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Reprocessing Anaglyph Images

Prof. Hank Dietz

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University of Kentucky
Electrical & Computer Engineering

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Anaglyphs

- Create illusion of depth by using color within a single image to separate left and right views
  - Many examples; popular for over a century
  - Easy to directly capture anaglyphs
- Can we use anaglyphs as an **input and storage format** for reprocessing?
- Generate full-color stereo pair, refocus, etc.

Anaglyph Properties That Degrade Reprocessed Quality

- Gamma – we want a linear representation
- Transverse Chromatic Aberration (CA)
- Lens projection distortions (e.g., Barrel)
- JPEG perceptual compression (YUV, DCT)
- Yaw, Pitch, and Roll WRT stereo baseline
- Fake anaglyphs (actually quite common!)
- “Corrections” of color to reduce Retinal Rivalry

Retinal Rivalry

- Objects with very different left/right brightness do not visually fuse – they alternate
- Anaglyph colors can be altered to reduce this
  - Monochromatic: no color information
  - Color: good to reprocess, bad rivalry
  - Half-Color: color from one side only, rare
  - Optimized / “Leaky” Color: problem colors replaced, corrupting color and/or ghosting

Deconvolution

$$d_i = \epsilon_i + \sum_j p_{ij} u_j$$

- Assumes image convolution is a summation
- The Point Spread Function (PSF) may be known, unknown, or known except for scale
- Many techniques...
  very common in computational photography

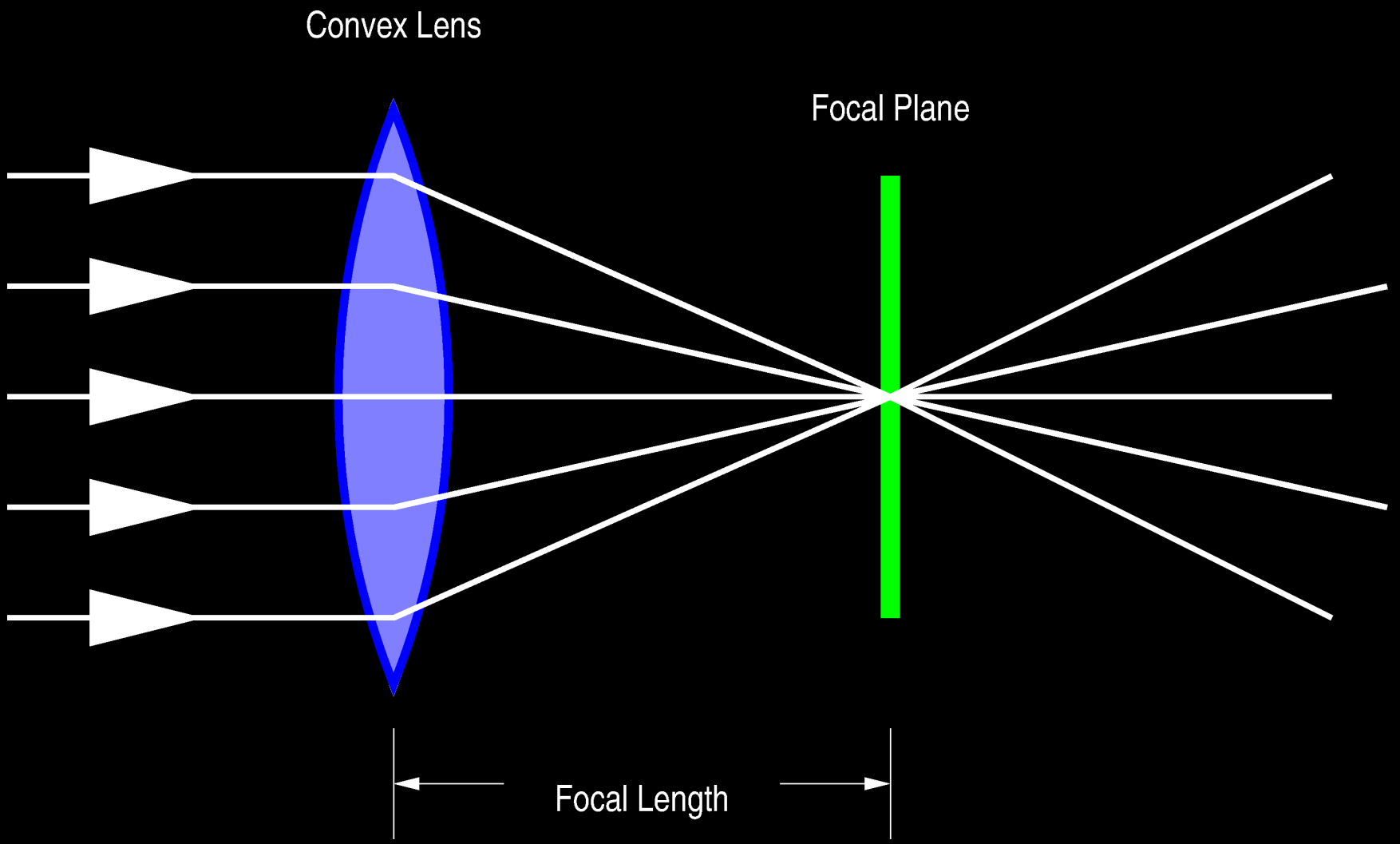
OOF PSF?

- What does an out-of-focus (OOF) point light source – point spread function (PSF) – really look like?

What People Think Happens

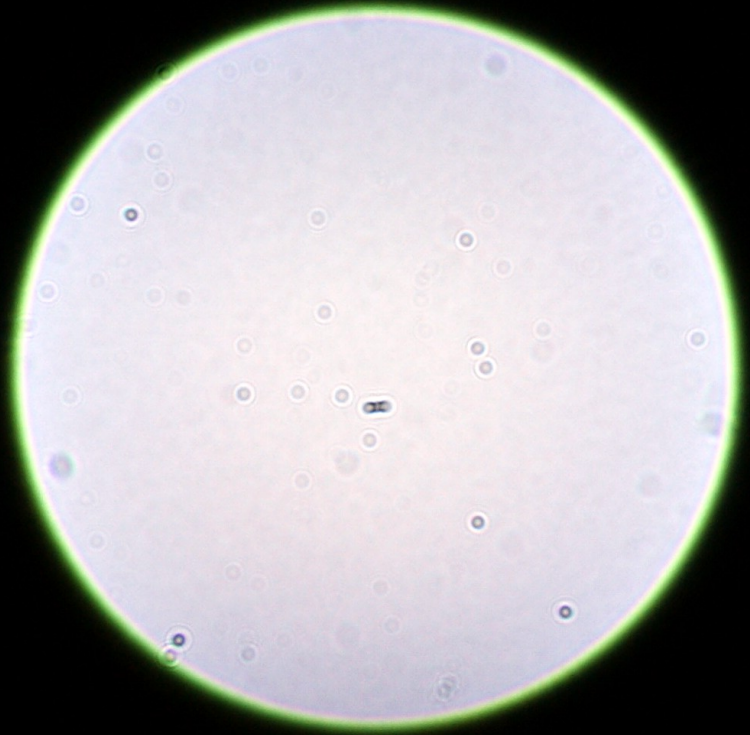
- OOF PSF is a Gaussian blur, right?
- E.g., assumed for contrast detect autofocus

What Really Happens



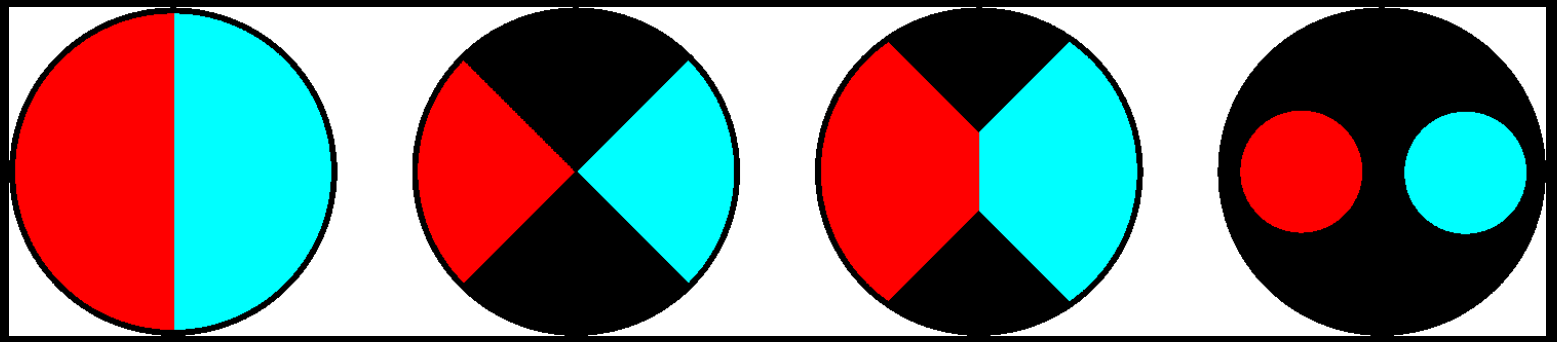
OOF PSF

- It is the rays not clipped by the aperture:



Songer's 1973 Patent

- Use a color-coded aperture to directly capture a “3D” Anaglyph with a single shot, one lens
- Apparently later used in Vivitar Qdos lens



My Color-Coded Apertures

- `aggregate.org/anaperture` designs them
- Programmable paper cutter makes them
- Use standard green/magenta gels
- Simply placed in front of existing lens
- Cost under $1

My Anaglyph

instructables

- Published 11/22/2010, featured by editors
- 20,000 readers; 7,000 uses of design tool

Intro: Use Your Camera To Capture "3D" Anaglyphs

An anaglyph is a color image that creates the illusion of "3D" depth when viewed through color filters that separate the left and right views. The image shown here is an example viewable through green/magenta glasses.

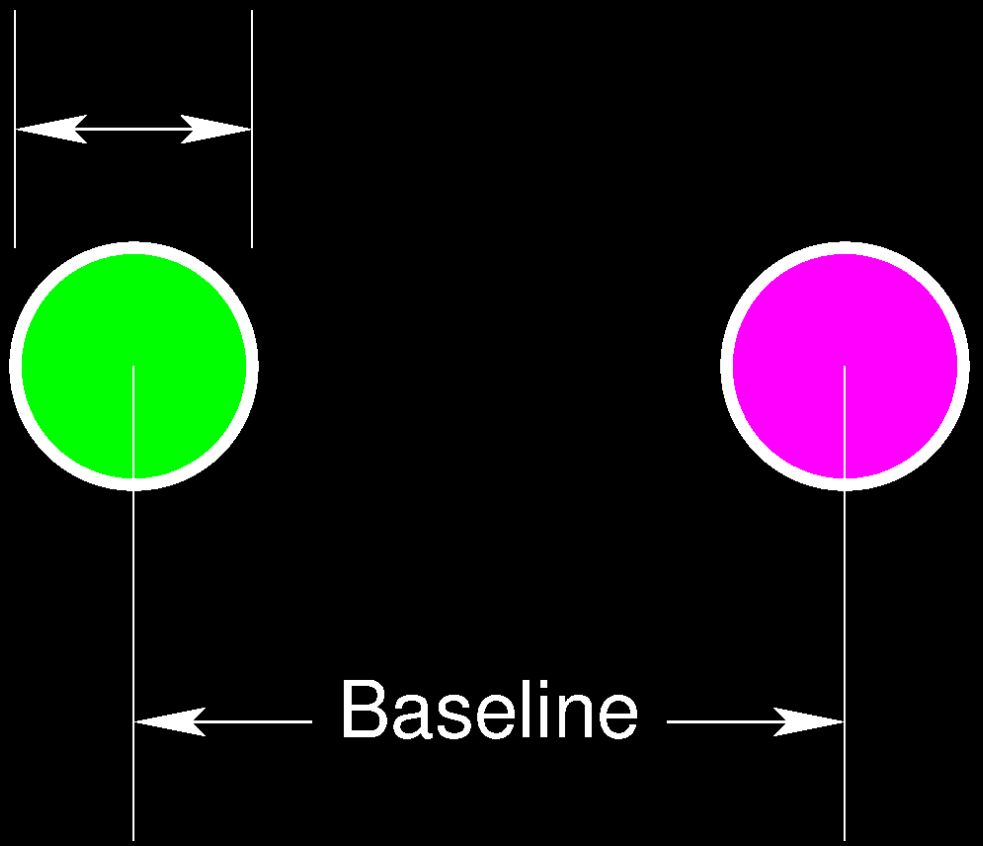
Although various color combinations and processing variations have emerged over the years, the basic concept of an anaglyph is largely unchanged since the 1850s. Nearly all methods start by capture of a stereo pair of images which are then manipulated to create the anaglyph. In contrast, the method discussed here involves **modifying a digital still or video camera to directly capture a high-quality anaglyph in a single shot -- with no post-processing needed** .

Did I mention that the **reversible modification** to your camera can **cost less than $1** ?

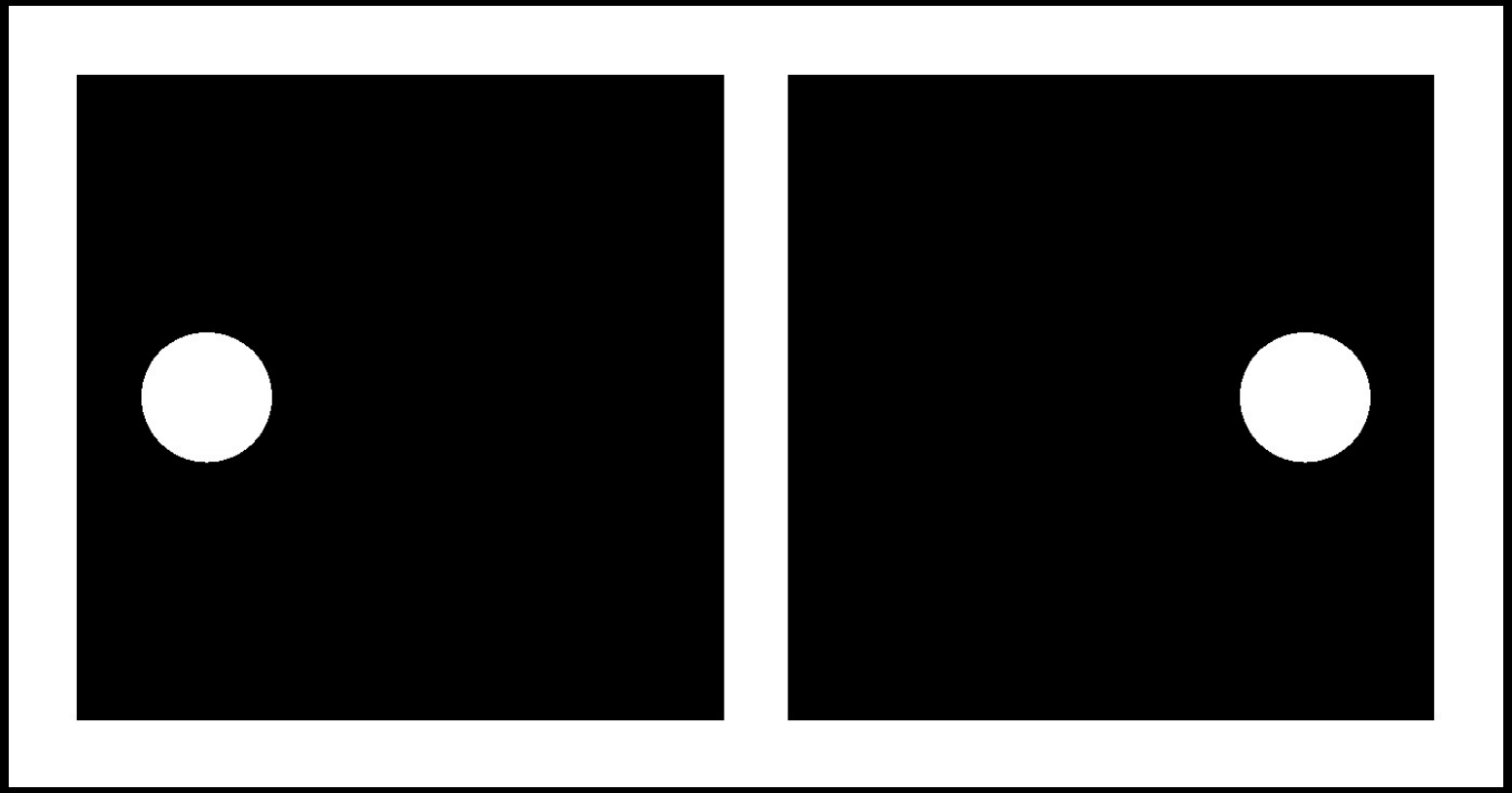
Image Notes

1. A green/magenta anaglyph captured using this little trick. Pretty cool, eh?

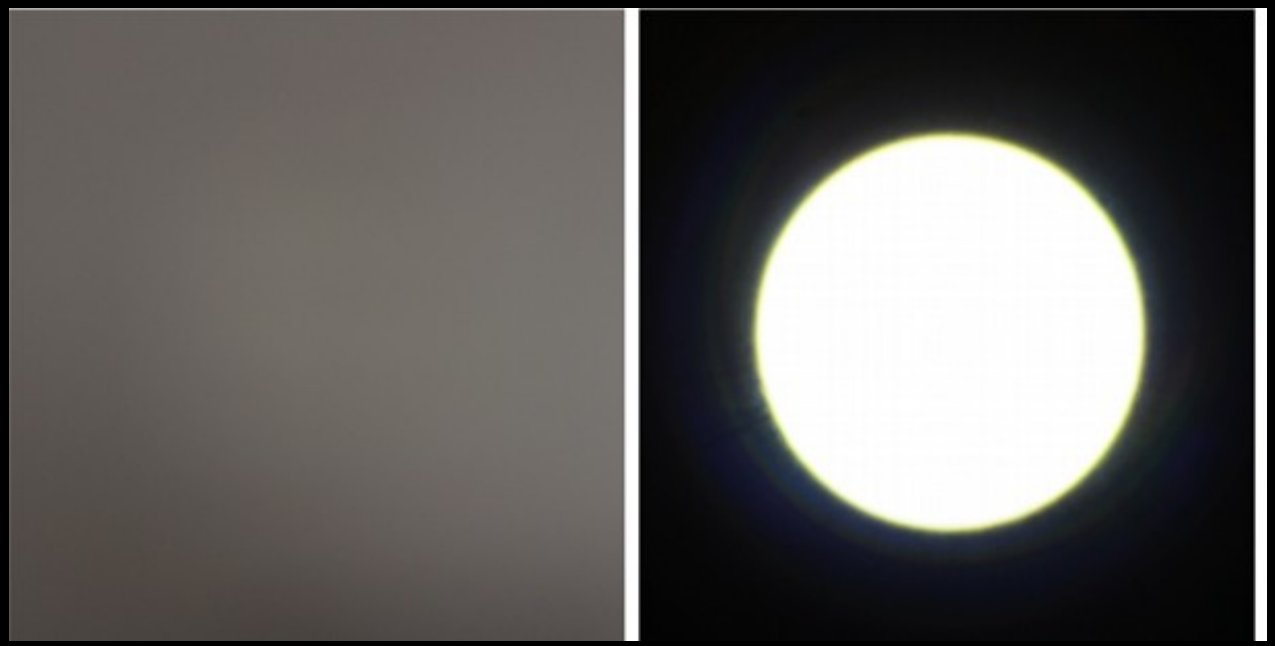
Every Anaglyph Has This Type Of Scalable "Virtual PSF"



To Recover Left & Right Images, Substitute These Scalable PSFs



OOF PSFs Don't Really Add



Occlusion Does Funny Things

Stereo Matching

- Match features between left & right sides
- Many methods
- Not very effective because features are often very different:
  - Different colors in left & right views
  - Different views (occlusion)

Red

Green

Blue

Shape-Based (Superpixel) Processing

- Group similar pixels together to form shapes; regulate shape size either by Superpixels or merging shape data from multiple thresholds
- Match shapes between left & right sides – more robust than matching colors/features
- Smooth color estimates within a shape

Color Analysis

- Try to reconstruct missing colors directly; Left has just 1/3 colors, but Right has 2/3
- As Edwin Land observed, colors are not really properties of individual pixels, but of elements of a scene in context
- Recognizing scene color properties allows credible synthesis of missing color info

How Does This Work?

(Land, Scientific American, 1959)

Color Analysis

- Some portion of the scene is naturally aligned and in focus; those colors are correct
- Smoothly-shaded long horizontal runs contain some pixels that are approximately correct
- Fringe areas can be identified
- Guess missing colors are like those known in other areas – this can handle occlusions

Results

- All the following were captured as anaglyphs
  - Single-shot green/magenta using front filter
  - JPEG images, no calibrated fixes – essentially “worst case” input anaglyphs
  - Some vignetting at frame edges
- Best reprocessing as of February 2011… using color analysis & shape smoothing

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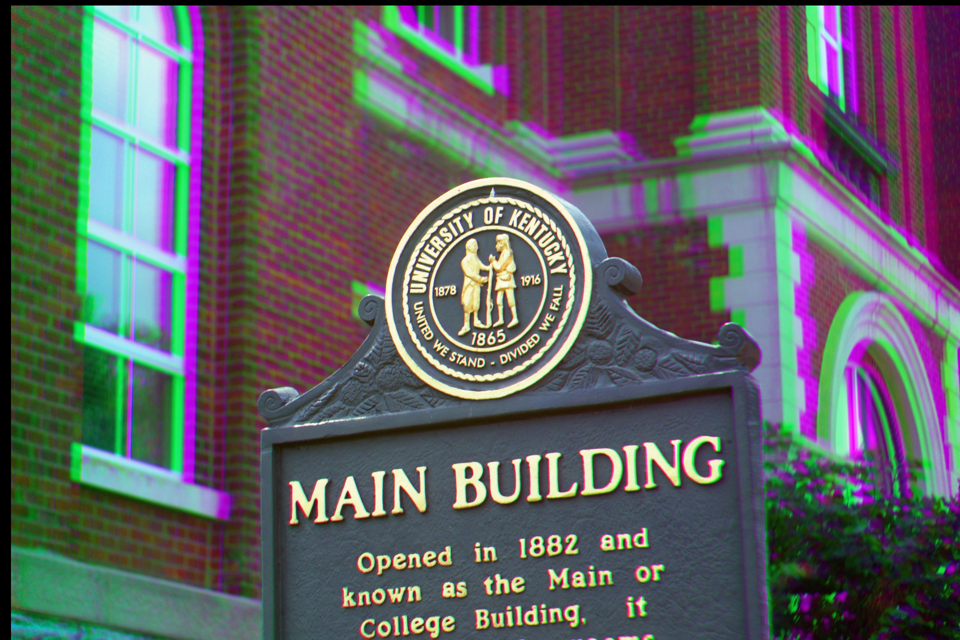

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Conclusions

- Cameras can **directly capture** an anaglyph
- Anaglyph data is a lot like plenoptic data:
  - Color quality is somewhat poorer
  - Resolution (pixels & angles) is much better
- Using neural and GA supercomputing to develop better reprocessing algorithms
- Key is determining scalable OOF PSF and {+/- scale, R, G, B} for each scene point

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