



MANAGING THY COLORS

Colorist Craft-Track Presentation

Daniel Davis

Advisor : Ricardo Figueroa

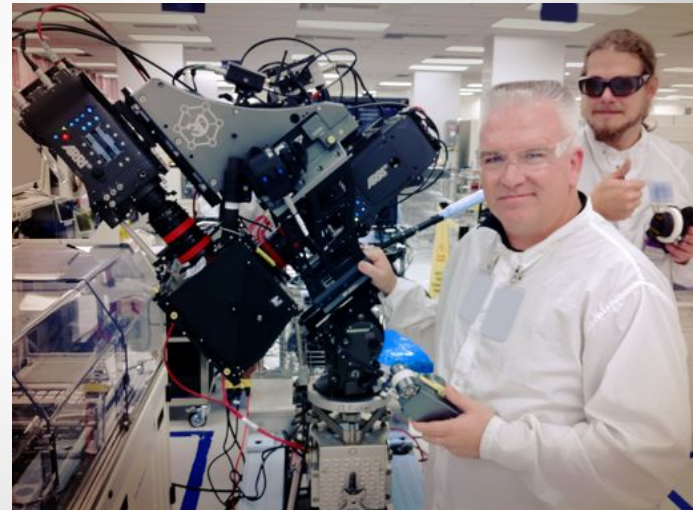
BACKGROUND

❖ I always considered myself an technically minded person that was interested in art. After beginning at RIT in computer engineering, I quickly realized an atmosphere where the creation of something without a true aesthetic and individual value was not what I wanted.

❖ Becoming primarily a filmmaker (albeit a bad one) before gaining further technical discipline as an engineer/scientist was an experience that provided true clarity to what I wanted to do. Undertaking a year of film education as an art form helped me step back and truly analyze what I thought about art and my approach to it. And this approach I found was a very quantitative one, that led me to where I am now.

BACKGROUND

❖ Practical thinking is a very important part of the filmmaking process, and that is why the fine men and women like myself are employed. As well as being a post-production position, I enjoy the cooperation with filmmaking while it is still in progress, in whatever capacity I can be involved. Finding a more simple and efficient solution to attaining what the artist pursues is just as important as the idea pursued itself, as it will liberate the artist in achieving goals that they didn't think possible, new technology being a very important part of this.



PROJECTS:

- Colorist
- Workshop productions:
 - Steve Spindler's *As Long As There Is Whiskey*
 - Asah Cramer's *One More Time*
 - Gordie Earle's *Jack And Jill*
 - Adam Chitayat's *It's All Right Here*
 - Jeremy Sickels' *The Claws That Catch*
 - Reed Nisson's *The Strike Of A Note*
 - Warren May's *Thr33 Men And A Zombie*
 - Max Lopez, Maggie Boyle, and Sean Malony's *Daedulum*
 - Jason McLagan's *An Elegy For Eden*
 - Chris Lavelle's *Vern And Terry*
 - Greg Hoople's *Greg's Movie*



PROJECTS:

Thesis projects:

- Technical Project: HVX Characterization
- Graduate Theses:
 - Romeal Hogan's *Above the Flesh*
 - Andrea Romansky's *Pills*

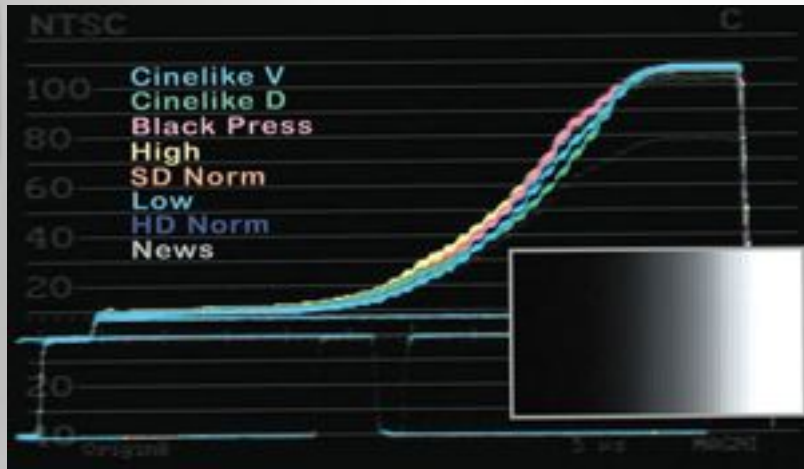
TECHNICAL PROJECT BACKGROUND

❖ The Panasonic AG-HVX200 is one of the HD digital cameras we possess here at RIT SoFA. We have eight units, and these cameras get loaned to whichever student who decides to check one out. Although with the influx of several new makes and models of Canon cameras, the HVX still remains a great choice of capture system to make images with.

❖ Alex Durie, my classmate who graduated last spring, conducted an investigation into the gamma and color matrixing settings of the HVX as the technical aspect to his colorist craft track, and my goal was to further explore the HVXs and how they compare to one another camera by camera.



TECHNICAL PROJECT BACKGROUND



❖ Gamma – Carrying over from its necessity in the realm of CRT devices, every digital capture device performs a gamma encoding on its tristimulus values (RGB) as they are captured. The HVX possesses many options for how this encoding is performed.

❖ Alex found that the Cinelike-D gamma encoding function provided the longest exposure latitude and largest dynamic range, which can be seen from the left plot where the Cinelike-D setting has the longest straight line portion of a DlogE curve. This is advantageous as this will provide the greatest amount of tone information available to the colorist in the grading process.

TECHNICAL PROJECT BACKGROUND

❖ Color Matrixing – Due to the imperfect spectral nature of sensors, manufacturers will also employ color correction matrices in order to accommodate several different purposes. Some may boost saturation and employ hue rotations, but the only desire for such a matrix in a colorist's interest is one that restores the proper purity and appearance of colors.

❖ Since each other setting employs hue or saturation alterations which can impair creative flexibility in the grading process, the Norm matrixing mode is the ideal one for color capture. This information also comes from Alex's work from last year.

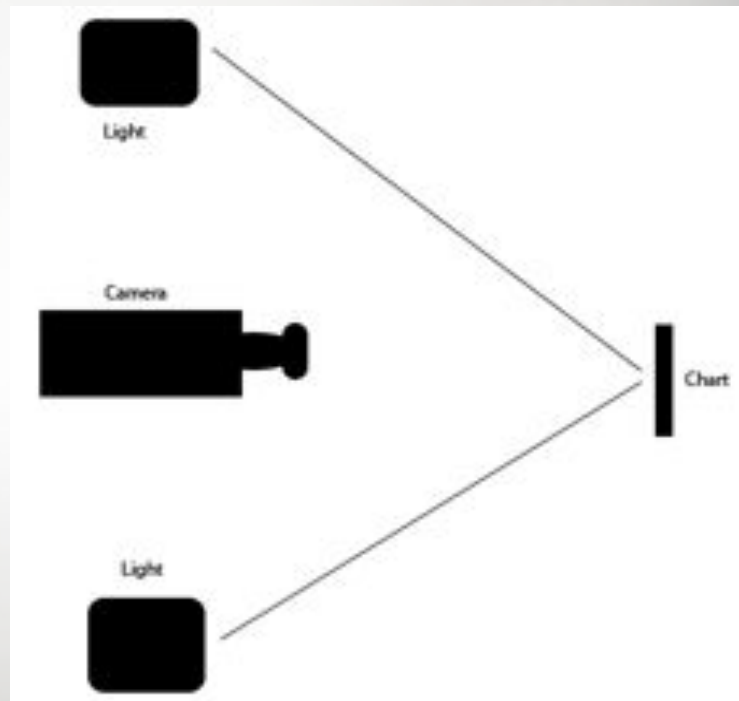
$$\begin{bmatrix} a_{11R} & a_{12G} & a_{13B} \\ a_{21R} & a_{22G} & a_{23B} \\ a_{31R} & a_{32G} & a_{33B} \end{bmatrix}$$

TECHNICAL PROJECT - SHOOTING

- ❖ The aim of the comparison of the HVXs took place on the basis of the four major image characteristics: dynamic range, color reproduction, noise, and sharpness.
- ❖ In order to demonstrate each of these characteristics in a fair context, each camera was conformed to the set of uniform optimized settings that would ensure a fair comparison amongst systems. Charts to demonstrate each characteristic needed to be shot for data collection.
- ❖ The conditions/settings for the camera shoot-out were:
 - Cinelike-D gamma
 - Norm color matrixing
 - All gain functions OFF (Detail level, absolute black, exposure gain, etc.)
 - White balance to a foam core at the same position under the scene illumination
 - Normal $f\# = 5.6$ (for the ability to open and close iris for OECF series)
 - Shutter speed = $1/60$

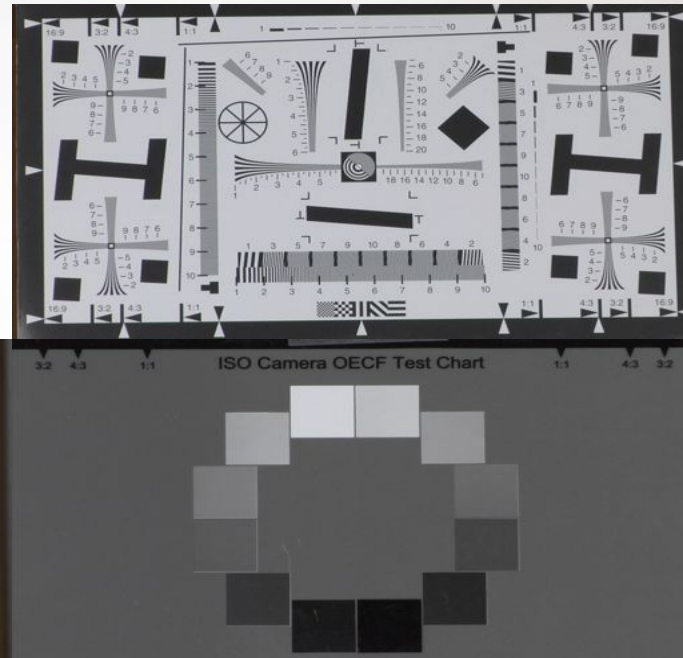
TECHNICAL PROJECT - SHOOTING

- ❖ The scene setup for the chart shoots was as basic as possible. Two Mole Richardson 1Ks were set up at an equal distance on either side of the camera, at about a 45 degree angle to ensure an even $f\#=5.6.0$ incident light meter reading at all points of the charts surface. Any lighting inconsistency could act as a serious source of error.
- ❖ Since every system is identical in its capabilities, no exposure compensation is needed in order to match non-integer stops.



TECHNICAL PROJECT - SHOOTING

❖ A MacBeth Color Checker, an ISO 11223, and an ISO OECF were the charts used to gather the data for the four characteristics previously discussed. Capturing the charts properly took three attempts!

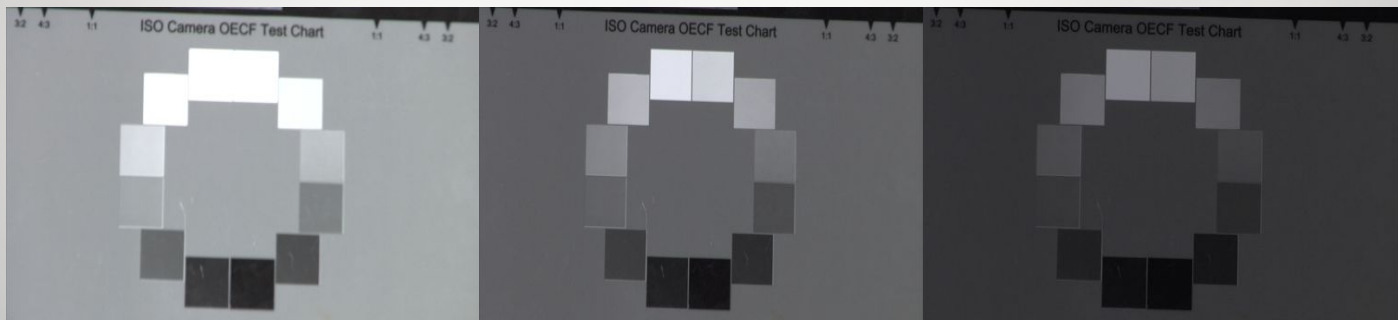


TECHNICAL PROJECT - DATA



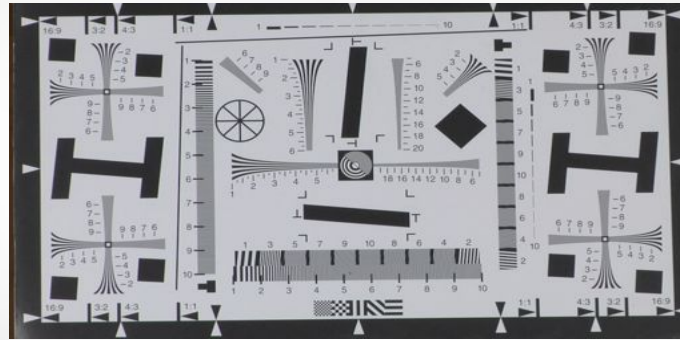
❖ The MacBeth Color Checker is a chart made of carefully crafted and standardized patches that represent common colors in scene content. Using code values from this chart generated in each camera, one can plot each system's ability to reproduce these common colors patch by patch.

TECHNICAL PROJECT - DATA



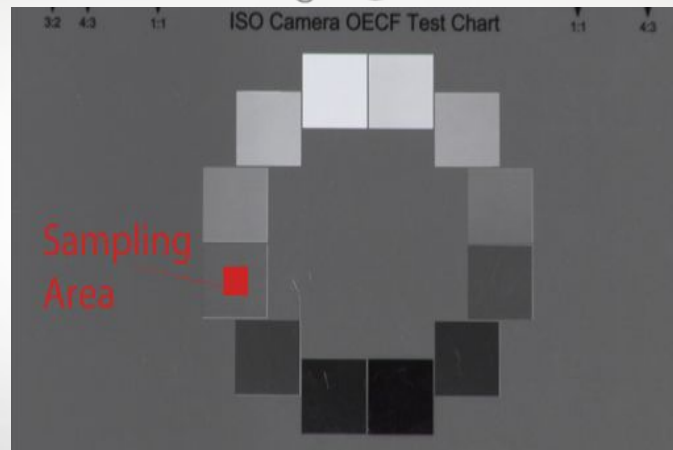
- ❖ The OECF chart was shot in a -2, normal, and +2 exposure series. This was done by adjusting the f stop from a 5.6.0 normal to a 2.8.0 for the overexposure, and an 11.0 for the underexposure. This is necessary because the dynamic range of the chart on a single exposure is not a challenge to a modern capture system, so more range through adjusted exposures must be performed for data at the extremes. Also, it is necessary to color correct the unexposed chart to match the normal exposure in the determination of noise, because when an attempt is made to recover information crushed into the shadows, the noise floor will rise with the recovered detail, giving an amplified area to sample the noise.

TECHNICAL PROJECT - DATA



❖ The 11223 chart contains a wide variety of visible spatial detail that can simultaneously provide a qualitative measurement of sharpness with the ability to generate a quantitative descriptor also, through the use of the Imatest processing software. The software generates data points by determining the modulation about the slanted line by spatial frequency. This software will also compensate for image processing based sharpeners utilized in the camera's on-board processing.

TECHNICAL PROJECT - DATA



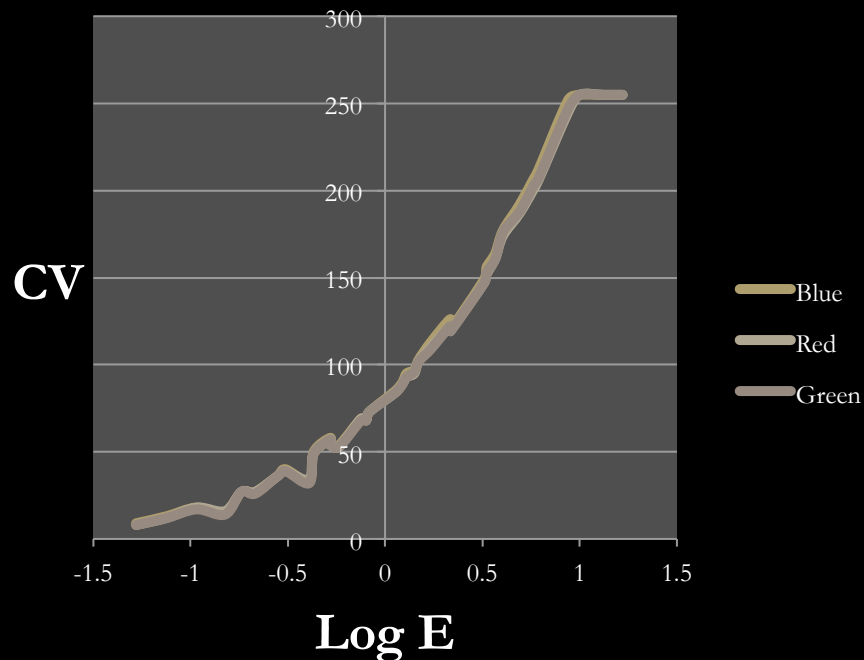
- ❖ Once the charts were captured, respective data for color and tone were sampled from the Color Checker and OECF patches with a 101x101 pixel Adobe Photoshop area color sampler. A custom IDL script was used to take a sampling area for the noise calculations. And lastly, Imatest processing software was used to derive the slanted edge MTFs for the evaluation of each system's sharpness.

TECHNICAL PROJECT – DATA ERROR

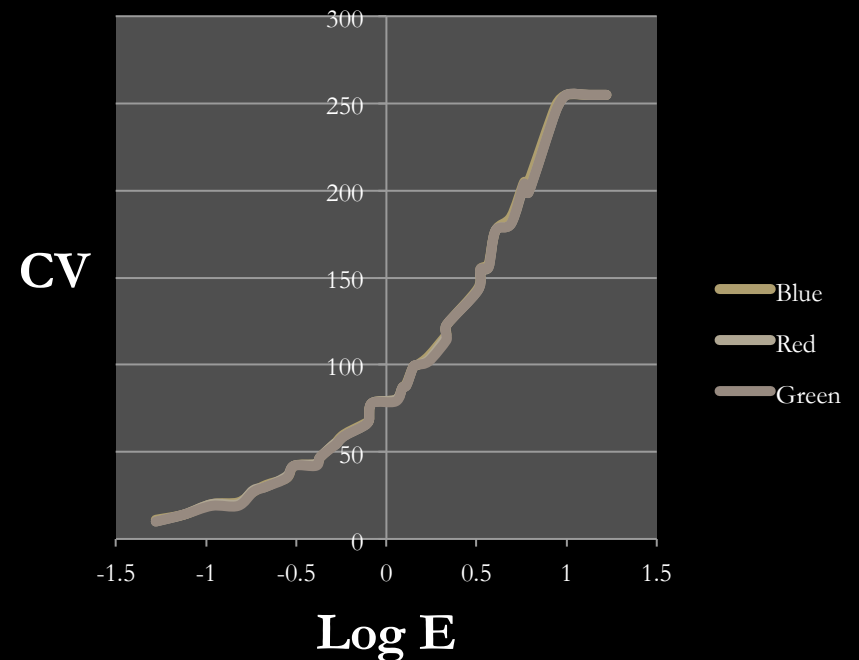
- ❖ Before the results are shown, it is important to realize the potential for error at any point of this process.
 - The f# ring on the HVX is not a locking ring, and can slip anywhere from a half to eighth stop and still register as the rounded f# on the HVX LCD screen! As much accuracy as possible was attempted, and this was accommodated for in the fitting of the CVlogE curve.
 - When the lens is focused at infinity, the light collection solid angle differs from when the lens is focused at scene content. Attempting to have every chart in focus was the goal, so that this variance was minimized.
 - Due to the duration of time the lights were running, there could have been a slight decay in the illumination from the bulb, or the bulbs may not have been allowed to warm to the proper state before shooting, and were not as bright as they could have potentially been.
 - Since preset white balance was not used in an attempt to provide balanced tone data, there could have been a variation in the white balance in each attempt. This was minimized by balancing on a target area for each attempt.
 - HVX#6 fell victim to a misbalance, and had an orange hue to all charts shot. Normally, this data would have to have been thrown out or reshot, but due to the quality teaching opportunity that white balancing in post has a tone consequence, it remained in. Keep this in mind when interpreting any data present from HVX6, besides sharpness.
 - For the color calculations, Photoshop's color management and $L^*a^*b^*$ calculation were trusted as valid, which may not be the case, requiring further investigation. It is at least known that the Photoshop $L^*a^*b^*$ s offered only have integer precision.

TECHNICAL PROJECT – DYNAMIC RANGE RESULTS

HVX 1

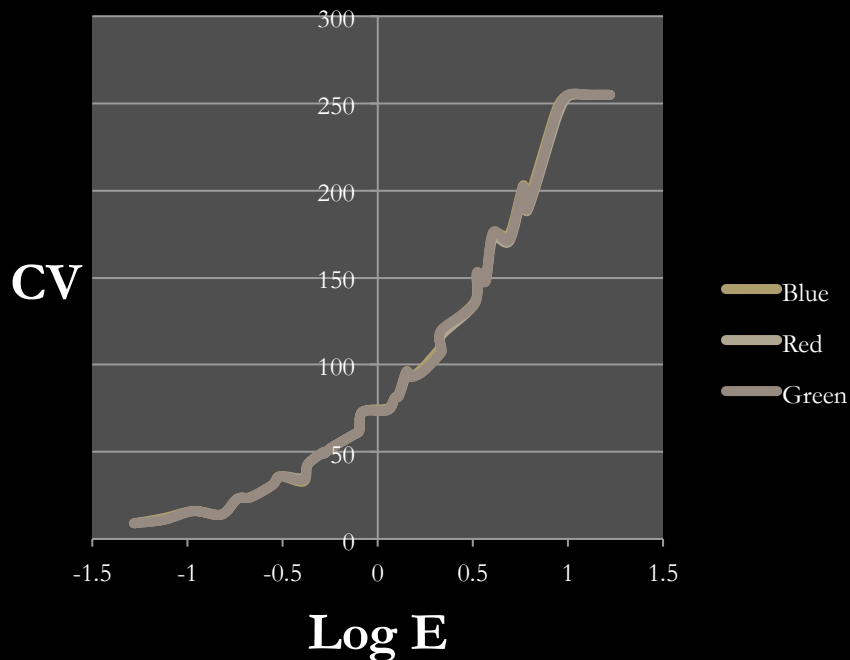


HVX 2

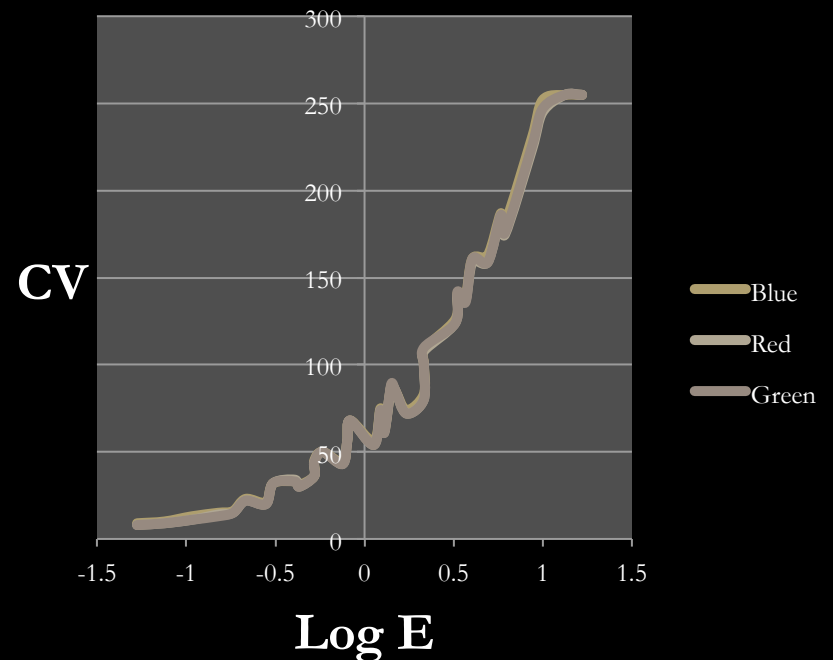


TECHNICAL PROJECT – DYNAMIC RANGE RESULTS

HVX 3

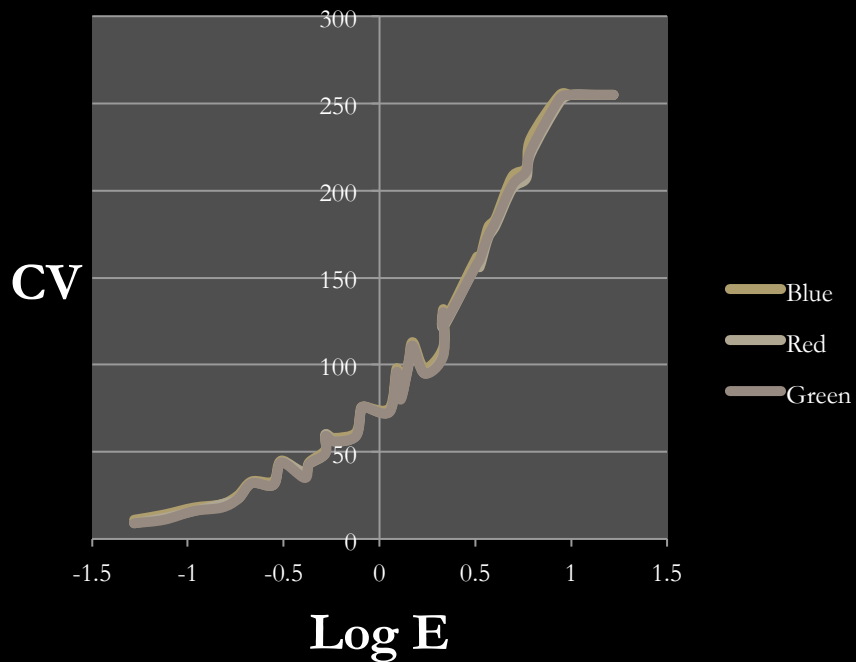


HVX 4

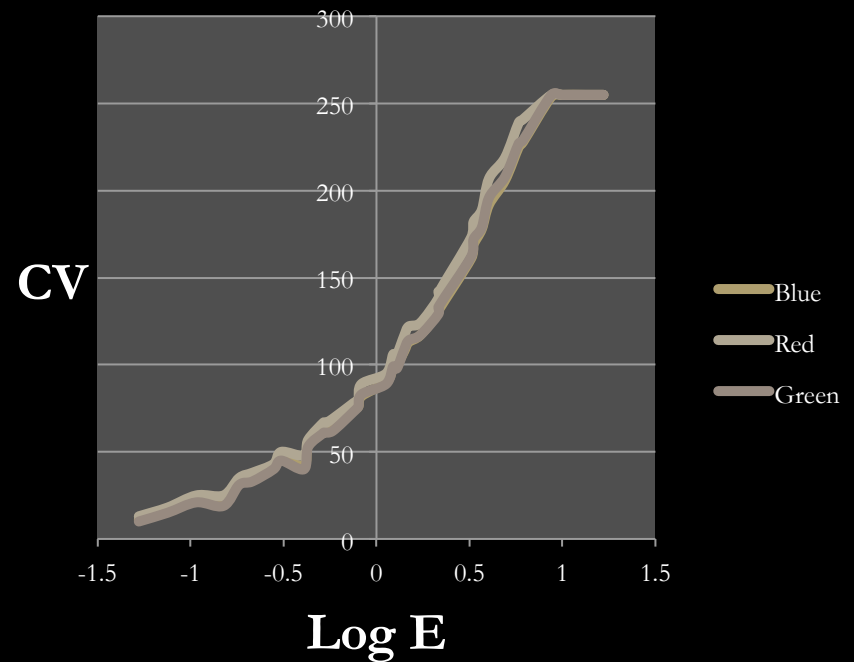


TECHNICAL PROJECT – DYNAMIC RANGE RESULTS

HVX 5

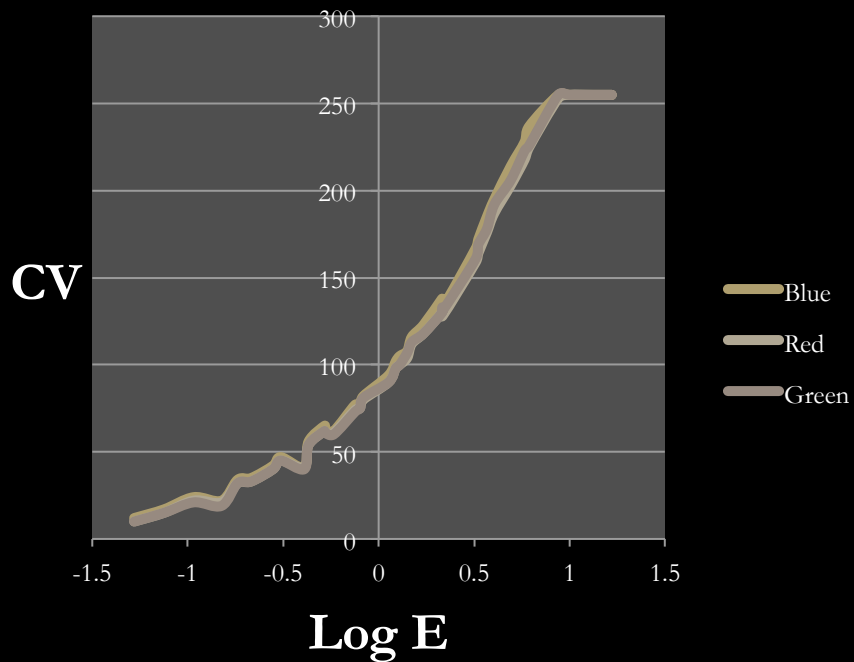


HVX 6

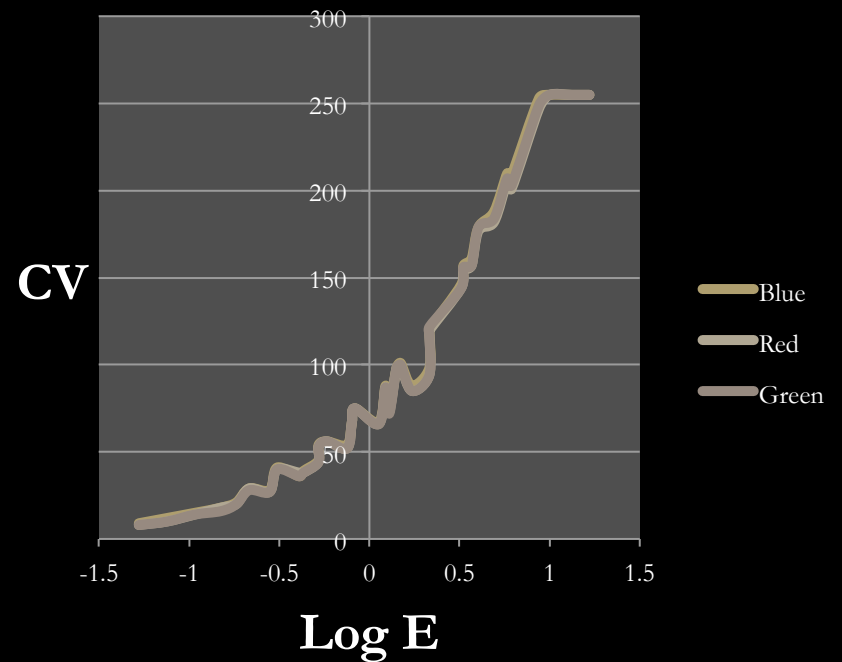


TECHNICAL PROJECT – DYNAMIC RANGE RESULTS

HVX 7



HVX 8



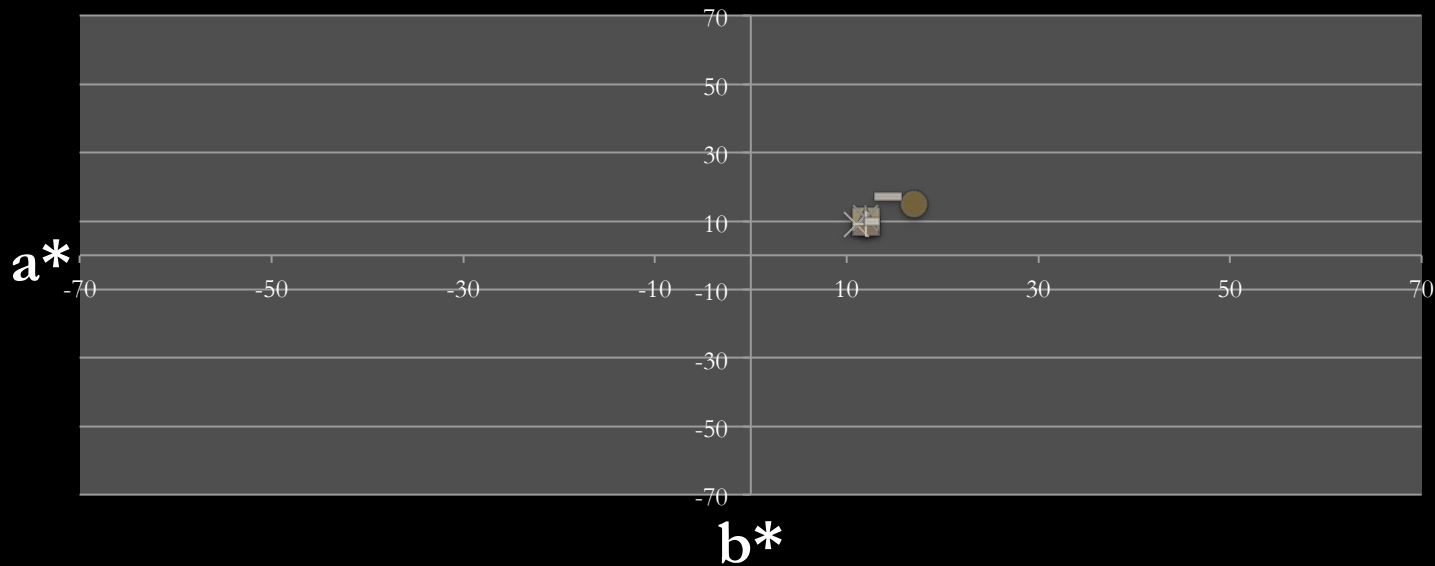
TECHNICAL PROJECT – DYNAMIC RANGE RESULTS

- ❖ These values were compensated with a $-.13 \log E$ for the normal, and a $-.3 \log E$ for the +2 OECF. This was done to accommodate for curve misalignment due to the slipping f ring and the fact that $f\#=11$ is not a true whole stop.
- ❖ $\log E$ for the x-axis was calculated by the formula $\log E = \log_{10}(.65 * L / f\#^2)$, which is the relationship of scene luminance to image plane irradiance, taking into account system transmission (.65) and aperture size ($f\#$), and also logged for perceptual relevance.
- ❖ As can be seen, there is small variation in the systems, with a few cameras performing worse than the rest. HVX 6 and 7 were close in the best performance, followed by 1 and 2. HVXs 5, 8, and 3 had some noisiness and faster clipping, but not as bad as HVX 4, which was by far the worst.

TECHNICAL PROJECT – COLOR RESULTS

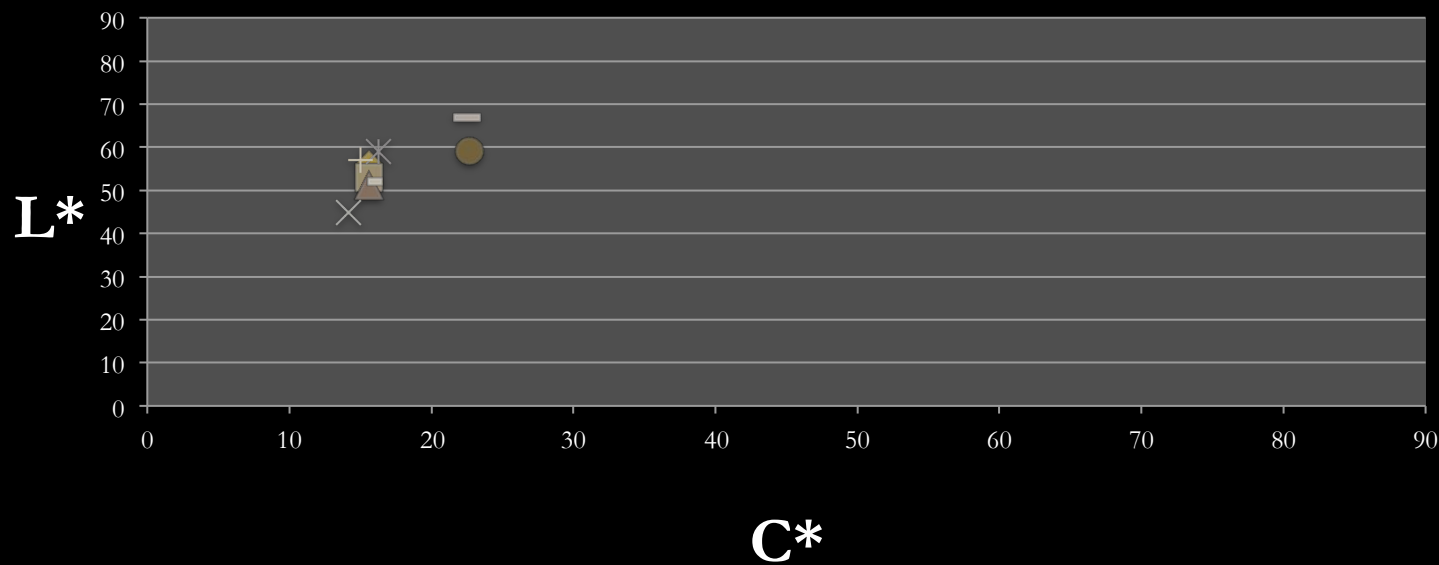
- ❖ 36 plots, 2 for each of the MacBeth chart patches were the resulting data. Due to redundancy, only select patches will be shown for discussion. The patches chosen were done so because of their L*C* characteristics. (One high lightness and high chroma, one high lightness and low chroma, etc.)
- ❖ Here, the HVX 6 white balance error shows that even after careful correction back to neutrality, the tone shift of your scene content will still be distorted and irreconcilable.
- ❖ A sample human observer based on the CIE 1931 standard observer was also modeled in the data, and this is to draw a comparison between how a camera witnesses color as to how we see it. The captured values are not meant to be close to this human data, but it is here simply as an indicator as to how reality is distorted by the system.

Light Skin



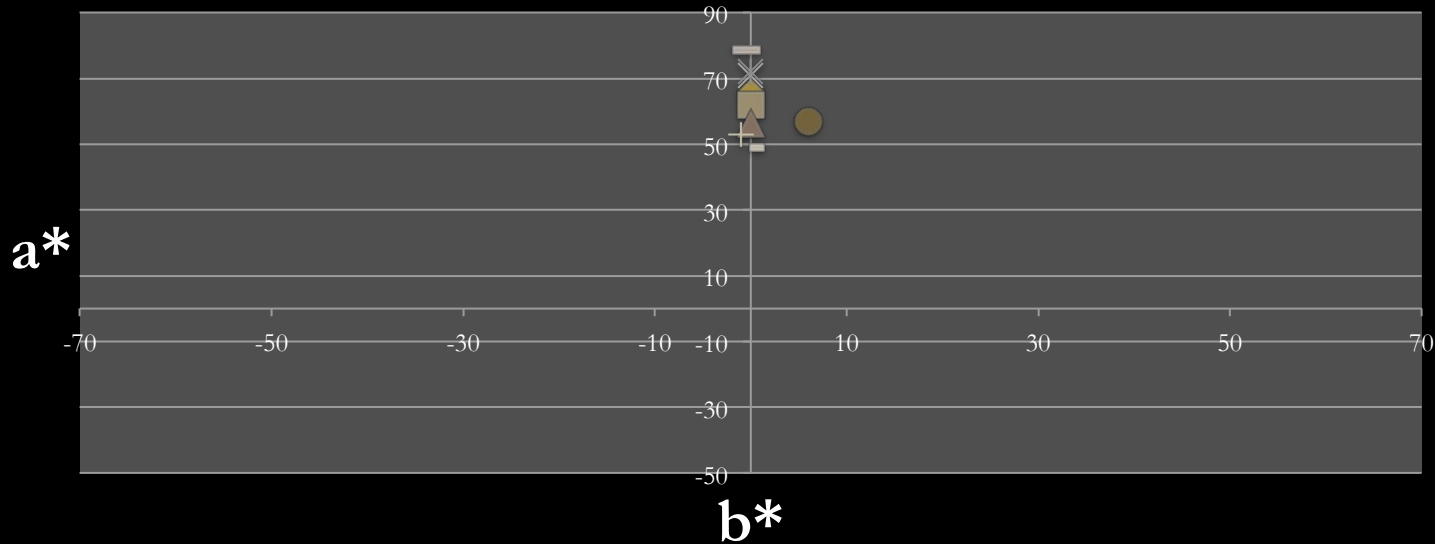
- ◆ HVX1
- HVX2
- ▲ HVX3
- × HVX4
- ✱ HVX5
- HVX6
- + HVX7
- ▣ HVX8
- Human Observer

Light Skin



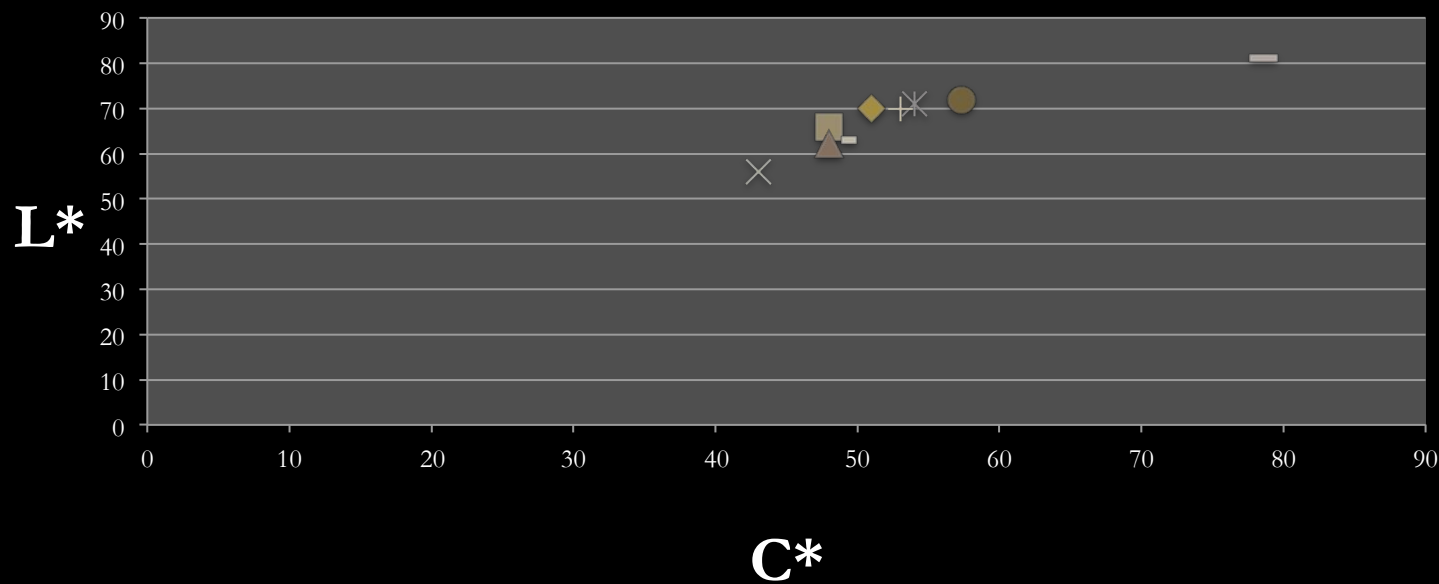
- ◆ HVX1
- HVX2
- ▲ HVX3
- × HVX4
- ✱ HVX5
- HVX6
- + HVX7
- ▣ HVX8
- Human Observer

Yellow



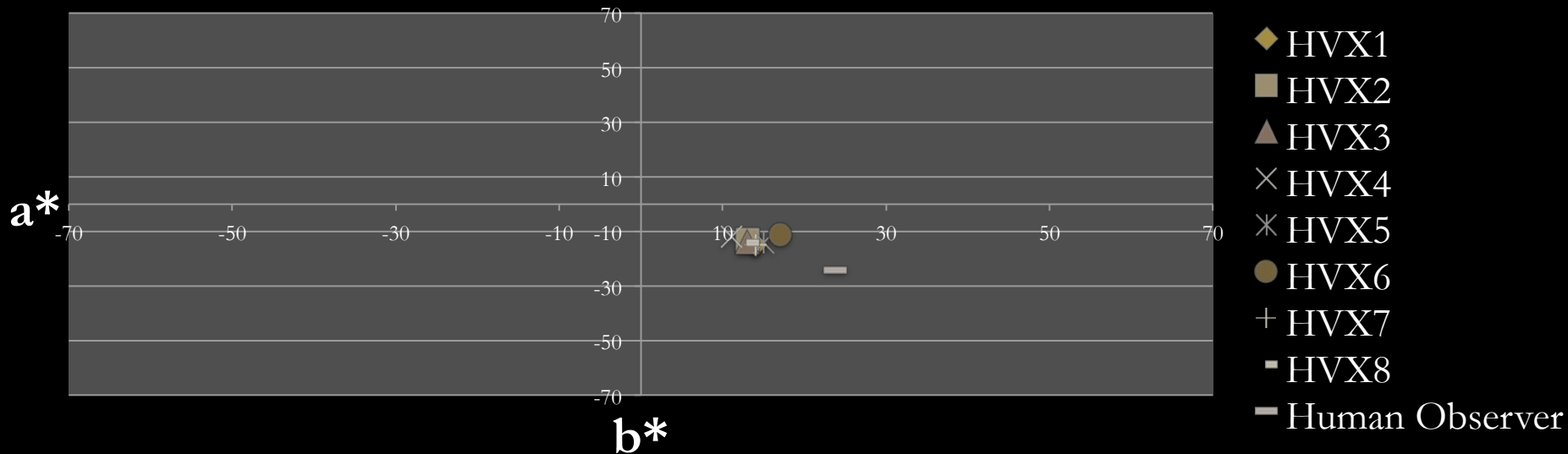
- ◆ HVX1
- HVX2
- ▲ HVX3
- × HVX4
- * HVX5
- HVX6
- + HVX7
- HVX8
- Human Observer

Yellow

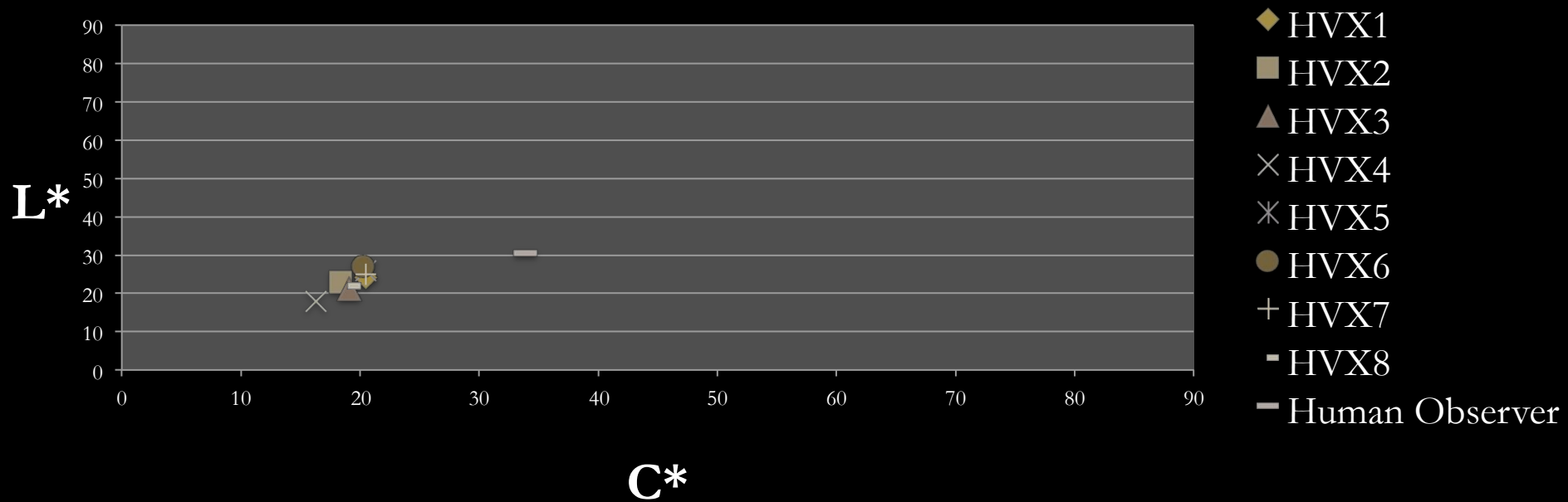


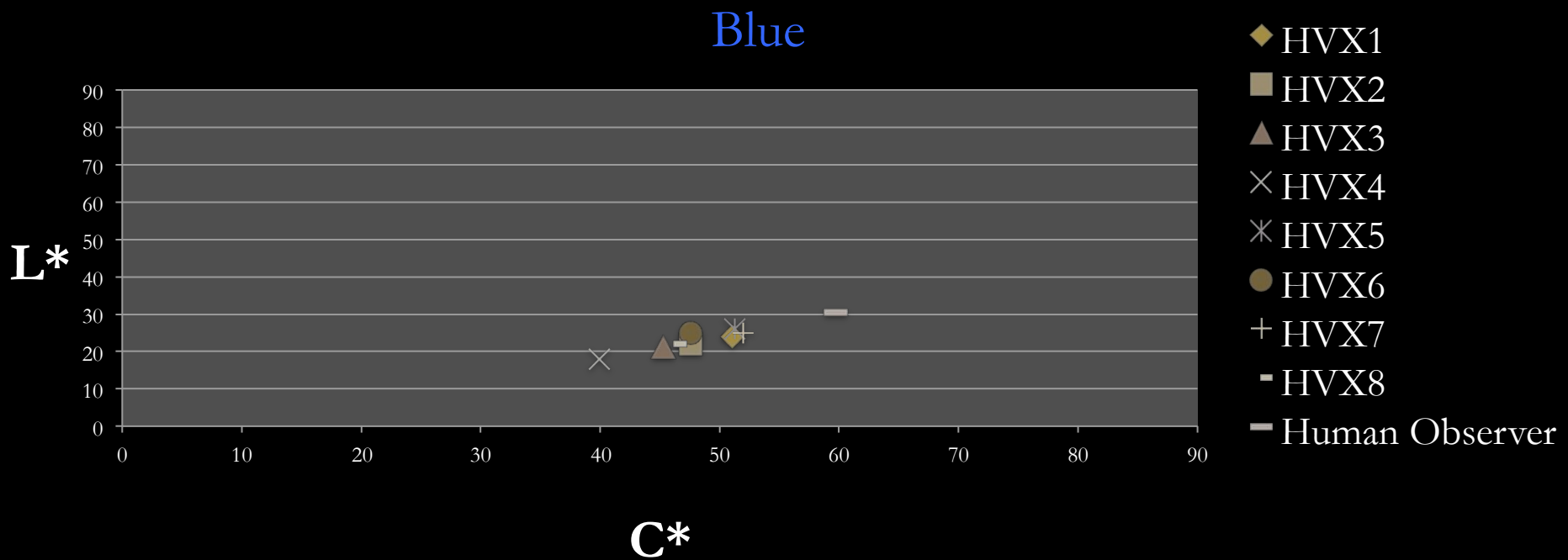
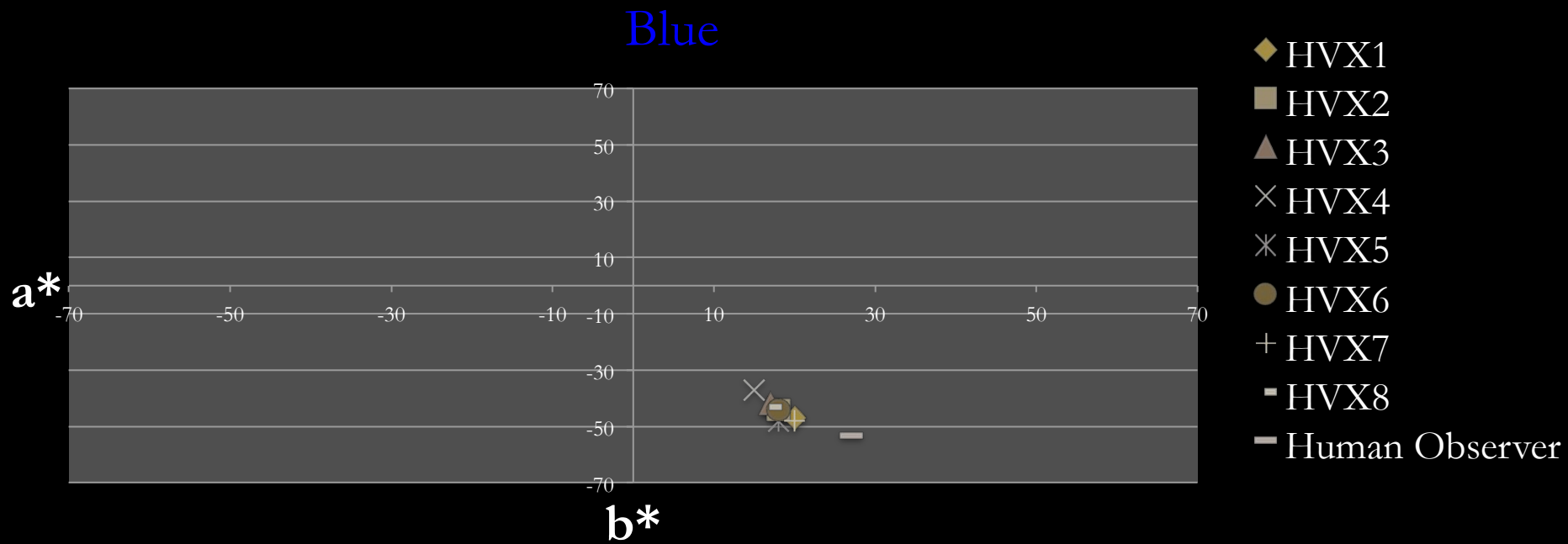
- ◆ HVX1
- HVX2
- ▲ HVX3
- × HVX4
- * HVX5
- HVX6
- + HVX7
- HVX8
- Human Observer

Purple



Purple





TECHNICAL PROJECT – COLOR RESULTS

- ❖ In the skin tones especially, it can be seen how large of a consequence there is when skin is not properly exposed. There is a significant noticeable difference here that will be explored in the final version of this document.
- ❖ From the data, it can be seen once again that HVX 4 is the weakest performer, having the dullest sensor that cannot properly achieve acceptable lightness and colorfulness. HVXs 3 and 8 were the next worse, followed by 2. Past that, the cameras remained around a somewhat stable average in their color performance.

TECHNICAL PROJECT – NOISE RESULTS

- ❖ There are three different types of noise collapsed into two categories, dark and read noise that make up fixed pattern noise, and photonic noise that makes up the temporal noise. These two noise categories can be combined formulaically to achieve a figure that is representative of the total system noise.
- ❖ The blue noise will be higher than the other two channels because blue does not have as much significance in lightness weighting as compared to the other two channels. Since 90% of lightness information is in the red and green and only 10% is in the blue, it is much less crucial to have optimum blue noise performance than red or green.

TECHNICAL PROJECT – NOISE RESULTS

| Noise | 100x100 Sample | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--------|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----|-----------|
| | | TotalRGBn | 2.4386344 | 2.4241497 | 2.4751827 | 4.0025208 | | 2.4434883 | | |
| HVX200 | Left Chart side | oise | 33 | 67 | 33 | 33 | 2.8473921 | 2.3662246 | 33 | 3.3848714 |

| | 1 | | | 2 | | | 3 | | | 4 | | |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | R | G | B | R | G | B | R | G | B | R | G | B |
| | | 0.6122392 | 0.9101541 | 0.6475116 | 0.5858308 | 0.7293954 | 0.5879203 | 0.5756673 | 0.7323575 | 0.8518402 | 0.8054935 | |
| Fixed | 0.6544939 | | 3 | 4 | 2 | 2 | 9 | 5 | 1 | 4 | 2 | 50.9213549 |
| Temporal | 2.0958303 | 2.0441172 | 2.8443507 | 2.2364891 | 2.1161864 | 2.6497772 | 2.2547489 | 2.2393251 | 2.6851949 | 3.6444942 | 3.5771663 | 4.5048516 |
| Total | 2.1956472 | 2.1338352 | 2.9864211 | 2.3283374 | 2.1957784 | 2.7483335 | 2.3301382 | 2.3121353 | 2.7832749 | 3.7427223 | 3.6667341 | 4.5981064 |

| | 5 | | | 6 | | | 7 | | | 8 | | |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | R | G | B | R | G | B | R | G | B | R | G | B |
| | 0.6644726 | 0.6439839 | 0.9789235 | 0.9308228 | 0.6263446 | 0.6568951 | 0.6288622 | 0.6257751 | 0.8602002 | 0.7732746 | 0.7537354 | |
| Fixed | 3 | 4 | 1 | 2 | 1 | 8 | 5 | 8 | 9 | 7 | 8 | 1.130716 |
| Temporal | 2.4562218 | 2.4618089 | 3.3113502 | 2.4334401 | 2.2200373 | 2.0855756 | 2.0797328 | 2.2188084 | 2.7195721 | 3.0092642 | 3.0173113 | 3.7717146 |
| Total | 2.5445136 | 2.5446453 | 3.4530177 | 2.6053909 | 2.3067018 | 2.1865811 | 2.1727302 | 2.3053644 | 2.8523704 | 3.1070282 | 3.1100297 | 3.9375563 |

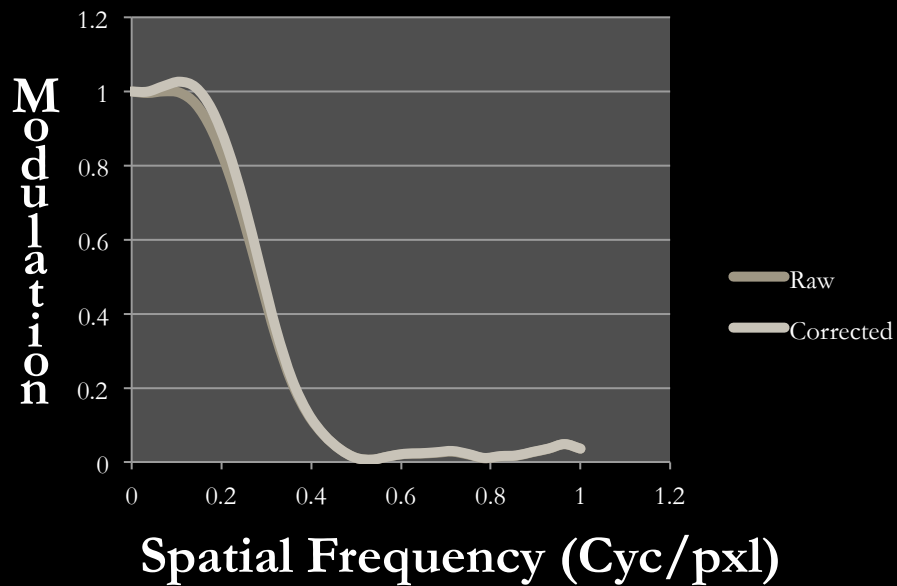
TECHNICAL PROJECT – NOISE RESULTS

❖ As can be seen once again, is HVX 4's lacking performance. It has a much noisier picture than the rest of the cameras, with HVX 8 a small way behind it. Besides #5, the rest of the cameras have very similar noise behavior. At this point it is same to say there has been a large amount of wear on the sensor of HVXs 4 and 8, moreso 4 than 8.

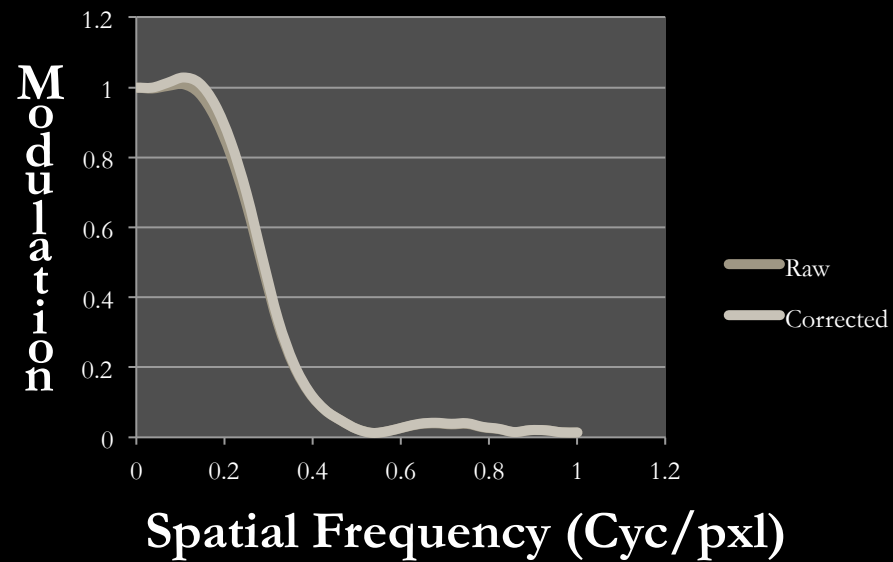
TECHNICAL PROJECT – SHARPNESS RESULTS

❖ Due to an unknown sharpening filter in HVXs 5-8, it was not advisable that the raw data be plotted by itself. The Imatest software was used in its capacity to null any post image processing, so that all cameras could be compared in an equal light. The results for sharpness difference were much less conclusive than the other tests, wherein this test, all the systems performed about the same within a small tolerance.

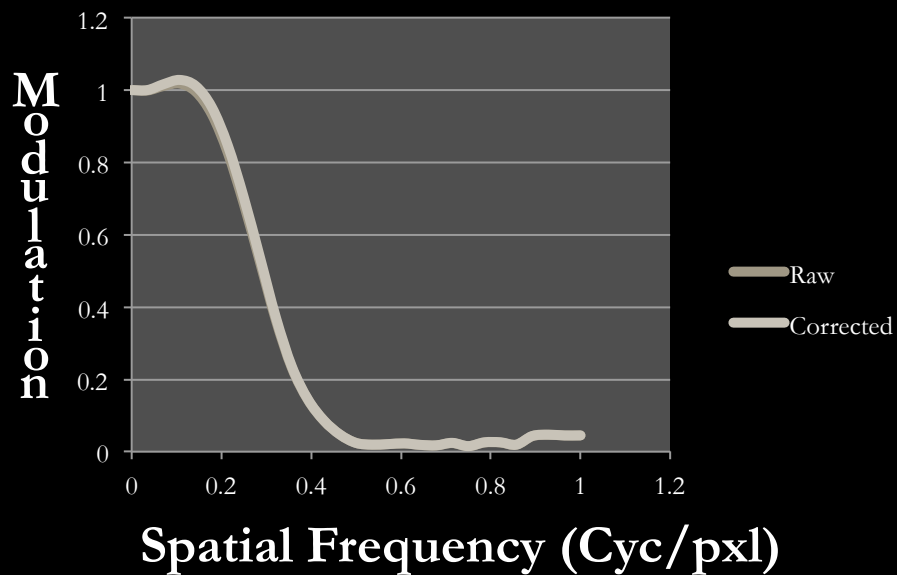
HVX #1



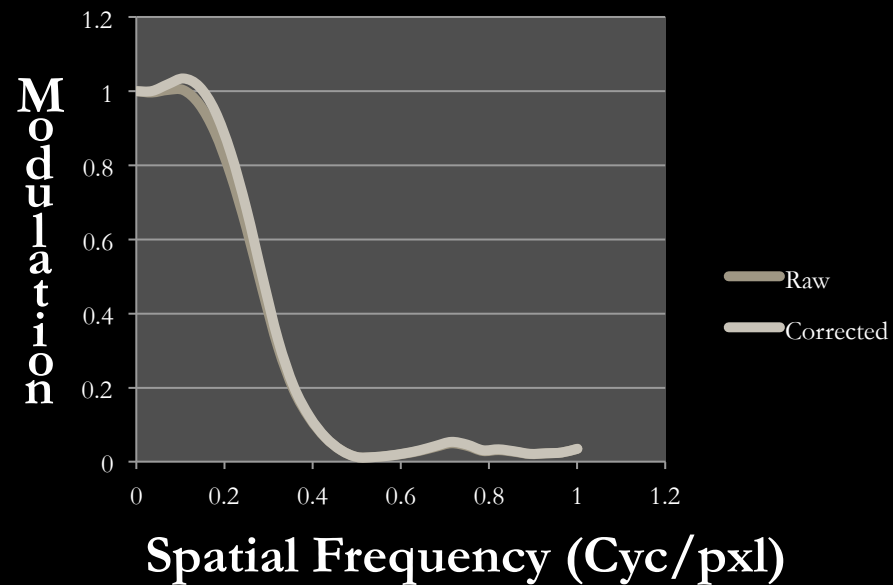
HVX #2



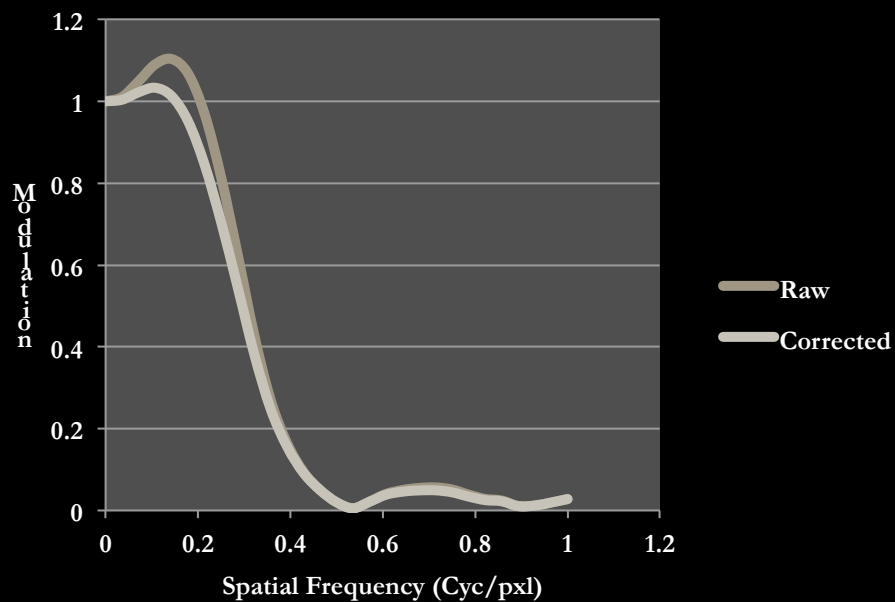
HVX #3



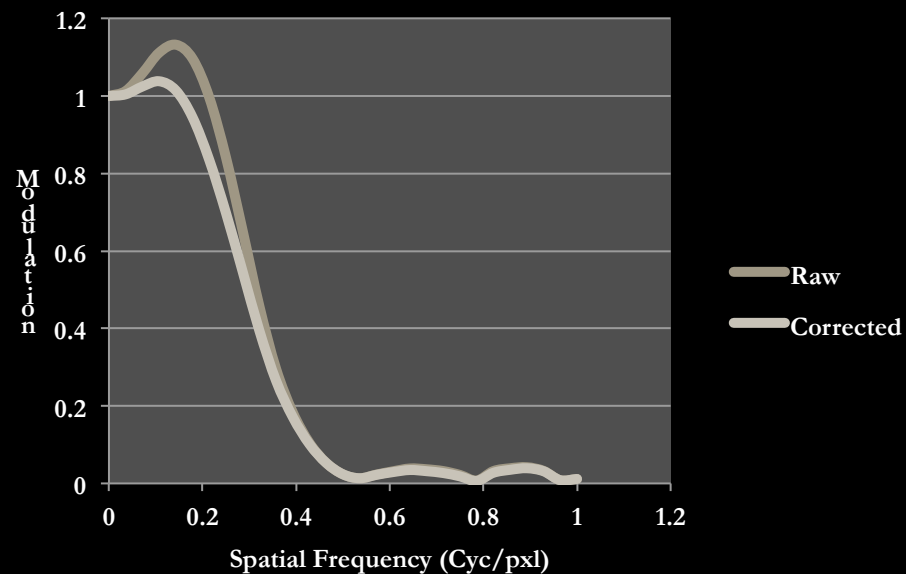
HVX #4



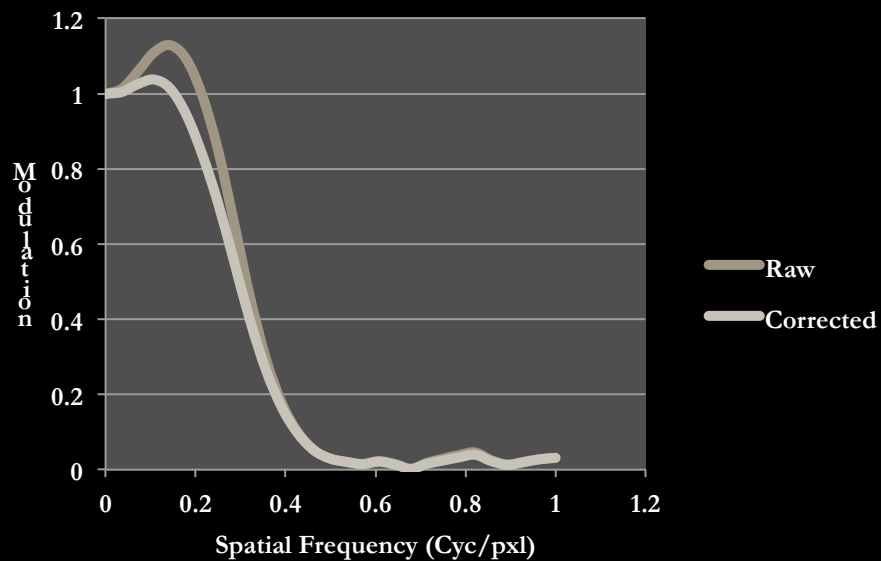
HVX #5



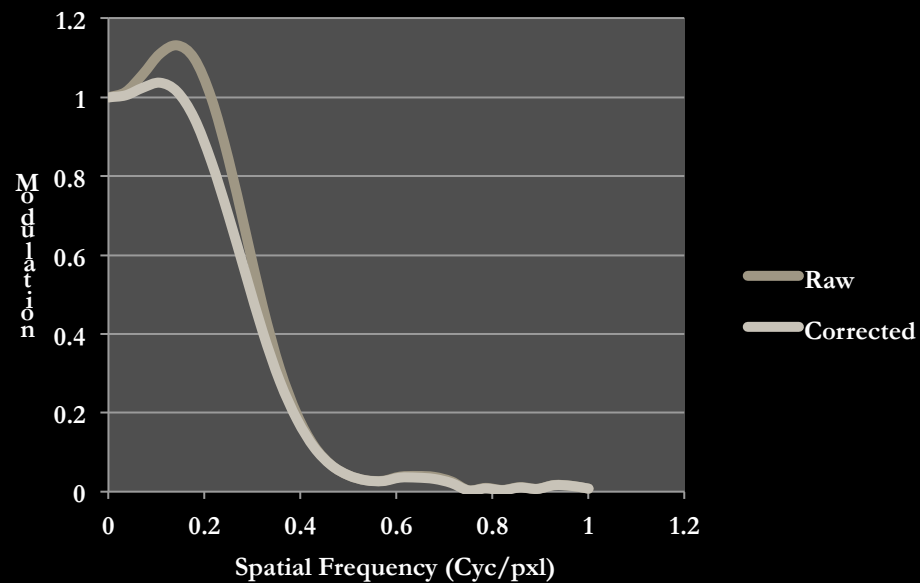
HVX #6



HVX #7



HVX #8



TECHNICAL PROJECT – SHARPNESS RESULTS

❖ As all gain functions to my knowledge were nulled during the shooting of these charts, I was surprised to find out that there was a sharpening filter employed in each of the newest four HVXs. These last four systems apparently are capable of achieving better sharpness because of their age, but this sharpening may also introduce artifacts. There is little to be said about any differences in sharpness across each of the eight cameras.

TECHNICAL PROJECT - OVERALL

- ❖ To the question of “**are all of these cameras within an acceptable tolerance range in terms of behavior?**”, I have the answer of **no, they are not.**
- ❖ There are a few systems (HVX4, HVX8) that are not performing nearly as well as the other cameras. The need to create a 3DLUT to match these cameras to one another may arise in the future once they become even more different. But until then, it is advised to be careful and consistent in which one of these cameras you capture your material on, because there is a big change in more than one image characteristic if an inferior camera is used alongside one that is in good shape.
- ❖ Developing these transforms could be another chapter to the work done with the HVXs.

DUTIES OF A COLORIST

❖ In pre-production:

- Aiding towards the overall feel of the aesthetic that the director and director of photography have envisioned.
- This stage is important for making sure that the choice of equipment (camera, film, lights) is optimal for whatever the creative implications of the production are.
- Grade any test footage with the directors, decide what content/processing can possibly be problematic. Testing here is highly advantageous for getting better results for creative looks, and special grades like day for night.
- Understanding the location to minimize any visual hazards. (Mixed lighting from fluorescents or daylight, for example.)

DUTIES OF A COLORIST

❖ On set:

- Being aware of possible complications and working around them. Almost synonymous with a VFX supervisor in this capacity. In this respect, the colorist is another set of eyes image-wise next to the director of photography.
- The image will ideally have a proper workable dynamic range without blown highlights or lost shadows, undistorted color information, proper focus, and a manageable noise floor.
- With this comes ensuring the best possible white balance for the scene. When mixed lighting becomes inevitable, this is not so simple.

DUTIES OF A COLORIST

❖ In post:

- Deciding what needs a reshoot due to poor quality. (This should be done immediately)
- Calibration of the working environment to exhibition environment. (Workstation display calibration, exhibition device calibration, proper work around of any distortions in the color management system)
- Correction and stylization! The height of collaboration with the directors is in the grading process, as now they can be making decisions on the grades with the colorist at the workstation.

ABOVE THE FLESH PRE

- ❖ Doppelganger has the intention of scene by scene stylizing rather than an overall look. Romeal Hogan nor Reed Nisson the DP had a true idea for an aesthetic during production, so it was all about leaving our options open by not restricting the feel of the frame with heavy handed lighting or other visual aggression. With neutral, middle of the road looks for each scene, I am able to transform them into anything they need to be, without having distorted information from the start.
- ❖ The amount of pre-production from my position as colorist was very light because Romeal seemed that he was very focused on his story and the production itself that the energy we would invest at this stage would distract from other aspects of preperation, which also needed to be adressed.
- ❖ Romeal knew he was going to shoot on the 5D at this stage, which I wish I had investigated further into shooting profiles. There is a custom user shooting profile that can be loaded into the 5D, one of which is the “super-flat” low contrast profile, which does its best to imitate low contrast capture. This type of capture is **ideal** for when a piece is going to have a large amount of work done in post. Unfortunately, at the time, I was unaware of this shooting profile.

ABOVE THE FLESH SET

- ❖ I began on Romeal's movie as expected, starting as an AC/auxiliary crew member, and was always watching the playback and frame-up from every shot that was taken. It was my job to make sure light didn't leak into our scene area from any errant sources, so I was always equipped with a roll of garbage bags to make the fix. I also had the unofficial role of dumping the cards from the camera, and giving a quick look as the takes came out to determine if anything needed a reshoot in terms of aesthetic.
- ❖ On Romeal's movie I took over the role of director of photography in the absence of Reed, who was also committed to filming Noelle Evans' thesis. This was a fun and interesting experience, as I somewhat controlled my destiny in terms of what I would be able to create from the footage we were shooting. Imitating the lighting and framing style of Mr. Nisson was not an easy task, but I did my best to make my hand behind the camera invisible.
- ❖ Romeal's piece contained some very interesting content, some of which being day for night shots that we will see in a moment, as well as masked characters undergoing metamorphic transformations. In the correction process, we will have many tools to accentuate such action within the frame.

ABOVE THE FLESH POST

❖ As was said before, the majority of the decision making for Romeal's footage is made in our grading sessions together. I will approach a shot with a strong intention for a look, overshooting the mark in terms of dramatics, and having Romeal tell me how strongly he wants it dialed back. The amount of times the shots have been re-adjusted in this fashion is pretty much split down the middle, in terms of him liking my original look, or wanting a slight variation.

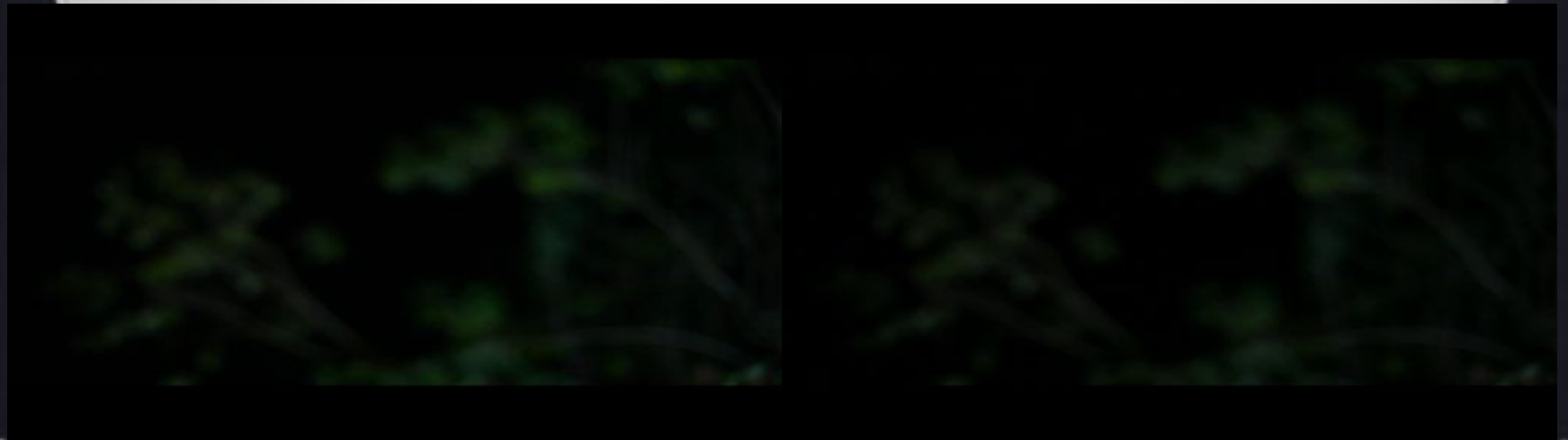
❖ Romeal has some interesting dynamics in his film, where he wants the mother and twin brother character saturated and lively, but wants the protagonist to look as though he is deathly ill. I achieved these effects through curves, tracking vignettes, and HSL keys to properly isolate Evan, Tyson, and Sheryl's skin in each shot, and to make the appropriate changes based on Romeal's intent. Content where HSL keying will be very useful is the transformations, where I can use keying to accentuate the ghastly appearance of Romeal's art direction, which will be a very strong contribution I can make to the feeling of his piece. A challenge will definitely be trying to conform shots of varying appearance from idyllic fields to dark interiors to the elements of suspense and terror that Romeal is trying to implement.

ABOVE THE FLESH POST





ABOVE THE FLESH POST



PILLS PRE

❖ Andrea also welcomed me onto her project without a great investment of what she wanted the role of correction to be in her piece. We decided that we would try to use higher contrast and more frantic and serious looking aesthetic in the beginning of the story, tracking with the progression of her main character Marco, leading to looks that are very idyllic and calmer, as Marco gains more control over himself.

❖ Andrea had decided to shoot 16mm color negative, which was exciting news for me, knowing that the best quality footage I could be working with in our workflow at SoFA was exactly this. My goal was to go to Kodak for at least one transfer session with Kyle just to oversee exactly what was done to the footage before its digitization, which did not turn out as I wanted, unfortunately. Each round of stocks came back beautifully as expected, thanks to DP Jordyn Ruth, but it would have been a quality educational experience to oversee the telecine session of footage I have vested interest in.

❖ Andrea also planned to shoot one of her scenes on a Canon 5D, but as this scene was meant to look different and jarring from the rest of the footage, there will be no worries at an attempt to fully integrate the two mediums together aesthetically.

PILLS SET

❖ Working with film is interesting because of the sensitivity, but the result will be a more rewarding picture. I trusted Jordyn (DP) to be doing her job very well from my initial assessment, so as long as grey cards were shot, I simply focused on potential light mixture problems. I watched every roll that came back with Andrea, and every roll looked optimally placed for exposure, which is great news to hear before even entering into the post-grading process.



PILLS POST

❖ There has been no grading done on Andrea's piece as of yet because she is still in the editing process as well as there were very little shots that needed attention. All the film footage looks great as raw, and proper reviews were made of the DSLR footage so that Andrea knew which shots were too overexposed, would not integrate well into the scene, and needed to be reshot.

❖ As soon as a few days from now, grading will begin on Andrea's piece, and we have great flexibility in how we want the pictures to appear because of the similar scene by scene, aesthetically neutral style that was the approach to filming.

PROFESSIONAL INDUSTRY VS. FILM SCHOOL

- In our current environment, we have limited control over our film workflow. We depend on Kodak and other labs to perform our processing and digitization. The educational value of being able to perform telecine transfers and scans here at RIT would be immense, but these devices are expensive. (A telecine could cost as much as 700,000\$!)
- We do not have a workflow for high resolution data capture or projection. This would require not only a digital cinema camera, but a data recorder, a designated station with proper cables, and a much more powerful color correction console than what we currently have. (But, implementation of this could come as early as next year!)
- The role of the colorist without such high end equipment becomes a lot different on set. With much higher quality scientific displays, it is the role of the colorist to calibrate the set displays, as well as using emulation LUTs to simulate the final look of the footage on the set displays as takes are captured. With higher quality set monitors, we could do the same, but again, displays with sophisticated controls for calibration are quite costly.

THANKS!

❖ Thank you to the audience for your attendance! I hope you enjoy the rest of the 2011 SoFA craft and script festival. Make sure you come to screenings to see my work on Romeal's and Andrea's films, as well as the rest of the finely crafted work from our program.

❖ Special thanks to: Ricardo Figueroa and David Long, for quality advising as always. Ben Bodner for assistance in the noise calculations. Aaron Gordon for assistance in the chart data collection. The cage for their cooperation. And many others I probably am failing to mention.

REFERENCES

❖ 3d ALEXA rig photograph -

http://lh5.ggpht.com/_-1LNYvMjNtQ/TRq6lagt4LI/AAAAAAAAABW2E/YcMNR25mXoo/photo%2023.jpg,

Christianfilmmakers.org, 2011

❖ HVX photograph - http://brandonwadevisuals.files.wordpress.com/2010/02/hvx200_new.jpg, Brandon Wade Visuals, 2011

❖ HVX200 gammas - Exploring the HVX200, Adam Wilt, September 20, 2006 - <http://www.dv.com/article/11394>