotography
Digitally moving the observer

• moving the observer = moving the window we extract from the microlenses
Example of moving the observer
Moving backward and forward
Implications / commercialization

- trades off (excess) spatial resolution for ability to refocus and adjust the perspective

- sensor pixels should be made even smaller, subject to the diffraction limit
  \[
  36\text{mm} \times 24\text{mm} \div 2.5\mu\text{m pixels} = 266 \text{ Mpix}
  
  20\text{K} \times 13\text{K} \text{ pixels}
  
  2000 \times 1333 \text{ pixels} \times 10 \times 10 \text{ rays per pixel}

  or

  2000 \times 1500 \text{ pixels} \times 3 \times 3 \text{ rays per pixel} = 27 \text{ Mpix}
\]
Other devices for capturing light fields

Stanford Multi-Camera Array

Manex’s bullet time array
Other devices for capturing light fields

Stanford Spherical Gantry

used to measure light scattering for rendering translucent materials
Lego gantry for capturing light fields
(built by Andrew Adams)
Flash-based viewer for light fields
(written by Andrew Adams)

(see http://lightfield.stanford.edu/lfs.html)
Flash-based viewer for light fields
(written by Andrew Adams)
The Lego gantry captures a light field of itself