PSM Jellyfish 06-09-2011

Schlieren Photography

-convert refraction into observable representation
-useful in computer vision and graphics
-angular resolution very good with these lenses
-traditional schlieren uses big expensive equipment that must be calibrated and are restricted to laboratory settings
-other schlieren setups are quite large
-backgrounds must be far back because the changes are very small (sensitivity) and because you actually measure a point on the background (scan volume must be small in comparison to the background)
-current implementation is a lenslet array

Main contributions
-4D probes instead of 2D probes (allows for new methods to do the same thing as traditional methods)
-in this type of acquisition we only observe the illumination part

The Unicorn Example:
-the probe allows us to see the colour
-rainbow schlieren
 -point light source columnated by lens: rays become parallel
 -similar to knife-edge schlieren

Background vs Rainbow Schlieren
-Background uses printed backgrounds (
-Rainbow more equipment and setup
-Rainbow: Background or Object can be put into focus (tradeoff between spatial and angular resolution)....postcard example
-Background Schlieren: fails completely with certain setups

-Rainbow: 4D (space and angle) probes that emit the light field
-Tradeoff between spacial and angular resolution

-encoding underlying pixels under the lenslets

-transparent object in front of probes demonstrates the directional gradient where the details would normally not be visible

-schlieren used for microscopy

-colour wheel under each lenslette (rainbow schlieren)
-rainbow schlieren can be used with liquids
-cannot be used quantitively due to uncertainty with absorption (in object and lenslets)

Spatio-Angular Filters
-colour channels allow a single shot to gather information on Vertical and Horizontal Gradient as well

as Vertical Position (on background)

-refraction wavelength independent

-co-linear rays (camera ray and background ray) are ill-conditioned for 3D refractive point analysis
- -two refractive events one bumpy and one smooth; approximate the difference (epsilon)
- -throw away almost co-linear lines

-sparse set of control points that ...
-surface integration throws away areas that have high absorption (i.e. around the boundaries)

-single shot so we can do moving objects
- -water drop example
- -from colours can integrate normals
- -then use this information to render textures in animation
- -half-toning from printer causes distortions in combination with lenslets

spatially varying absorption term possible to reconstruct as well as index?
- -not in absorption
- -compensate for color change in absorption
- -maybe with multiple shots (uniform background)

new setups:
- -What do we want to construct?
- -Panos director of ICICS has lab on third floor has monitor with lenslets attached (autostereoscopic display) might be able to use it
- -iPhone?
- -lens array specific for display

Manufacturing issues

Difficulties with printing the colour space behind the lenslets

Absorption and Fernel effects problems with absolute colour indexing vs black and white rings which are more of an interferometry calculation

3D stripe scanning
- -to determine which stripe using codes (like bar codes)
- -look at neighbourhood
- -neighbourhood would be stretched

600 dpi print-out
300 dpi lenslets

Replace lenslets with diffraction gradient
-columnated lens to parallelize light source

How big can we make individual lenses in arrays?

-problems with mounting and focal length

large baseline for reconstruction? Dense measurements

German company
2mm lens and 512x512 pixels under that
-colour space under lens is exposed on pre-bonded film per lens
-similar to 3D postcards

<u>Tomographic Image Generation...</u>

multiple layers of attenuated material (layers of transparencies with images printed on them)
constant backlight
-compute layers that generate 4D light field
    -7x7 images of object at slightly different angles
Tomographic:
-each viewing angle corresponds to a layer in the display
Non-linear problem but can be solved in logspace
-Problem: error distortions
-sum in log space (normally product)
-cannot aim different scenes into multiple different viewing directions/angles
    -limited degrees of freedom
-higher resolution than lenselette arrays
-higher .... than Parallax Barriers
-depth-dependent blur
blur introduced for objects that are outside of the display stack

Stack of LCD Panels
-linearly polarized light in
-each layer rotates the polarization until the last one
-the last layer polarizes the light on the way out
-additive layers
-function that transforms rotation angles into intensities is not linear
problems with light loss for this model
    -Fernell terms at every boundary between layers, due to air gaps
    -throw away 50-60+% of light with polarizers
    -RGB pixels side by side each absorb some of the light
-Moirê effect caused multiple layers
real-time solver implements SART
can initialize the input from a frame by the output of the previous frame
for moving objects introduce motion blur (tradeoff between motion blur and frame speed)
log domain error causes loss of high contrast areas
-large angles for rotation the model slightly breaks (does not invert as expected)
voxel in one layer absorbs some light
absorption is visible in all directions

-benefit from a solver that converges quickly (handle and spout blur)
-display layers do not correspond to voxelization of the object, but also have colouring from other layers and angles