Extending Human Vision

Film and Sensors

Victoria RASCals Star Party 2003 – David Lee
Extending Human Vision
Film and Sensors

The Limitations of Human Vision
Physiology of the Human Eye
Film
Electronic Sensors
The Digital Advantage
The Limitations of Human Vision

- Poor low light sensitivity, unable to accumulate light

- Difficulty in viewing through a constantly changing atmosphere … viewing from the bottom of a swimming pool

- Unable to see certain wavelengths of light
Physiology of the Human Eye

**CONES**

- Colour
- Average Count: 6 to 7 Million
- Acuity and Resolution

**RODS**

- B&W
- Average Count: 120 Million
- Low light sensitivity and motion detection
Rhodopsin – light absorbing pigment

With dark adaptation there is an increase in sensitivity up to the 500 nm wavelength
How do we optimize what we see at night?

- **Dark adaptation** – Rhodopsin builds in 20 to 30 minutes to give a magnitude difference of 2 to 6 magnitudes.

- **Averted vision** – rod vision is 4 magnitudes more sensitive than cone vision.
How do we optimize what we see at night?

- **Attention** – conditions in the night sky are variable and change rapidly, observing requires attention and time

- **Practice** – experience is what trains the brain to perceive detail
Sketching

Sketches by Richard Harvey
Film
The Structure and Characteristics of Film

- Film is a **light sensitive material** that can be used to capture a virtual image from optics

- Composed of **silver crystals** that change when exposed to light

- Chemicals are used to produce dense areas of **metallic silver** where light is
The Structure and Characteristics of Film

- Sensitivity, granularity and colour sensitivity are characteristics of film.
- Films with large silver crystals will be more sensitive but will suffer from higher granularity and a lessening of detail.
- Every film has a colour signature, sensitivity to specific wavelengths vary.
Film Vision

- By substituting film we are able to accumulate light for dim objects

- Although light can be accumulated, reciprocity law failure sets it, this varies with each type of film

- Enhance the detection of wavelengths the human eye is less sensitive to
Film Vision

- Film can be hypered to remove moisture, increasing the sensitivity

- Chilling film for increased sensitivity has also been used
Aurora
Comet Hale-Bopp
Constellations
Star trails – Orion’s Belt
Electronic Sensors
**Electronic Sensors**

- CCD ( Charged Couple Device ) sensor
- CMOS ( Complementary Metal Oxide Semiconductor ) sensor
- Monochrome vs. Colour Mosaic
Electronic Sensors

- CCD – charged coupled device

  Found in video cameras, webcams, digital cameras

  Composed of a grid of photosites that are light sensitive

  Photosite size varies and accounts for different levels of sensitivity between sensors

  Larger photosites have less noise
CMOS sensors are manufactured using the same methods as computer microprocessors and are less expensive because of this.

- Lower power consumption
- Traditionally more noisy and less sensitive than CCD
- New technology has made recent CMOS sensors on par with CCD quality.
Some sensors are monochromatic.

Colour images must be created using individual RGB or CMY filtered exposures.
Electronic Sensors

- Colour mosaic

Sensors can be made colour sensitive by applying a colour mosaic to the sensor. This is done by applying filters to each photosite in a set pattern. The most common pattern is the Bayer pattern. Processing is required to determine a photosite’s colour.
Sensor Vision

- Sensors have the same ability to accumulate light for dim objects.

- In addition to accumulating light the response is linear as opposed to film’s characteristic of diminishing returns (reciprocity failure).

- Increased electronic noise is a factor in long exposures.
Sensor Vision

- Sensors with colour mosaics may have artifacts associated with the translation of the colour pattern especially in areas of colour transition.

- Processing times are dependant on the device the sensor is attached to.

- All sensors are subject to photosite defects such as permanently on or permanent off photosites often mapped out by the device manufacturer.
Sensor Vision

- Sensor images are inherently soft and require post-capture processing

- Sensors are heat-sensitive and for best results require cooling, noise reduction processing during or after capture ... or all of the above

- Sensors by nature are statically charged and attract dust, this is a maintenance problem especially with devices where the sensor is exposed while being attached to optical systems
The Digital Advantage

- Why use electronic sensors with all their problems?
- Immediate feedback
- Ability to have a large number of images in a cost effective manner … so you only keep the good ones
- Image processing can reduce noise to reveal detail
- “Grain” structure in high sensitivity settings can be superior to the equivalent speed in film
Conjunctions
Partial Solar Eclipse

June 10, 2002 Centre of the Universe Victoria BC
(c) 2002 David Lee
Pleiades
Andromeda Galaxy
The Digital Workflow for Long Exposures and Uncooperative Subjects

- Systemic electronic noise – remove with noise reduction or dark frame subtraction
- Systemic optical defects – remove vignetting and dust in the optical system with flat frames
- Capture large sample of images – cull for the best
- Remove random noise to reinforce “good” signal – stack images in registration
Questions and Contact Information

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