THE PLACE OF THE VIEWER'S EXPANSION IN OPTICAL SYSTEMS: THE USE OF TIME IN MEDIA AND ITS SPATIAL APPLICATIONS

by

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Abstract:

The real spaces we deal with everyday and the representations of them that we create all are mediated through the experience and reconstitution of them with memory and media, both of which are molded from our anatomy, psychology and experience. Visually, experience and representation conforms to the workings of our own vision through the eye and our perception of the sequence of images that it produces. Perspective is a trait of this type of vision that allows us to locate ourselves in our surroundings. It is enhanced by time but not assisted by the other senses. As a result, the simulation and manipulation of it are critical to the development and advancement of art and visual media up to the advent of photographic film and motion pictures. The 'Kino-eye' brought advancement to the process of seeing by providing a mechanical apparatus for the equal segmentation of vision and time. Sequential recording made time accessible, editing made it malleable, projecting it made it able to be reconstituted into new forms. The visual part of the camera bears little difference to the optics of the camera obscura and the eye.

This expands our perception of time beyond our position in it. Filmed motion made the linearity, continuity, duration and singularity of time and sequence variable. The structure of film makes many provisions for this new way of interpreting time and we have easily accepted and adapted to it. These new abilities are explored in film montage, chronophotography and

photodynanism. There has not been an equal expansion on our view of space and our position in it. The camera allows us to go to many places and see many things, but these processes are a derivative of movement. It does not allow us to be in many places or see things in a way greater than we can already. In this way, the camera gives us an ability to expand or modify our temporal experiences of the image sequence. The camera has not afforded us an equal expansion of our understanding of the spatial image and experience in a similar way. We experience an expansion of space not in itself but through time and sequence. Image capture does not necessitate an exploration beyond the optical systems of the camera obscura and the eye.

Perspective is a format, bias and affordance in media and actual experience. It is perhaps one of our most basic affordances; it is the system by which we can relate our position, distance and scale to our environment. In trying to explore space and geometry as far as we have explored time in film, we must consider the internal processes (and distortions) we use to make sense of our experience in space, and the apparatus that we have to simulate it. Time and sequence let us create and reconstitute the image and motion of an object or self. The same sequence can be used to expand our experience of the spatial properties.

The research done has resulted in a new process to expand the place of viewer through a new idea for the process of storing images. This is an additive process that aims to expand and question our perception. This is in contrast to the process of editing and montage that is a selective process to focus our experience. Key to this new system is using devices normally dedicated to the capture of chronographic information to instead capture the depth of a scene. Because of this, the process will be just as automated a system as moving film. The reconstitution and projection of the image will be a remapping of this visual information onto a new system. New ways of seeing can be found through researching this new system of alternative optics and perspective.

1. Introduction

This is to be a paper concerning vision and apparatus, the camera obscura is the point of origin for this discussion. Our system of vision shares many common functions with camera obscura's presentation of images. This analogy has been established, and there is not a pressing need to verify it again. My research concentrates, then, on how we understand the collected actions of this system as perspective. Let's consider our perception of the camera obscura itself. Our *recognition* of the camera obscura's reception and projection of light to image comes from our processing of the projected image on its screen. We receive this image after seeing it through our eyes which function as a similar optical system, projecting that same light onto the retina; a second screen — all that we see is a projected image. Though there are many routes to explore in the realm of psychology in vision that happens after the retina, but as I am concerned with apparatus and optics, I will focus on this primary image, and the systems that it allows for.

As these systems of projection are similar and constant, there are certain expectations of visual representation that we hold to conform to certain rules. Since those rules apply to our mediums and our firsthand experiences, they become a somewhat immutable factor to the way that our subjective perception works. One of most telling facts about this system is the focal point. Constrained within the aperture of the camera obscura, the focal point indicates the subject and the viewer. More importantly, the convergence of light that defines it indicates a position of the view, one that is a point in space, virtually zero-dimensional. This indicates the limits, or definition, of the system only through which we can see.

In this paper, and in the accompanying project, I have explored these limits, and why there may not be ample opportunity – or a perceived need – to exceed or modify them. In the comparison to similar limits or perceived deficiencies which have been notably re-purposed into functions and aesthetics I have worked towards – and have completed – a working project which functions on a malleable system of perspective. In this new systems function, the location of the viewer is expanded dimensionally beyond the single point of the aperture. This expansion is both a result of the process and the catalyst for the process and the necessary prerequisite for its function. Most importantly, the system is designed to simulate an optical process, rather than a synthetic one. In the process of research for developing the ideas for this system, it is important to consider the attributes of vision and perspective that it is intended to address, as well as the questions through which I approached them.

1.1 The Optical Process and its Limits

What would happen if you were to try and expand that view of the camera obscura beyond its standard design? A second aperture would provide a second image. This second image would be affected by the differences in the geometry of the image resulting from this different viewpoint. The differences would be weighted more severely on the objects closest to the viewer. Measuring those distances would give you an idea of the range of the image you see and the relationship of objects to each other in scale and proximity. This shows the effects of a third, measurable dimension — depth. What we have created in this process is stereoscopic vision. What we have not accomplished is the expansion of the viewpoint. We have only found an application for the comparison of two independent viewpoints.

Expansion from this single point view is limited by the optical function of what we consider to be 'vision'. To widen the aperture in diameter or along a single axis will result in a multitude of images projected onto a single shared surface.[1] All the light traveling from that surface to the eye is condensed to the eye's single viewpoint. Compounded together, we cannot separate any single projection on that surface. This is why we need to isolate it prior to projection, which is the hindrance to expanding that viewpoint. Widening it only confuses[2] all of the imagery that was introduced to the system. This, or at least our understanding of it is the phenomenon of optical focus, or lack thereof. We correct this phenomenon or avoid it outright since is undesirable for our usual purposes as it hiders legibility.

If not corrected for by constricting the aperture, and bringing us back to where we started, we can find a new point for focus for this wider aperture. The projection surface of the obscura can be pulled back from the aperture. This would lead again to a single, point sized view of the subject, but one different than the original one. In doing so, we discover the focal plane, and an analog for selective focus. Now we are back to a similar ratio of sizes for the frame, subject and aperture. As well, the

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[1] William de Wiveleslie Abney, *A Treatise on Photography (Longmans, Green and Co., 1881), 208*

[2] Note: Confuse; in the literal sense of *to fuse together*

distance to the aperture from subject and projection surface is close to its original (focused) ratio. The subject is the same as the first time, but we see a change in its appearance. As usual, objects closer to the camera appear larger in the projected image. But now, this distortion is differently weighted. This is because the steps we took to re-focus our image brought us to recreate another photographic property: focal length and the compression of depth that is a result of its use.

We can summarize the reason for this, initially, by recognizing two reasons why objects appear larger or smaller. The first reason is that they actually are different sizes. The second is that they take up more radians in lens' (or aperture's) field of view. This translates to a greater area affected when the radial system is projected, or translated, to a Cartesian plane — such as a screen. It is because of this translation that we hold two presumptions as to how seeing works. The first is that things become larger as they get closer to the viewer, the second is that closer objects obscure the ones behind them. Both of these observations of the subject indicate back the singular point of existence for the viewer. This would also imply that those properties of scale and the obscuring of the background could be modified if that point could be expanded to a path. The place of the viewer would be defined by the extent to which the observer's sight can envelop the subject, and not just the line of sight that the observer has in relation to it. As mentioned, this is the goal and presumption of the later part of this research.

1.2 Problems, or Properties

Since the optical properties that we were able to find analogues for in the camera obscura are so basic, it is not in itself impressive that we were able to find analogues for them. The importance is in revealing why these properties are so fundamental. As we tried to expand the place of the viewer for a single instance in simple steps we found the limits of what is, for us, legible vision. We already innately know that situations too dark or too bright for us to see are experienced as low signal to noise. Experienced first hand the extremes of light levels express themselves as hard limits on our own physiological capabilities. Extreme brightness can even be felt as physical pain. When darkness follows images it shows our limits differently, as the phenomena of afterimage, which shows a subjective side of our vision. The deficiencies of the medium make it no longer transparent, and we are experiencing our process of seeing. We are aware of the limits of brightness and darkness, and have found ways to work around them. The limits we see in the camera obscura don't express themselves as problems, but properties. We deal with them as intrinsic parts of viewing; they are the ways in which we see. As such, an alternative is not immediately apparent or actively sought as there is little to necessitate a need for one.

2. The Kino Eye and the Stored Image

This system of optics, being as it is points us away from a need to search for ways to deal with a multitude of perspective and an expansion of viewer. Perhaps this is because the first step towards that goal leads us to a defocused image. It can be assumed that clarity and legibility are desired in our optical systems. This might suggest that the smallest of apertures would be those most desired for all applications. The reality of the situation brings the consideration that a smaller aperture brings with it a decreased transmission of light from the subject to the medium.

This attenuation needs to be compensated for in photography through a 'faster' film, or a longer exposure time. Cinematography has adapted a general acceptable standard of 24 frames-per-second. As there is not much variance in frame-rate or shutter angle smaller apertures are usually compensated for through the use of faster films and much additional lighting. In still photography, there is not always the same pressing need for the next frame, so longer exposures are possible and common. This leads to a departure from the model of the eye or camera obscura. We perceive through the eye immediately, and we perceive the image from the camera obscura immediately. But, because the film negative is exposed for duration of time it is subject to a *duration* of events. Any substantial movement in the duration of the exposure, whether it be of the subject, or of the entire camera, will register as *motion* blur — another property.

2.1 Motion as a Multitude

This new blur is distinct from lack of optical focus, though it might appear similar. A defocused image is the result of trying to view a subject from too many positions. It is, in a way, a wide confluence of perspectives that cannot be compounded in its complete form to a single legible image. Motion blur is not a confusion of positions, but of instances. Focus is a phenomenon of aperture, a confusion of many positions in space. Blur is one of the shutter, a confusion of many instances through time.

This blur is the form of motion in photography. And it can only exist through a persistent medium. In cinematography, it is the only form of motion recognizable on the single frame. The 'motion' that we most immediately associate with motion pictures comes from the differences in-between individual frames projected in sequence. There is motion there, but it exists only through reconstituting it through the projector[3]. This is because there is not motion in the frames; it only exists in between the frames; in Vertov's interval[4].

For this interval to exist, differences need to be apparent. The instances around the intervals need to be distinct and separated. This is what the shutter, and multiple exposures on the filmstrip accomplish. The shutter constricts on smaller, more defined instances in time. The advancing film segregates those instances while maintaining order of sequence. The individual frames have less of the inscription of motion (blur) which now exists in the intervals of the sequence. This makes the projector necessary, so that those instances can be reconstituted to a simulation of motion.

2.2 Depth

There is a different interval, and in it we find depth. In our stereoscopic system

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[3] D.N. Rodowick *Afterimages of Gilles Deleuze's Film Philosophy* (University of Minnesota Press, 2010), 85

[4] Dziga Vertov *The Writings of Dziga Vertov*, edit. Annette Michelson, trans. Kevin O'Brien (University of California, 1984), 91

of vision two images occupy two eyes. In the periphery of our field of view are the parts of the image exclusive to 'right eye' and 'left eye'. Everywhere else, there is overlap and dissimilarities between the left and right channel of vision. Depth perception is our ability to render from these discrepancies some spatial information about what we are view. Depth comes not from either image, but from the interval and the active comparisons that take place in it. Our stereoscopic input consists of flat images that are offset from each other by some distance. From this one offset, we synthesize depth.

With this stereoscopic depth, two images occupy nearly the same place simultaneously. Conversely, cinematic motion has two images occupying nearly the same time in the exact same place. The reconstitution of motion comes from images that represent 'before' and 'after' rather than 'left' and 'right'. In this way, the experience of motion and depth bear some similarities. It takes time to see time as anything but a blur, and the projector mediates this need. We can't see from two times at once, but afterimage through the interval allow us to perceive it from the before and after.

Depth perception results from our ability to see from two places simultaneously, as we have two eyes. But, as sure as we only see (and perceive) from one point in time, we have not expanded our perception of space either. Depth perception only suggests two zero-dimensional points. The function of the optics remains the same. The ability to see from many places is still hindered by the phenomenon of blur. Consider the simple act of making a shadow from a candle.

The shadow would be crisp and the image would be recognizable. An image in the same way from two candles would produce two shadows, which would get closer together as the object is pulled farther away from the source of light. But, to try and make a shadow where the source of light is coming from an overcast sky would prove to be difficult. The projection surface for the shadow would be lit from too many places. Replacing the light source with a camera would be a reversal of this example process. And the examples stated would correspond to photography, stereo-photography and the blurred image that is a result from the 'seeing from too many places' that optical blur implies. This is similar to the 'seeing from too many times' that motion blur suggests.

The use of the phrase 'too many' in the preceding paragraph may be read as 'unnecessary excess', but it is meant as, simply, more than the eye normally deals with. Usually such problems are physically corrected for before they need ever be perceived. Motion blur is hardly ever perceived, since it is actively cancelled out in processes like saccadic vision. Our eyes adjust their own focus and iris aperture involuntarily. But, in photography we are brought to make conscious choices for those two factors. For just one example, we can widen a camera's aperture to create selective focus, one of the many methods in the art of photography. In that instance, depth of field takes what was a deficiency and makes it a property in a new system. It becomes a way for us create a hierarchy that relays the depth information lost in the flattening of the real subject to a two dimensional image. In the way that the process of vision deals with both the domains of real spaces and perceived ones, we could know this system in images as an affordance, or at least an 'environmental niche'[5]. We know blur, in prints, to signify that something is too close, too far or too inconsequential, it is the artifact of depth and a signifier for the photographer's process and intention. The fact that this indicator, blur, is malleable allows for play in the artistic methods of photography beyond the goals of absolute reproduction. Depth of field has a band of clarity that is — with the use of focal length — controllably wide or narrow and can be placed at any distance.

2.3 Measurement and Experience

What was a problem in the eyes we now understand as part of an art form on the print. The motion blur that we cannot see with the eyes we do view in film. It draws attention to and signifies a quite different meaning of *focus*. This is one of the most important things that the camera provides. It is a system that can expand our view of time more than it can our view of space, which it simply replicates. In this way the camera provides a new meter where there was none before, internally or otherwise for time and motion in such a direct fashion. The camera replicates our view of space in the way that we see it through the eyes; irises, focal points and all. We can only come to understand the way that we see through relative measurements of scale. At the base level our sense of reach becomes our estimate of

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[5] Gibson, James *"The Information for Visual Perception", MIT Open Courseware,* http://courses.media.mit.edu/2004spring/mas966/Gibson%20Theory%20of%20Affordances.pdf (accessed Nov. 8, 2011).

distance and position, as Bishop Berkeley asserts[6]. We can categorize things as being larger or smaller than we are. We have internal metrics for space; the camera provides few if any enhancements to it. The camera does not in its function cry out for an exploration of space as so much as it does time.

Since we do not have an absolute internal register for time, the introduction of the photographic medium and apparatus begs for exploration of durations and motion. Through the camera we brought ourselves to view the duration of time, not just the measurement of the instance. Unmediated, time can be abstracted down to the base level of interplay between cause and effect. Always in that order. This is how we can see sequence. The photographic print receives duration but not order. 'Before' and 'After' is something we infer, either by the mechanics of the apparatus (the first exposures start at the beginning of the film strip) or by experience and assumptions (it would be wise to assume that a horse was not running in a full gallop *backwards*). In this way, there is a certain ambidextrous nature to the way that that motion and time are captured. Order is reconfigurable like depth is reconfigurable in stereography — it can only be reversed.

When the system is reversed concerning motion, or more specially, motion blur and sequential frames, the result is completely legible. The sequence of before and after brings the effect of 'forwards' and 'backwards', not 'correct' and 'incorrect'. We can only infer such things with situational hints, such as the properties of

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[6] George Berkeley *"An Essay Towards a New Theory of Vision" Wikisource, The Free Library,* http://en.wikisource.org/w/index.php?title=An_Essay_Towards_a_New_Theory_of_Vision&oldid=688927 (accessed March 12, 2011).

acceleration due to gravity and deceleration due to friction. Outside of that, these images of time and motion concern themselves mainly with duration. There are only concerns of logic, not legibility. This is an exploration only made possible by the persistence of the photographic medium. In the camera obscura there is not motion blur because there is not a period of time being compressed to an image. Everything is 'live', the camera obscura captures only spatial images, and the responsibility for all things temporal is relegated up to the retina and everything after it.

2.4 Capturing Light

The photographic medium may be a silver nitrate plate, it may be 16mm color film, it may be a CMOS chip in a video camera. In all these instances it adds a new factor in the equation, light in the resulting image is now proportional to the light brought into the camera and the amount of time the medium recording it is exposed to it. This has the effect of coding a long-exposure not for sequence, but duration. Light is coded to represent both its actual intensity, and the speed of the subject. All this is because light compounds over time on the negative.

The basic example of this is that a still object will expose brighter than a moving one, assuming both are within the dynamic range of brightness that the camera is able to capture. For the same reasons, a moving object accelerating, or just moving at a inconsistent speed will expose brighter in its periods of slower motion. This is the one of the bases of Futurist Photodynamism, one of the camera's first avenues of exploring time. In looking at '*The Slap'*[7] by the Bragaglia brothers we can view this in action. But, this goes beyond just brightness. Since both moving and stationary subjects are captured, objects in the background will be exposed onto the film for all moments when they are not obscured by the moving object. For example, in *'Typist'*[8], also by the Bragalias we can visually understand how speed translates into something like a quality of temporal opacity.

Figure 1 : *Typist*

In the attempt to expand our presence in space, we produce the optical blur discussed earlier. Position becomes so expanded and the representational form of the image is altered. The effect itself is legible and has meaning in relation to duration and position, and all of their derivatives (speed, acceleration, etc.). An object in motion is less present over the duration of an exposure for a location it

[7] Anton and Arturo Bragaglia *The Slap* (http://www.luminouslint.com/app/photographer/Antonio_Giulio__Bragaglia/, 1910)

[8] Anton and Arturo Bragaglia *Typist* (http://www.luminouslint.com/app/photographer/Antonio_Giulio__Bragaglia/, 1910)

passes by. A stationary object at that location is more present for the duration. This presence in time translates to this presence in the single frame — the opacity of the object in relation to other ones. The visual output of this system takes its form from the information it knows of presence, duration, and speed. This single exposure is still not defined by a beginning and end, or rather, it is ambiguous as to which end is which.

This is another responsibility of the projector; addressing sequence. Where the shutter alone made photodynamism possible, the shutter combined with the automatically advanced film strip (as opposed to a plate), makes motion in photography possible. Having made it possible, the apparatus of the projector then makes it visible. There is something more guided and mediated about this process. The photographic plate and print provided such a natural and organic way for duration to show itself. The effects caused by movement, when it is intentional to record it can be understood not as an artifact of the process, but evidence of the phenomenon. In much the same way that the constricted aperture provided for spatial clarity, a similar process of deletion and reduction would provide for clarity and simplification in temporal images.

3. Stored Time

Before the film reel and the projector provided for moving images, there were technologies and methods that would foreshadow its existence. Étienne-Jules Marey brought us from the long exposure to the multiple exposure. His gun-shaped camera could capture 12 exposures every second on to a single frame.[9] This is an advancement over long exposure only for the seeming clarity it provides. The 12 frames in that one second which his gun could capture does not record much more motion than a one second long exposure would. The gun only clarifies the motion through summarizing it. In its effect and process, Marey's camera does not introduce 12 instances of images to the photonegative. Rather, it substitutes in 11 instances of *nothing* in place of imagery to the long exposure. Duration, speed, and motion itself do not directly mark themselves on the print. We actively interpolate motion from these stroboscopic exposures through intuition and knowledge of the photographic process.

The kinescope takes Marey's ability to isolate and uses the 'blank time' to isolate frames. Time has an apparatus for capture and reconstruction from this collection of frames. Because of this it becomes a distinct element of the image no longer overlaid on existing ones. As the frames are independent, they can be spliced together and we have the process of editing. Most primitively, in-camera editing is the simple act of choosing *not* to record a duration of time and joining together the before and after periods. In the narrative of film it certainly can be used to connect two disparate spaces. But as a technical and physical aspect, time is the only factor being explored in this process. The fact that in a finished piece of film we can be transported hours in the interval between the two frames in a jump cut does not

[9] Simon Cook, *Our Eyes, Spinning Like Propellers: Wheel of Life, Curve of Velocities, and Dziga Vertov's "Theory of the Interval"* (*October*, 2007), 79

speak much to the camera presence in space. Rather, it speaks to the fact that the camera can be present, or more importantly sometimes, not present for durations of time. This is the exploration. The camera's presence in time becomes malleable through the division and atomism of duration and the durable nature of the process of reconstructing what has been captured.

As advances are made with frame-rate, time in film becomes more malleable. The uncanny pixelation[10] in stop motion works, or films shot with narrow shutter angles make us increasingly aware of the interval. This effect, though interesting is another process of deletion. In the other direction, many would assume completion, perfection in a sense, to be to fill the interval between frames with a capture of additional frames to the best of the apparatus's ability. Multiple-thousand FPS cameras are available today, and they are bound to only become more advanced and accessible. An 'ideal' system of capturing video would be developed to the point where, working with normal amounts of light, thousands of frames could be captured every second, missing nothing from a closed shutter. A matching system of projection could provide for a way of filming which does not allow the medium to provide any temporal distortion.

3. 1 Methods of Output and Reassembly

But, in itself, would such a system be important or revolutionary? Perhaps not.

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[10] Note: Pixelation refers to frozen motion. This is not to be confused with pixilation, which is used in reference to low resolution in digital systems.

We already have such a system, and though increased amounts of perception are important on the intake, accuracy isn't always paramount on the output. Such a system we have now is, to bring it up yet again, the camera obscura. The main difference between it and the theoretical 'ideal' one for capturing motion is that the theoretical one doesn't have to be always 'live'.

This is the other important avenue of exploring time that the kinescope brings us. It concerns the medium after the capture of the subject. In real-time capturing and replaying motion, the kino-eye can only develop to the point of the camera obscura on a time delay, if accuracy and simulation is the goal. When it isn't — and when we explore — the advantage and opportunity offered by the film camera that are not native to the eye and other unmediated optics. Beyond the fact that the camera allows for storage, it also allows for a disconnect between the methods of input and methods of output. If editing can be acknowledged as a process of deletion, then remapping film time between input and output can be acknowledged as an expansion.

3.2 Remapping Time

Changing the frame-rate, between input and output is one of the more common examples of this. There are, of course cameras that have the capability at frame rates far beyond what we are able to perceive. When they are used, it is not for the ideals of fidelity but rather for the purposes of distortion. These high-speed cameras are designed to capture at high speed and be viewed then at relatively low speeds.

The result of this scenario is what we call slow motion. Slow motion has its connotations that range from ideas of scientific instrumentation to the dramatic and gimmicky. But, for the purpose of this discussion the importance is not so much what its images show, but what the system as a whole reveals: there are ways of viewing beyond what our eyes can normally process. As well, it shows that there is a strange economy set up due to the fact that ultimately the eyes and the limits to them will be involved. In the case of slow motion, the greater temporal detail captured is only perceived when we sacrifice expediency in viewing.

Only by giving ourselves more time to look at the film do we have sight of all that is beyond our normal perception. Imagine a film shot at 60 fps and another shot at 1,000 fps. Played back at their respective rates they would seem nearly identical. Both of them remapped to play at 5 percent of their speeds would show something different. The 60 fps would be showing three images every second. You could probably figure out the motion taking place (assuming that the subject was ideal, e.g. fast-moving), but it would be an active process in figuring it out, you would be aware of the interpolations you were trying to make rather than just passively ‘seeing‘ them. The 1,000 fps would still be showing 50 frames every second, a little more than twice the frame rate we get with standard movies. The motion would still be fluid. And all that was missed in the intervals of the other camera would be apparent. Consider the revelations seen in some of the first high-speed films such as those done at MIT of hummingbirds and those done earlier by Lucien Bull of insects; exploring nature just as Eadweard Muybridge did with the

Zoopraxiscopre. But now we can receive greater detail in time in exchange for a greater amount of time needed to view the subject. It should be noted with our 1,000 fps camera running at 5% speed, if we wished to view some recorded action, we would either have to commit to viewing something that now runs twenty times as long in length as the actual action it captured or view only a portion of the duration. This is the exchange we make with the medium.

Time-lapse photography works on the same economy of time and information. A time-lapse film has the effect of a low pass filter for motion, only the very slow retain any sort of fluid movement. Consider a film where one frame is shot for one second at five-minute intervals overnight. The moon and stars would make their subtle motions obvious when the film is projected out at 24 fps, A moving car in that same scene would be viewed as a quick blink of red taillight glow, if anything at all. In this way we gain a summation across time, a quick overview at the expense of temporal detail and resolution. In a way, this may relate back to photodynamism, which has a similar exchange. The characteristics of the long exposure provide for a similar filter. Consider the only visible people in *Boulevard du Temple* by Daguerre; the two who stopped so that a shoe could be shined. In this way, the long exposure can be considered as the derivation[11] of sorts to time-lapse film. The multiple exposure would then have the same relation to slow motion film, with any intervals not covered implied through the viewers interpolations.

There is a dividing line that separates slow motion and the multiple exposures

[11] Note: In the notion of a single simplified measure of a sum of changes, as speed is to position and acceleration to speed, for example.

from the time lapse and the long exposure. This median is the 1:1 balance that we call real-time. At one extreme of this scale we have the long exposure, where motion for a captured duration can only be recorded in one instance, simultaneously on one frame. At the other extreme we have the multiple exposure. The captured duration of time is also compressed to the single frame. But, on this end of the scale the motion doesn't exist on it at all. When we interpolate motion from these multiple exposure prints, we see in a place that is, by nature, not on the print; we see it only in the interval. Those extremes, and everything between them on the scale is what the kino eye actually brings us. The camera is thought to be a machine of, and concerned with, the image. This accounts for the iris, and the lenses, and the image projection. All of which are important things, but nonetheless are thing that do not make the camera 'new' to our ways of seeing. That part of the camera works on the same mechanics of the telescope, the microscope, the camera obscura and the eye itself. All of these apparatuses work only at that one point in the scale in the center, that is to say, real-time. All this cinematic exploration comes as a result of the shutter and the medium, and as such is in the domain of time.

4. Hidden Equipment and Spaces

There are limits to our vision and the camera has worked to expand past many of them. Other technologies rely on our limits. Present day technologies such as CRT displays, color dithering in flat panel displays, Pulse-Width Modulation in LED dimming and Digital Micromirror Devices in video projectors all rely on an upper boundary to the speed at which we can perceive changes in light. A PWM dimmed LED is simply turning on and off hundreds of times every second, the ratio of on to off durations is variable. We do not view a light turning on and off very fast. Instead we see this as intensities of light, depending on the duty cycle. Above 20khz the visual flicker and any incidental sound produced is imperceptible[12]. These technologies all are designed to exploit a limit in our sight and they all need to be taken into account when a camera is present. The camera can not miss or ignore the way those devices function. Conversely, the film projector relies on our not noticing the amount of time that the lens is shuttered on every frame during normal operation.

In the previous example the camera is a tool to reveal. As well, it has shown an important role to *conceal*. In one sense, editing shot footage and creating links between imagery set apart in time is one way to skip over the durations of shot (or non-shot) imagery that is not relevant to the final film. In a different example, consider when the subject is not to be shot in real time, by its very nature. For instance, stop motion animation was another initial use found for film when it was new. Stop motion has it's roots in the early special effects in cinema, such as Méliès turning stars into people as if by magic in *Le Voyage Dans la Lune* [13]or the stop-action effects in the Edison Company's *Fun in a Bakery Shop*. Such early examples

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[12] Ian T. Ferguson, Nadarajah Narendran, Tsunemasa Taguchi, Ian E. Ashdown *International Conference on Solid State Lighting: Volume 5187* (SPIE, 2007),

[13] *Le Voyage Dans La Lune,* Digital Copy, Directed by Georges Méliès, 1902, Public Domain through The Internet Archive, 2010

of stop motion lead into the first bits of animated film. *The Enchanted Drawing*[14] and *Humorous Phases of Funny Faces*[15] deal with much more than a 'stop-down and switch' method incorporating long stretches of single frame exposure, and are closer to what we consider animation today. This method creates motion from still images, leaving out any views of the single image being drawn.

In later films we start to observe things done with time and animation that are unique to film, going beyond the stage of advanced flipbooks. The films such as those of Ladislas Starevich, particularly *The Mascot (Fétiche Mascotte)*[16] provides a more intricate example of the use of time to conceal and create. Many instances in this film combine stop motion characters with real-time backgrounds. In one memorable shot in *The Mascot* Duffy, the stop-motion protagonist is suspended in front of the rear window of a moving car. Assuming this shot was done with rear projection, we have an interesting outline of the method that would have been used. As the animator manipulates the puppet, a frame is shot for every new position it is put in once the animator clears out of the frame. At the same time, with each progressive exposure, the already shot footage of the rear view from the car would need to be advanced by a frame. In this way, during production we have real time footage being slowed to speeds that allows the animator to create entirely new

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[14] *The Enchanted Drawing,* Digital Copy, Performed by J. Stuart Blackton, Edison Manufacturing Co, 1900, Public Domain through The US Library of Congress, 2010

[15] *Humorous Phases of Funny Faces,* Digital Copy, Produced by J. Stuart Blackton, Vitagraph, 1906, Public Domain through The US Library of Congress, 2010

[16] *Duffy the Mascot,* Digital Copy, Directed by Ladislas Starevich, Gelma Film, 1902, Public Domain through The Internet Archive, 2010

motion on top of it. Having both combined — in-camera, no less — we see two realities of film, one superimposed on the other.

With all stop motion there is an obscuring of the apparatus and the production process that takes place. Concealing the mechanics of of theatre is done with curtains and sight lines. The camera too takes the production elements either out of the frame or even keeps them not-at-all present.

5. Expanding Space Beyond Selection

These innovations all show the camera to be a product of and tool for time. But why not some equal explorations in space? Ones that are beyond concealing it. What more could be seen? Consider if we were to eliminate the frame. If we view the lens and the frame of the camera to be a tool of selection, we must also recognize that a frame's process will primarily concern itself with rejecting images. Beyond just accepting its presence in imagery, we also accept a standard shape for the frame: rectangular. Though we assume light and optics to work in a radial manner, we use this four-sided crop much in the same way that maps are derived from actual globes. To make a globe, or a similar model of any object, one would first need to view the object before recreating it. This means rotating the object, or rotating the viewer about the object to view all sides of it so that it can be modeled and recreated. This is done sometimes with cameras and computer vision in a method that involves much in the way of digital computation and composition to calculate, model and synthesize a final three-dimensional model. This is an involved process that requires much 'thinking' and calculated assumptions on the part of the electronics and programming involved in the system.

5.1 Looking out

A mechanical method for this, which produces two-dimensional images from a one-dimensional input is rollout photography, scanning a scene with a single column frame. What makes this process less traditionally photographic is the fact that the resulting composite image is synthesized from many simultaneous points of observation. When this process is used expansively to look about a space rather than around an object, a photograph is produced that has no and needs no specific subject with its lack of frame. The point of capture that we look out from is in itself the main subject, when all directions are simultaneously viewable.

To look around – that is, *all* the way around an area at once can prove to be difficult. Capturing imagery in all directions at once expands the idea of the frame to the point where one of the frame's key properties, the border, is eliminated. To get to this point we have to overcome the limitations of lens width and flat mediums such as film. The methods that aim to take on that task bring in their own specific distortions, and in doing so, have us question the idea of an optical distortion. There are catadioptric systems that use glass and conical mirrors to provide a full 360-degree view in one axis. This produces an almost complete sphere of imagery, save for the fact that as long as there is a camera there will be an apparatus that will block the possibility of the single continuous frame. We can produce with that system coverage in the shape of a dome or ring, but a complete sphere becomes possible only through the composite image. In doing so we use exposures separated by time to produce increased coverage in space, rather than motion in time.

5.2 Composite and Collage

Panoramic images, and the process by which they are made show us a method by which this is possible. Multiple exposures around a single point are integrated to create a larger, complete composition. This method can produce an image that could be considered a composite or a collage, depending on the level of technical refinement used in making it. Early plate based and current digital panoramic photography both use a process referred to as ‘stitching’. This could be a process as physical as cutting and aligning many photographic plates or negatives to produce a new composite master. It can also be done in a more computational manner with digital files. Traditional photographic panorama aims to render a final image in such a way so that the original individual images are not distinguishable from each other.

Another form is the *panographic* image. This consists of several photos, with their frames still visible are placed to create a larger image in a form of collage which is much more self-apparent. This form of photography features the process and shows the exact method and actions that the photographer took. To go a different route and create a seamless panorama, errors are to be corrected for as the edges of those individual photographs will not be identical. We find that same area, photographed twice, does not produce the same image when it resides in different parts of the frame. Sometimes this is error on behalf of the photographer's method; the camera may be moved laterally, rather than just rotated. This is parallax distortion. The images are dissimilar because we have a subject viewed from two different locations. This happens to some degree whenever the camera is rotated around anything but the nodal point of the lens.

Aside from that occurrence, lens distortion occurs in this system due to this issues involved with a spherical project upon a flat surface — the film or CCD of the camera. On the wider lenses this manifests as a 'fisheye' distortion. Though the same subject may be being captured from the same location, there is a clear bias in the way the image is rendered that depends on whether the subject was on the left or right side of the frame. This effect is at its most severe at the edges of the frame. At the center line for each axis the distortion is balanced. And so, to avoid a composite print that reveals the individual elements, this middle portion is used. Some systems go to an extreme length to capitalize on this.

5.3 Translating Images

Such a system is a swing-lens camera, an early analog example. Rather than have an entire projection of the image be exposed onto the film at one time, it exposes the film progressively through a single, narrow vertical aperture. This allows the exposure to sweep across a large horizontal area of film, while using only the central vertical stipe from the lens. As the name implies, the lens swings rotating around the focal node. Newer technologies have expanded upon this idea.

The Panoscan camera[17], developed by Panoscan Incorporated is able to capture a full sphere of imagery, having a fisheye lens with a 185-degree angle of view. Like the swing lens camera, it also uses one vertical column for exposure, having only one line of sensors. As the design incorporates a rotating tripod head, the 180 degrees of vertical coverage is compounded over time with 360 degrees of rotation. This is one way of viewing all that there is to be seen in one place. There are other panoramic ways of doing this that respects a radial, rather than Cartesian model for stored imagery. Though flat photographs can be produced from this method, it is more true to its form and method to treat this entirety of view as a sphere. In fact, much of what we consider 'optical distortion' is, ironically, induced by a flat medium made to work incongruously with a radial projection. These are the same difficulties faced long before photography by mapmakers, trying to fit a portion of a round globe on to a flat map. In that regard, if we treat photographs as maps, we find that the complete composite, the globe in this analogy, is a similar product. The exception being that we look onto a globe, and we look outwards from within a sphere of image when we deal with these completed panoramas.

A simple panoramic strip could be represented as a cylindrical projection. Bringing the circle of that projection to be symmetrical on all axes surrounding the camera produces the sphere. Considering this sphere to be a completed, frameless image, all photography uses only some part of this sphere. Framing and composition

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[17] Scott Highton, *Virtual Reality Photography: Creating Panoramic and Object Images* (Self Published, 2010), 185

in a shot shows a subject through intentional cropping and deletion while focus is a technical attribute that signifies distance. The photographic compression of space is present in smaller crops from this sphere. To expand this compressed space, the camera must be positioned closer to that same subject. In doing so it is further shown that the only permanent subject in the frameless photograph is the point of capture. This is the same point in the aperture of the camera obscura that, in his discussion of Descartes, Jonathan Crary describes as "…a single mathematically defined point, from which the world can logically be deduced by a progressive accumulation and combination of signs." [18] Completing the sphere and resolving it in its definition works towards this possibility.

5.4 The Complete View

Treating the sphere as the complete form, we are left to view photography as an editorial process, one of selection and deletion. The only constant that we can not modify after capture is the position of the photographic apparatus, it will always be in the center of that sphere. This origin is inflexible and both limits and defines photography and vision as we've come to understand it. The geometry of the resulting imagery all leads to and reveals that point through the effects of perspective. Obtaining focus instead of blur in an image is done by keeping that point precisely defined, as close as possible to zero-dimensional and volumeless as

[18] Jonathan Crary, *Techniques of the Obsever* (MIT Press, 1990), 48

was previously discussed. All conversions from radial to Cartesian, and from light to image take place through this point. The negative spatial effects of optical blur and the corresponding negative temporal effects of motion blur prevent us from using though any other different forms than this point in traditional optics.

Consider, the relations between optical and motion blur and their corresponding domains of space and time. Remember that the subdivisions of a motion blur in the long exposure are the individual short exposure frames of a sequence of frames. Those frames produce motion in part by using time as a filter. A fuzzy distortion, a perceived limitation in the optical system showed itself able to expand our use and recreation of time images through proper dissection and mechanics. In my research and the accompanying project to this paper I have worked towards an analogous system to subdivide optical blur, with the goal that doing so can give us an ample opportunity to manipulate the geometries of perspective in a way that goes beyond how we can normally be expected to view.

6. Time and Dimensions

My research, and the process that I made for it attempts to expand the presence of the viewer in space. It does this by using sequential exposures, which build up a smooth series of perspectives rather than the smooth series of events that a motion picture camera produces in motion.

There are technologies that exist today which use frame differencing and feature tracking to try and create a rough three-dimensional sketch of an image. Such a method is interesting, but I find it to still be a process of estimation and simulation. Early painterly explorations into perspective made similar use of calculated processes. However precise the capture is and how convincing the resulting models are, I find it important to create a system that uses optics rather than constructed renderings. The goal is not so much to produce accurate three-dimensional models, but to introduce malleability into the system in regards to position both in capture and projection. In this way, accuracy and precision are the virtues of a system that accepts distortion as an artifact and signifier. Clarity and legibility are paramount in this process of seeing, not measuring. These distortions and artifacts are of great importance they are new ones. So much of what we see and expect of standard photography could be considered a problem or artifact, but instead, these signature deficiencies are seen as being what define the form. So, in trying to develop this new imagery, I find the consequential effects nearly as interesting as the intended results.

6.1 Compounded Sequences

That being said, this method has precedence in methods used today. To try and explore a multitude of positions for the viewer in one image implies being able to record and reconstitute an extra dimension that the apparatus cannot see in its current mode of operation. Time is considered an additional dimension or attribute to a moving image. Time and movement result from the capture of a sequence of two-dimensional images. This skips a step, the third dimension of the image — depth.

We deal with depth in film and in vision as a simultaneous recording of two positions, the product of which is dual two-dimensional images. We have the hardware, two eyes, to interpret that as three-dimensional imagery when each channel is projected exclusively to its respective eye. In this way, the three dimensional properties of the image, an attribute dealing with space, is resolved through a simultaneity of imagery. In a similar way, time and movement are resolved through sequence, a subdivision of events which, when projected, is seen by the viewer as fluid motion. This is a result of an aggregation of imagery given to a receiver (the viewer) who extrapolates this sense of movement through the viewing of the single frame compounded on the viewing of the previous ones. Time is in fact used often to aid in adding dimension to an image beyond what the initial apparatus is built to view

There is an early example of such a process in the Belinograph, an early device that lead to the development of wirephoto. To transmit a still image, a photocell would scan an image progressively; left to right, then top to bottom. A reversal of the process on the receiving end would imprint the same dark and light areas in the order that they were received and in the pattern that they were recorded. Similar early technologies such as the Pantellograph did similar tasks through the use of a large pendulum and drum to produce the scanning motion. However these devices did not ‘see’, optically at least, as they relied on electrically conductive ink.

These processes create a two-dimensional image with optics which function in zero dimensions. The modern flatbed image scanner is able to create two-dimensional image with one-dimensional optics. Rather than relying on a single photocell, it builds images with an aggregate of individual instances of columns, not pixels. The Panoscan camera, discussed earlier, operates in the same way, only with an outward-facing radial system. With sequential images in film, motion is a result of a process of subtraction, as the phenomenon of movement is seen through the differences between the frames. In all of these spatial applications of sequence there is a process of addition, the accumulation of images happens in part through the storage or abilities of visual persistence held by memory in a computer, ink on a page, or the phosphorescence of a CRT monitor.

6.2 Gradients of Duration

Such a process is reliant on durations of time, though the process is not intended to illustrate any events that would reveal them as durations. Such events would render as motion if a film camera captured them. When captured by these systems, they render as distortion. This distortion is not necessarily synonymous with ‘problem’ as the effects form the basis for many artistic methods of photography. A long-standing example of this is the field of slit-scan photography. Early rolling shutters and current CMOS system made this effect possible, though not always intentional, as their design exposes a frame in a vertical progression, not all at once. An early unintentional example of this is Jacques-Henri Lartigue’s 1913 photograph *Car Trip, Papa at 80 Kilometers an Hour*[19]. In this piece, the fast moving racecar is visually sheared to the right as it was going faster than the photographer's camera was panning. It has progressed further across the frame at the top of the frame, for this skew we can suppose then that the rolling shutter moved upwards.

Figure 2: Jaques-Henri Latrigue's *Car Trip, Papa at 80 Kilometers an Hour* Likewise, stationary viewers skew to the left as they are traveling in opposite direction of the car and relative to the panning camera. This photograph is a happy accident of sorts that shows what would later be possible with this system. Space in the resulting images of this system has a temporal gradient upon it. In a way, this could be seen as a long exposure, but one that is read in a much different manner as each line of the image is distinct and shows only a short period of time.

Artists like William Larson[20] and Zbigniew Rybczynski would make this effect critical to the work that they were making. This dimension of time was brought into the single frame instead of existing in the in-between space. Through this, both imagery and the form used to produce it were made visible. Paul Virillio highlighted

[19] Golan Levin, *An Informal Catalogue of Slit-Scan Video Artworks and Research*, (http://www.flong.com) , 2010

[20] Particularly his *Figure in Motion* series, part of the George Eastman House still photography archives, accessed at http://www.geh.org/fm/misdig2/htmlsrc/m200115090002_ful.html, 2010.

this new layer in an article on Rybcznski's *Fourth Dimension*, a film which incorporated slit-scanning into full video, not still photographs. Virillio states:

> "That slippage and the baroque elements are truly the product of a geology rather than a geometry of the image. The horizontal lines are to him what the layers of sedimentation are to a geologist and this, in my opinion, is highly original. He no longer plays with the plots, but with the horizontal lines, like a musician that lets his notes glide through the musical staff. Deleuze would like that, the fold. Ah, yes, that there is truly the fold!"[21].

Figure 3: Stills for Rbczynski's *The Fourth Dimension.* [22]

As well, in a similar use of what might otherwise be considered a 'distortion' there are Miska Knapek's[23] 'spatiotemporal' images. They are notable for their multiple-day exposure times. Sequential images produced in such a manner can show time progression on the level of seasonal changes. In Knapek's case, a natural

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[21] Paul Virillo, *Le phþnomúne Rybczynski* (Cahiers du Cinþma, 1989) translated at Rybczinski's online portfolio, at http://www.zbigvision.com/

[22] Zbignew Rbxynski *The Fourth Dimension* (Portflolio of the Artist, http://www.zbigvision.com/gfx/4D_Multi1.jpg, 1988),

[23] Miska Knapek 's online portfolio and biography can be found at http://knapek.org/

exposure cycle of 24 hours is used. She refers to her process as using neither a still camera or motion camera, but a 'time camera'.[24]

Figure 4: An image from Knapek's *Helsinki 2nd Shortest Day* series[25]

Aside from the idea of slit-scan as the traveling shutter, there is also the use of slit-scan methods where the shutter remains stationary, instead relying on the subject or the camera to move. Michael Awad[26] uses this method in his art, relying on a stationary camera and a moving subject. He has found suitable subjects in luggage carousels, elevators and commuters entering a train station. Slit-scan, done digitally can show time progression in two axes. Such an example is shown in

[24] Johanna Korhonen, Photographs in Time. Lapses In Time: Interview with Miska Knapek (New! Magazine, 2007), 48

[25] Miska Knapek *Helsinki 2nd Shortest Day* (Collection at http://www.flickr.com/photos/miska_too/)

[26] NOTE: Michael Awad is represented by the Nicholas Metiver Gallery, a portfolio can be found online at http://www.metiviergallery.com/artist_artwork.php?artist=awad

ART+COM's *The Invisible Shape of Things Past*. This 'filmobject'[27] created, among other things, an entire object of imagery. This was created using only the edge of the frame. Still a one pixel wide column, but one built from four sides, in a way acting like a very narrow panorama. Having the tracked the location and direction that the camera was pointing, four slit scan composites were created and contoured to show the actual path of the camera.

7. Perspective

In all of these instances the larger composite can be made smoothly by using a 1:1 ratio of input to output. Having each row or column is entirely proprietary to the imagery it shows. There is no 'frame' in the sense of a limit. There is simply the extent to which the picture was captured. This is similar to how the duration of a piece of filmed motion is separate from the exposure times of its constituent frames. All of this is achieved through the narrowest possible slice of video, a one-pixel column. On many occasions, this column is sourced from a traditional video camera, with a two-dimensional input. Usually, a center column is used to have an equal weight on the image's perspective. Left and right side slices on the input result in oblique projections on the output. So, with a standard input of 720 vertical lines[28], 719 are discarded. My project seeks to put those ignored columns to good use by creating a system to which they are appropriate and necessary. In all the slit scan

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[27] Lev Manovich *The Language of New Media* (The MIT Press, 2001), 87

[28] NOTE: In this instance, the input is assumed to be the NTSC-DV standard, as that is what I have used in my research. It is 720 columns wide and should not be confused with

examples, we are able to produce two-dimensional images from a one-dimensional eye through the compounding of sequential views. In doing so, this captures volume in an optical fashion. It does not simulate depth as a stereographic system does, but rather goes further to capture a more complete geometry of the system. This is most important and most visible through its result of being able to modify the functions of perspective in its output.

7.1 Painterly Methods

Consider perspective as a property and device that relies on a single point for the viewer in the recreations of an optical system. Our artistic interpretations of it are all part of the same system of receding lines to a vanishing point. A central perspective in painting or photography implies that the scene being viewed is directly in front of the viewer, the vanishing point being in the rear center. An oblique perspective implies that the viewer is observing a section of an image from which the central point has been blocked out. Giotto di Bondonne's Frescos[29] are notable examples of this. The *circini centrum*[30] in the front paintings relates to

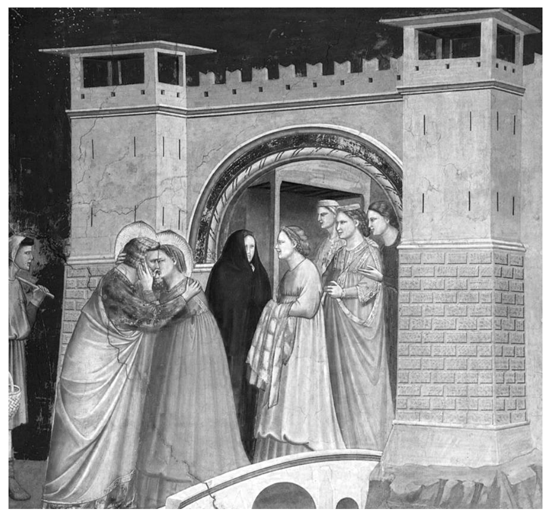

Figure 5 : The lines of perspective skew to the right in Giotto's *Meeting at the Golden Gate* indicating the position of the viewer to be to the left of the image.

[29] Pictured: Giotto di Bondonne *Meeting at The Golden Gate* (The Web Gallery of Art, http://www.wga.hu/tours/giotto/padova/cycle/joachi6.html, 1239(approx.)),
[30] Erwin Panofsky, *Perspective as Symbolic Form*, trans. Christopher S. Wood (Zone Books, 1997), 38

the side paintings, the oblique projection in them faces towards it. Overlaying the system of perspective onto the space of a room, with the presupposition of a correctly placed viewer creates a system that, as Panofsky states is:

> "…A revolution in the formal assessment of the representational surface. This surface is now no longer the wall or the panel bearing the forms of individual things and figures, but rather is once again that transparent plane through which we are meant to believe that we are looking into a space, even if that space is still bounded on all sides."[31]

Consider also the implications that perspective has as a tool for subject and viewer. In being key to vision, perspective can show its importance as well in its absence or modification. Brian Rotman makes note of this Johannes Vermeer's *Di Schilderkonst*, or 'The Art of Painting' perspective symbolism. In both recognizing and then deconstructing the anteriority of 'realism' perspective goes beyond framing to become such an integral part the subject so that the viewer cannot separate "the world and the visual signs for the world."[32]

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[31] Panofsky, *Perspective,* 55

[32] Brian Rotman, *Signifying Nothing: The Semiotics of Zero* (Stanford University Press, 1987), 40-41

Figure 6: *Di Schilderkonst* by Johannes Vermeer[33]

With these considerations, we know perspective to be a key tool in our interpretation of space and that the functions of optical systems and the artifacts of their operations form a base level for realism, neutrality and accuracy. So, in in the development of the accompanying project it became of high importance to create a system that could create malleability in perspective and the placement of definition of viewer. This is done to avoid any pre-composed intent in the rendering and allow for as much exploration of the system of perspective through analogues to a optical/mechanical process.

[33] Johannes Vermeer, *Di Schilderkonst,* Oil on Canvas, 1666 (Kunsthistorisches Museum, Vienna)

8. Research

To consider how this project is to go beyond normal operations of perspective and viewer, it is important to know the basic limits to the definitions that it hopes to subvert. At its most basic, perspective is a matter of scale and a hierarchy of obstructions. Certain objects are closer to the viewer to than others. To the viewer, this results in an overlap. One object, when placed in front of another, obscures the view of the rear object when it is opaque. It is also a system where objects that are closer appear larger. The result of this, when it seen through the camera obscura is the unity of objects, as Crary makes note of when discussing Heidegger[34], and the constant position from which they can be compared to one another. In this way the projection is of the objectivity of objects themselves. Escaping from the 'privilege' of that perspective's position, there are notable creative exceptions, such as with Byzantine style perspective in paintings. This style presents an order of importance and symbolism rather than strictly emulating perspective as it is known in vision. It is a system of knower and known and not of unattended subject and viewer. Likewise, orthographic perspective in drawings and their lack of receding lines serve diagrammatical purposes. For visual and photographic perspective, methods that match the way that we see, the system of scale and obstructions remains constant. If an object is obscured by another object from our position we cannot view around the front object to the rear one without changing our position or moving the

[34] Jonathan Crary, *Techniques of the Obsever* (MIT Press, 1990), 56

objects. As well, objects close to the viewer are larger and they become smaller as they recede to the vanishing point. We experience a maximum of three-point perspective, that is to say no more than three sides of a normal cube can be viewed at once. The presupposition of this project is that place of viewer can be expanded beyond a single coordinate of location, and thereby the system of perspective can be made malleable while maintaining accuracy to its own system and legibility. This can be done for an expanded, but still single, location.

8.1 Input Method

As discussed, expanding the place of the viewer is done through a multitude of images. Specifically, for this project the source material or input is simply a scanning view of a scene. In my research I've found that this — fortunately — can be created through something as simple as a camera in a car window or on a skateboard. The camera trucks alongside the imagery being captured, much like a flatbed scanner does with a photograph but this input is two-dimensional. To create a simple slit scan image, we would normally use only the centerline of each frame of the resulting video, pasting all the lines together to form a horizontal image. In the simple slit-scan, a panoramic photograph would be produced, the quality of which would be dependent on consistently level frame and constant speed. While these are still important to have within reasonable thresholds, the product of this project isn't to produce a panoramic photography, but enough information to reconstruct a range of perspectives and geometries. In this case, the parallax shift is what is most importantly captured at this point.

This project uses a similar framework, but a different method from slit-scanning to allow for deeper results. As the camera moves along, each frame captured is assigned to a horizontal position on what will be the output image. Each one of these vertical slices has a number of columns from the inputted frame that it can use as an angle of offset for that part of the image. Assuming we use a NTSC/DV camera and a 50mm lens we have 720 lines, each about .04 degrees wide, covering a 40 degree area. This project uses around 900 of those column elements to create a wide image representing the captured area, be it less than a foot or many miles across.

8.2 Post Processing

The geometry produced by these methods of capture and processing produces new geometries that extend beyond the idea of a new lens. This is largely in part to the many images this moving camera captures. In standard photography, a 50mm lens would translate to a 40-degree angle at which imagery could be captured. At 20 feet away, 15 horizontal feet are 'in frame'. About four and a half feet are in frame at a distance of five feet, 4,000 feet are in view at a mile out. But, in this system the lens angle represents the possibilities available for and unique to each horizontal column.

This particular configuration functions like the aforementioned Belinograph or flatbed scanner, but on a much larger scale. In capturing this scene, if we use only the center column in our output, 35 feet scanned represents 35 feet produced. This assumes looking only 'straight ahead' for all columns in the image. And those 35 feet captured are the same at all distances, near and far. The same width is captured 10 feet out as there is at 200. This does something of great interest to the vanishing point in this image; it eliminates it. In this one view, the geometry of the lens is taken away, and perspective flattens in the absence of it. Each column, in this instance is 'looking' in the same direction'. Widths remain constant horizontally because of this. Therefore, there are no lines receding to the horizon. A road or a sidewalk does not appear to get smaller as it goes out towards the horizon, it remains the same width, and its borders remain parallel. In this function of the system the vanishing point is non-existent. In a way, we can assume no geometric center to this image, the viewer is present for the full width of the image, nothing takes bias to the left or right of the frame. The frame's only limitation in width is where we choose to stop recording or outputting it, much like how we have no limitations to the duration of a motion clip besides practical and material concerns.

This is not to be taken as a distortion or effect; this is one of the ways that this camera can see. It is a natural and simple output of one configuration of this camera system. Is it any more odd than to assume that things should seem smaller when they are far from us? The viewer is not in the center of this 35 foot wide exposure, rather, the viewer exists throughout it. Objects may be to the left or right of each other, but none are to the left or right of the viewer, instead they are all directly ahead. The area in which the camera/viewer is located is not a 0-dimension focal point, but a wide parallel column.

In this system's operation, the lens finds a new derivation. The 40 degree lens angle on the camera translates to 40 degrees of freedom by which we can modify each column on the outputted image. Though the viewer and viewpoint does not move, perspective can shift around the image. We can explore in this way by keeping all of the input angles constant and shifting them at the same time. We keep our non-receding lines of perspective, but offset them all equally to the left or right. This creates a geometry of perspective where all objects are overlapped by their neighbor to the right or left. The last object eventually finds itself behind the initial object. Our lines of perspective no longer resemble a radial grid, but rather, a spiral.

As planned for, this ability to scrub through perspectives comes from the correct processing of a multitude of position-images, separated and stored to produce something other than blur. A motion picture filmstrip stores a motion as a divided and separated series of images. The source video feed can be understood to be doing something very similar here. As with regular video this project relies on the storage to itself have the memory of these specific instances *and* for the medium to have a meaningful order to it. As it is video, it has the implied meaning in its format that advancing through the sequence is to advance from before to after. This project also relies on a second meaning, in that the manner in which the input footage is shot must also translate to a transition for a start point on a real path to and endpoint. The temporal sequence of the film matters only for the fact that it guarantees chronological order, the actual amount of time elapsed in the recording does not matter.

Instead, as this project concerns itself with spatial aspect, it is entirely reliant on the fact that there is a constant spatial meaning to the advancement of the image sequence. Also, it is interesting to note how we can understand the method for storing this data in the project itself. We can imagine the slots in the data array in the project much like those frames of film, but with a spatial aspect to its sequence. Each slot for a full image in the input directly corresponds to a column on the x-axis of the output. This geometry, not time, is the division between frames in this project. This data structure could be understood as a three-dimensional array from which a two dimensional slice can be extracted from. In the instance that the input video is to be processed as a full 360-degree panorama, we can more easily picture this storage object as a torus. Any slice can be sampled from this static storage object; the position and shape of that slice will translate to a single and unique perspective geometry on the output image.

8.3 Live Manipulation

The function of these new geometries for perspective is best shown not through static pictures, but by the interactive nature of this project. The transformation between perspectives relates them to familiar modes and shows how they differ. It became clear in the initial development of this project that interactivity would be of great importance to have set up early. It was clear that it would be a great asset for exploring the system's potential. As such, it was important to develop a system that could be both detailed and fast in its rendering. The first versions that particular type of configuration could produce a few frames every minute, it was clear that it would instead need to be able to run in real time.

The project was further developed to do so, using many open source tools. The project and interface to it runs on Python. It accepts input frames in the form of a JPEG image sequence. Each frame is divided into columns using the Python Imaging Library (PIL, for short.) The image data from those columns is then converted to uncompressed strings, which are stored in a data array. One of the many interfaces produces a list of offsets for each of the output columns. The corresponding string are then pulled from the array and concatenated into one uncompressed strings element. This string is then converted back to PIL format, and is output to the screen, through PyGame — allowing high fps and interactivity thanks to a short pre-render.

8.5 Intentions in Function

Along with the increase in performance, the method used in this project keeps to the spirit of the exercise by using simple rules. This avoids it being just an image filter. None of the image manipulation deals with the data as image data. Because of this the nature of the method is significant. As my hope for this project was to model a novel system of optics and vision, I hoped to avoid having the computer make any real decisions. That is to say, that the concept can work through (Rotman

1987) physical mechanisms (film, string, paper and gears), so I did not need the computer to take on the job of creating any sort of synthesized realities. To do so would make some permanent intentionality in the process itself. This process works neutrally and it needs only to make the mechanisms through which the project can work practically. In this way, the machine is not a video filter to interpret perspective in a painterly way, but rather to simply act as larger and novel lens. Because of this, and for reasons concerning performance, all of the work that the computer does in real-time for this lens are simple concatenation operations. With time, skills and resources the methods that the programming uses could be ported to something as mechanical and 'unintelligent' as a wind-up film camera. All that matters are the rules and modes that this mechanism works with.

8.6 Research and Results

The first interactive experiment done in developing this project was to again make all of the input angles changeable by being able to change which column position is to be used from the input images. In the first example with this project, this was simple and static, the center column (360th out of 720) at 0 degrees was used from each image. As a result, all lines going to the horizon appear parallel and vertical in the output, as there is no vanishing point in this image. In changing this angle in real-time it was clear that we could see the entire front and side faces of objects without changing where the perspective of the image would suggest that the position of the viewer is. In this way we can also create four-point perspective, a type of perspective not possible with standard optics. Beyond the expected spiral perspective, the interactive moving picture provided a surprisingly clear process to look around an object to its background, which would normally be obscured without moving the viewer.

The motion of the interaction has a curious reversal of parallax scrolling. The viewer stays in the same place, as is evident by objects closest to the screen remaining mostly stationary. Objects in the far background move the fastest as the rules for perspective through this device are shifted. In keeping all the angles the same in this first experiment, we find that our field of view takes the shape of a variably skewed parallelogram. The base width of the parallelogram is the distance travelled by the camera. The length goes from the area immediately in front of the camera all the way to the horizon. This is with the simple example of an input camera traveling in a straight line. The system can also work with a camera traveling in a circle while facing outward to convert an area for a full 360 degrees. The slight bias towards a vanishing point that this method introduced can be nearly eliminated through a large enough circle or a long enough focal length. Failing that, the coding of the program can be set to correct for this by a few degrees.

The project further deals with different angles set for the individual columns rather than changing them all simultaneously. The natural step of trying to recreate normal perspective can be accomplished this way. This was found by coding the system to be able to create quick sketches through mouse input of curves that are translated to the angle settings.

Figure 7: One of the 418 input images for the 'Spines' set of test images used in developing the project.

When the left-most column was set to use information from the first (left-most) slice of its source image, and the right-most column used information from its source images last (right-most) slice — and with the middle columns settings properly interpolated — the widest possible angle for the output image was produced in a style which appears as linear perspective.

Figure 8: Linear perspective and input histogram

Curving the setting for the process allowed for the creation of a fisheye distortion and curvilinear perspective.

Figure 9: An exaggerated vanishing point

A sharp spike in the input provided for unnatural pronounced vanishing points.

Figure 10: No vanishing point

A flat input is devoid of vanishing point. The offset of than input shifts the view from the left to right as seen in the first experiment. Through the base examples we have already overcome many of the limitations of the stationary viewer in the creation of images by altering perspective around the viewer through simple math and a process that is not much more involved than cutting and pasting.

Figure 11: Multiple perspectives in one image

Beyond the fact that many types of perspective can be created, some of which are new, there is also the possibility for these types to co-exist in a single image. An image can be created which is entirely orthogonal save for the fact that is has one (or more) simultaneous vanishing points. Beyond simply recreating perspective that we've already seen, there is the opportunity to invert the system and create new perspectives that have not been seen before.

8.7 New Vanishing Points

Figure 12: Reversed perspective and input histogram

When we bend the system beyond flat and have the left side of the image favor right views and vice versa we create something more interesting than a reversed image, we create an inverted system of seeing.

In this configuration, right looks left and vice versa we create a system that leads to a reversed vanishing point. Lines diverge as they recede to the background. As such objects enlarge as they become further from the viewer. This point does not need to be at the horizon, it can be pulled closer to the viewer. Objects past that point then reemerge, though they are reversed. In a sense, we have pushed the focal node past the optics and within the area of the subject. In one image, we have a foreground on top of a background which has been inverted left to right, with a reverse vanishing point separating the two areas. Depth is still preserved, though left and right are reversed. This is experienced when this system’s stereoscopic features are used.

In a simple system such as this, stereoscopy was an easy addition. All that was needed was the ability to pull information offset by one or more columns. In effect, this sets up a second viewpoint that is separated by the distance between which any number of frames had been recorded. Through this stereoscopic view we can understand that though the parameters of how this lens works have drastically changed, it still 'works' and makes sense in a three dimensional view.

With this reversed perspective we can also produce a different sort of wide-angle shot from our source panorama. Wide angle in this situation does not mean a range of vision around the camera, but instead vision around the subject. With this perspective we can see up to four faces of an equilateral object — top or bottom, left, front and right — rather than just two at a time. This effect can be brought out further by the way that we capture the source images. A standard and easy way to do so would be in a straight line. Capturing on a curve amplifies the effect.

8.8 Demonstration and Exhibition

Through the input of these offset curves, different viewers can be created within this system. As it was important for this project to contrast with standard perspective and ways of viewing, it became clear that it must address a physical computer for reasons of demonstration and exhibition. Since this project shows also a subjective nature of perspective, it seemed important as well to be able to contrast between subjects. It would be important to view those who are viewing, what they are viewing, and to see the system as a whole.

With this considered, a system was made to track viewers in a certain area in front of a projected view of an area. This system tracks participants with an overhead camera, using blob detection and frame differencing to find positions to create viewpoints for in the system. For every new node, it will modify the output for the columns in the image that are in front of each viewer. As the viewer comes closer to the screen, the perspective of the system reacts to wrap around their position. When there is no viewer, the system is displaying its most neutral configuration; the central view from every column, an entirely flat image. In creating a curved perspective for each viewer, and amplifying it as they come closer to the screen, we create a small environment and simulation for them. The background recedes and its objects become smaller in scale as a vanishing point is created. To the viewer's left and right there is less change, as the geometries become less oblique, eventually becoming flat. This creates a periphery for the viewer. Smoothing the data results in the imagery of the system having an elastic feel to its interaction. It also creates a sweep of oblique angles to the left or right of the viewer when they move horizontally; they create a wake of sorts. When there are multiple viewers in the scene, the differences in perspective are reconciled through interpolation. Standing further back from screen in the interaction area, past a neutral point, brings that viewer's node of perspective

9. Applications and Conclusion

There are many possible applications to this system. Considering the advances in augmented reality systems, it is fortunate that this system can provide a window rather than a simulated object or a frame overlaid as a sprite. The configurations of this system can provide for any number of overlays on to that system. Beyond functioning as a window, the imagery introduced into any virtual or augmented environment can be processed to account for incidental effects. There are many entirely possible though not-yet-realized functions that this system can provide for this. Without actually needing to show the imagery produced for many locations in an augmented environment, the system can find what the view would be for all locations within it. In analyzing the color densities for those positions, an accurate sketch for simulated lighting can be produced. As such, we can produce three-dimensional lighting overlays in virtual environments without the need to model and render the entire outside world. Another application would be for the imagery to function in a virtual window of sorts. Considering the advances in auto stereoscopy and the abilities of display devices to determine their location and orientation this would be expected to function seamlessly once the processes developed for this method have been refined further. This system can also coexist well with current interest in 3D Scanning and Printing by artists that has come about through the greater recent actability to those technologies such as through devices like the Microsoft Kinect and Shapeways printing service. The development of this system for my research has not incorporated such technologies yet, as it still important to consider the systems form before focusing on secondary technologies.

To this end, it has been one of my conclusions through research that the existence of the developed process is a product and accomplishment it in itself. As I had set out to focus attention on the film cameras lack of spatial exploration I researched and developed a system which can legibly introduce non-Euclidean geometry into perspective and reconcile it legibly to a viewer in Cartesian space. Perhaps the most important part occurs before an output image is even produced. The process by which it assembles this image is most important, for it knows nothing of imagery. A lens as Abney suggests[35] is little more than a series of prisms having their frustra joined together.

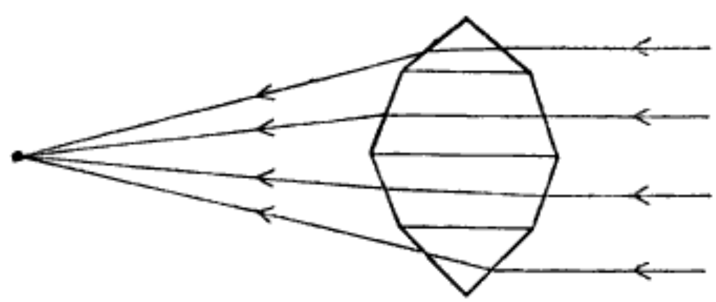

Figure 13: Joined prisms, an illustration from *A Treatise on Photography* by Abney

Increasing the number of prisms brings the surface of this object closer to a limit of a perfect curve and the sections are indistinguishable. These prisms know nothing of light or of their adjoining neighbors. My research has provided a system where these prisms are capable of having variable angles and can allow re-routing of light without interfering with adjacent rays. Abney's prism contains enough elements to

[35] William de Wiveleslie Abney, *A Treatise on Photography (Longmans, Green and Co., 1881), 208*

create a coherent system for images and not just rays from one location. The system I've researched has enough 'lenses' to project an area of 'viewer'. The internal division and routing in the system keeps this area organized much in the same way that sequential frames in film organize movement from motion blur. This process of reversing optics is significant for my research as its existence makes it known to be possible. I hope that future work with this system can explore any practical applications befitting to it. In developing this system I was not looking to make a closed statement but rather to open ended system for new opportunities and exploration. I expect to see more from this path of inquiry.

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