Experiments on Timescape: From Camera Apparatus to Frame Differencing

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The paradigm of drawing has always been closely affected by evolving tools and techniques. Computing, scanning, imaging, programming, simulating, are only a few examples that have brought revolutionary influences on the drawings, representation, or visual culture at large. This paper examines visuals in association with tools that produce them, posting questions on the longevity of techniques, as well as the transformable potential of design emerging from visual experiments.

Taking time as a material to be edited, this paper presents in depth precedent analysis and experiments on capturing and assembling swift movements that occupy a period of time and certain amount of physical spaces either in 2D or 3D. Excavating history of science, photography, and machine vision, the research seeks opportunities of autonomously generating drawings and images mediating perception and cognition within spatial-temporal frameworks.

The first part "The Mechanism" traces an analogy from techniques of representing time used in chronophotography, to the time based trace done with stroboscopic devices and lights, and to image processing and computer vision algorithms that manipulate pixel intensities. Cutting into the smallest manipulatable units- lens in camera apparatus and pixel in computer graphics, the analysis intends to connect basic shared principles for capturing temporal datum legibly.

The second part "The Drawing" presents a parallel set of methodology and related projects that generate visual images engaging assemblage of tools. *Motion Lens(es)* proposes design prototypes that extend the original functionality of camera apparatuses into spatial configuration. Based off the abstracted structure of photographic systems, these designed instruments consist of light distribution, laser beam projection, or extension of digital camera. Animated visual patterns are created responsively from subject matters in motion. *Record Mirror*, on the other hand, explores digital structure for constructing a similar visual effect. It assembles delayed time from live video feed into visual promenades. Operating on pixels of selected frames, different length of time periods recording oneself is controlled by a series of variables, turning the practice of trace conducted in Marey's chronophotography into a real-time installation.

> "Time, not objects, thus becomes the raw material of the moving image."
>
> — Sean Cubitt [1]

INTRODUCTION

For the past three decades, mass producing hyper realistic images with computer is less of interest than developing new tools, advancing computational methods, or transforming pixels on screen into actual materials. Beyond efficiency and functionality, more profound questions on digital have been discussed. We seek meaningful ways of transcending ever-evolving tools and techniques into informing new possibilities in design and representation.

Experiments on Timescape presents an ongoing investigation that traversing across precedents over centuries that focuses on representing movements and temporality in highly structural ways. Tracing an analogy between analog and digital mechanisms on the smallest manipulatable units— lenses in camera apparatuses and pixels on screens, these experiments challenge the use of only current technologies but excavate the initial emergence of scientific inventions. Drawings produced along the process are not only instruments of representation and expression, but are also mediums about mediation, montage, visual patterns being viewed in conjunction with their associated tools, and how these associations evoke transformed notion in design.

Starting with photographic and cinematic tools which challenge the perception of motion with either spatial or temporal constraints, this investigation looks at the concept of intermittent motion and its optical impacts across space and time. Though identifying the action of fragmentation as the basis of measuring time and mediating vision, a series of experimental projects seek ways of capturing, perceiving and editing swift movements. Built upon analysis and reinterpretation of scientific mechanisms, visual effects are composed through light distribution, laser beam projection, or real-time video feed, reconfiguring time and space utilizing physical instruments, or image processing and computer vision principles. Taking time as material, this research intends to critically situate between media archeology and technological future.

PART 1. THE MECHANISM

In his book *The Practice of Light*, Sean Cubitt elaborated on the fragmented movements that related to the reading of time. He described it as the "intermittence of motion"— a hallmark of the visual media in nineteenth century, which "trends toward a proto-digital decoupage of continuous motion into segments." According to Jimena Canales (2009), the action of fragmentation, from chronophotography of Etienne-Jules Marey to Frederick Winslow Taylor's time and motion studies of industrial labor, derived from the desire "to overcome the physiological problem of observation that plagued the nineteenth-century drive to accurate measurement"[2]. The manipulation of intermittency has taken various formats of augmentation— by subtracting background, isolating oneself, or deploying optical mechanism.

THE PRACTICE OF TRACE

The year of 1882 could mark one of the most important times in media archaeology. It was during then Etienne-Jules Marey constructed the first camera apparatus for his famous chronophotographs. "Slicing time", was the notion evoked the invention and development of chronophotography. Derived from the Greek word *chronos* (time) and combined with *photography*, it is defined as "a set of photographs of a moving object, taken for the purpose of recording and exhibiting successive phases of motion." [3]

Designed to record the whole series of chronophotographs on the one negative, his device consisted of a plate camera equipped with a spring motor-driven rotary disc shutter with a number of regularly spaced apertures. As each aperture passed in front of the plate, it recorded the position at that instant of an object moving across the field of the camera. A small object moving quickly recorded a series of separate images on the plate, the space between depending on how fast the shutter was rotated.

Working towards the desire of smaller and smaller units of a continuum that he himself conceptualized as "infinitely divisible" [4], Marey encountered limitations of Chronophotography: superposition and confusion caused by the spatial difficulty (a finite space, or a fixed plate), and the consequent legibility of time. To find a place between fusion and fragmentation became very critical in using this technique for representing time legibly. It was then, necessary for him both to "sample" precisely and to "contract" slightly with a certain amount of distancing [5]. To do so, he experimented with several methods, including gradually "excising distractive details" by clothing his subjects completely in black, attaching luminous dots and striping, and using "blacker background" [6], as a natural way of tracing, with the outcome as a series of chronophotographs consisting of only lines and curves in space, known as "geometric chronophotography" [7]. On the other hand, in a more ingenious method, Marey combined this geometric chronophotography with a manual way of tracing by rearranging the images cut out from a strip of film, placing them slightly overlap with one another, and then re-photographing the new arrangement. Or he would project the images and trace their outlines onto another image, transform photographic modes of representation into graphic ones in order to overcome finite plate limitation, as well as the separation between each individual strip of film. This spatial-temporal operation of tracing the intermittent motion paralleled another optical tool— the strobe.

THE ART OF WHIRL

Equivalent important mark of measurements and visual representations of time is the year 1931 when the electronic strobe light was invented by Harold Eugene Edgerton. Dr. Edgerton used an open camera to record an object moving in strobe light as an overlaid set of still images. Very short flash of light was used as a means of producing still photographs of fast-moving objects, such as bullets in flight. Most famous for its applications in high speed photography, the origin of strobe could credit to Joseph Plateau of Belgium, who used a disc with radial slits which he turned while viewing images on a separate rotating wheel in 1832. Known as stroboscope, it derived from the Greek words *strobos*, meaning "whirlpool" and *skopein*, meaning "to look at".

Stroboscope is a measuring tool editing time as the raw material using frequency. A succession of images is rapidly alternating between present and absent due to the slit structure that reveal them at certain interval. This interval is small enough that the segmented images present to our eyes with persistence of vision as a piece of duration, stitching intermittent motion into continuum. While operating at certain rates, a disc with slits, or a light flashing in the dark, excising a period of the moving images, will result in a freeze of motion, or an illusory perception of the pace as well as the direction of the movements. A fan running, a person moving, exposed to the strobe light throwing onto them, appeal to be fragmented. The mechanical projection of the high speed light flash transformed the man labor of the "tracing" as Marey performed with his one-negative photos, challenging the temporal dimension of the legibility of time.

FROM LENSES TO PIXELS

Parallels Marey's chronophotography, assemblies of optical lenses present a wide range of typological opportunities for time to be visually recognized and reconstructed throughout history of science and photography. The capacity of representing the smallest difference— either spatial or temporal— between each pair of adjacent images captured during a sequence of motion is the basis. Eadweard Muybridge's multi-camera device— tripped by wires as a horse passes through— takes 24 images within a swift period of time, from which the locomotion film was composed. Fast-forwarding to 1999, *Bullet Time*— a more recent model named after the famous time-frozen scene in *The Matrix*— records the same scene with an array of camera from slightly different angles towards the moving subject. The post-editing process will then stitch the scene together into a video clip, allowing itself to be slowed down or sped up. In the movie, the man dodging

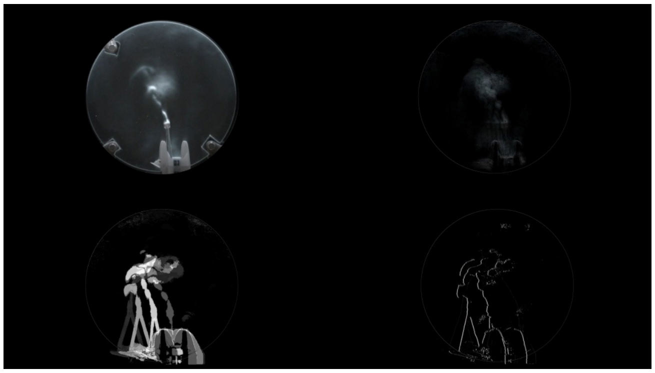

Figure 1. Screen shots from controlling variables using computer vision to generate visual images of movements. Top: raw video data (left), frame differencing applied sampling every other frames (right); bottom: frame differencing applied sampling every 10 frames (left); edge detection from the processed frames on the bottom left (right).

the bullet was shown as a slow motion in which the camera appeared to virtually moved 360 degrees around the shot. A piece of a frozen moment is presented in motion.

Digital imaging, on the other hand, captures the micro differences through another mechanism— pixel processing. As Jonathan Crary claimed that visual images from "computer-aided design, synthetic holography, flight simulators, computer animation, robotic image recognition, ray tracing, texture mapping, motion control, virtual environment helmets, magnetic resonance imaging, and multi spectral sensors images…" is referred to "millions of bits of electronic mathematical data" [8], pixel describes the smallest addressable element of raster images on screen. The word *pixel* is composed by *pix* and *element* in its etymology. Instead of stitching fragmented frames into a whole, this digital process dissects an entity into the smallest representable visual data. Defined by the value of intensity, a subtle change of each pixel could be recognized by machines through an updated number. The change of value of a pixel with specific coordinate forms the basis of image processing algorithms.

Frame differencing is a typical example of computer vision that operates on pixels of images. As the computer checks each pixel on two video frames, changes between frames due to movements will result in increases or decreases of pixel intensity values. By comparing the difference in these values of pixels that share the same coordinate on two separate frames, the cartography of movements spans certain time period could be computed and visualized. Similar attempts as Marey's tracing practices, background color, contrast, and legibility of individual figure in motion, could be adjusted accordingly with a set of variables such as the threshold of intensity changes, the number of frames extracted every second, overall number of frames on display and the transparency between each. (Figure 1).

PART 2. THE DRAWING

Transforming the *lens* and *pixel* based mechanisms in editing movements and time, drawings could be produced autonomously through either analogue instruments, or digital structures. Motion— as the input material— generates atmospheric visual output, an alternative topography, pattern, mediation of the perception of time.

MOTION LENSES

Motion Lens(es) is a series of operable devices developed by students in my Atmospheric Animations seminar in spring 2014. With the notion of tracing and assembling the dynamism of space, these projects derive from examining the interdisciplinary development of methods and tools of studying figures of motion. Coupling photographic and cinematic techniques to capture and to reproduce transitory motion imagery, instruments are made reconfiguring sophisticated optical apparatus abstractly with altered scale, material, and operation methods— to engage new technological products, and to produce accurate performance in measuring and tracing motion inputs.

Ambient complex environment are recognized through dynamic drawings produced in real-time, celebrating the concept of each element in space as a figure of motion, being sensitive to a specific period of time. Scale and construction of these devices are articulated in order to trace moving patterns of a cat or a turtle, while suggesting the potential of expanding their sizes and complexity.

Motion Device (Figure 2)— one of the examples in this series— takes Muybridge's multi-camera device as the precedent. The famous photographic experiment "Sallie Gardner at a Gallop" of a galloping horse was done with this apparatus in 1878. As previously elaborated, Muybridge used a series of equipment with trip wires triggering shutters. *Motion Device*, instead, encompasses a set of "trip lasers". Three RGB lasers emit from a curved brace and converge at a certain distance, where they are mixed through a collecting lens. Colors of the mixed lasers are then distributed from this lens to the display panels on the opposite side through a grid of optical fibers. The motion pattern is transformed into color variations while different lasers are being blocked by a cat walking through the device. With Muybridge's sophisticated photographic device being transformed into a spatial component, abstract drawing with color variance is produced responsively from cat movements and fiber optic panels.

Bullet Time Device (Figure 3)— another example from this group of projects— looks at the array structure of the camera assembly from *The Matrix*, particularly how individual camera reposition its focal point at moving subjects through a single master control mechanism. This particular design turns the moving subject into a laser beam input that could move along a linear path. A set of "lenses" are connected to

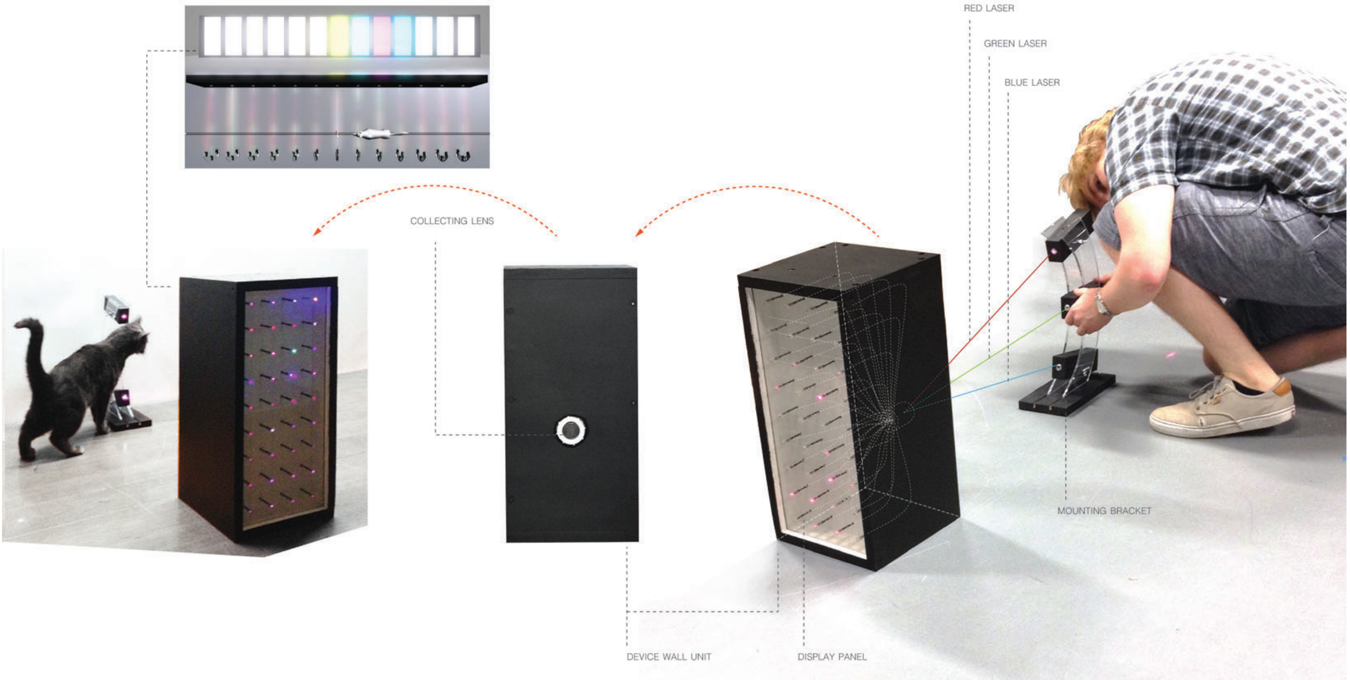

Figure 2. *Motion Device* by Garrett House, project from Atmospheric Animations seminar, Spring 2014. Diagram by author.

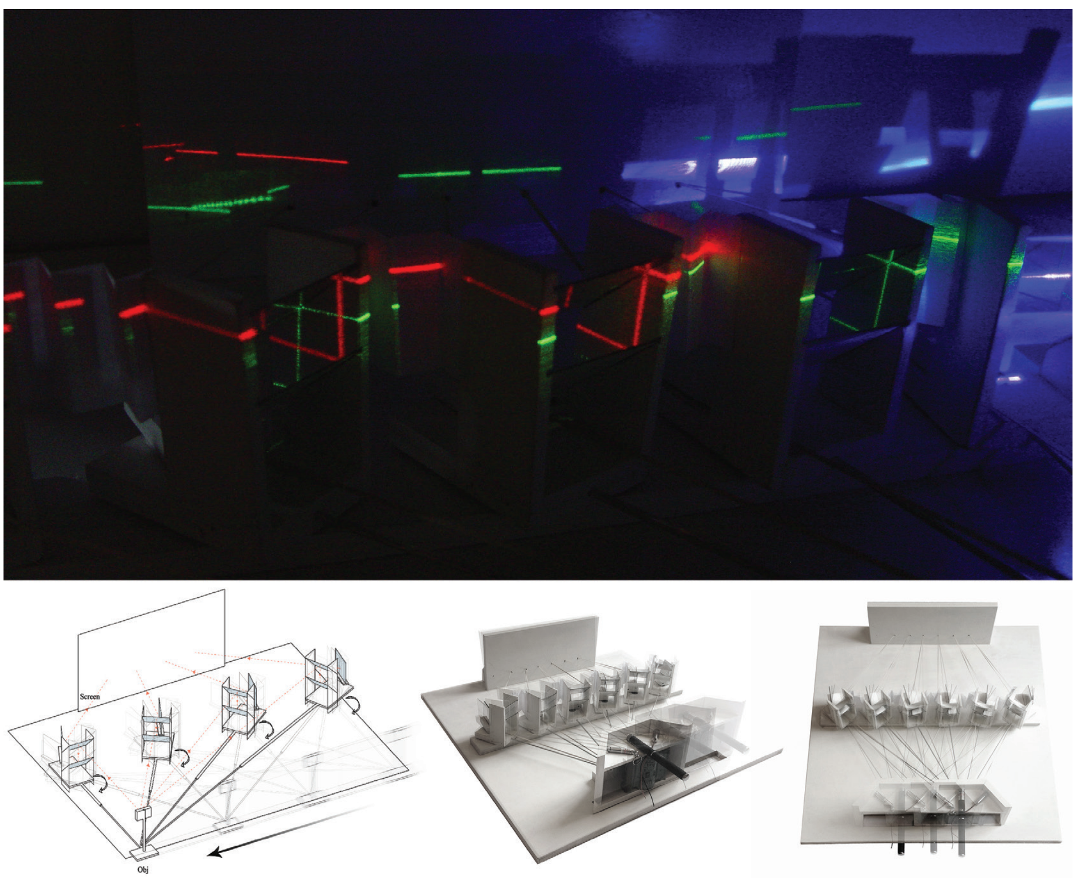

Figure 3. *Bullet Time Device* by Nasim Daryaee, project from Atmospheric Animations seminar, Spring 2014. Diagram edited by author.

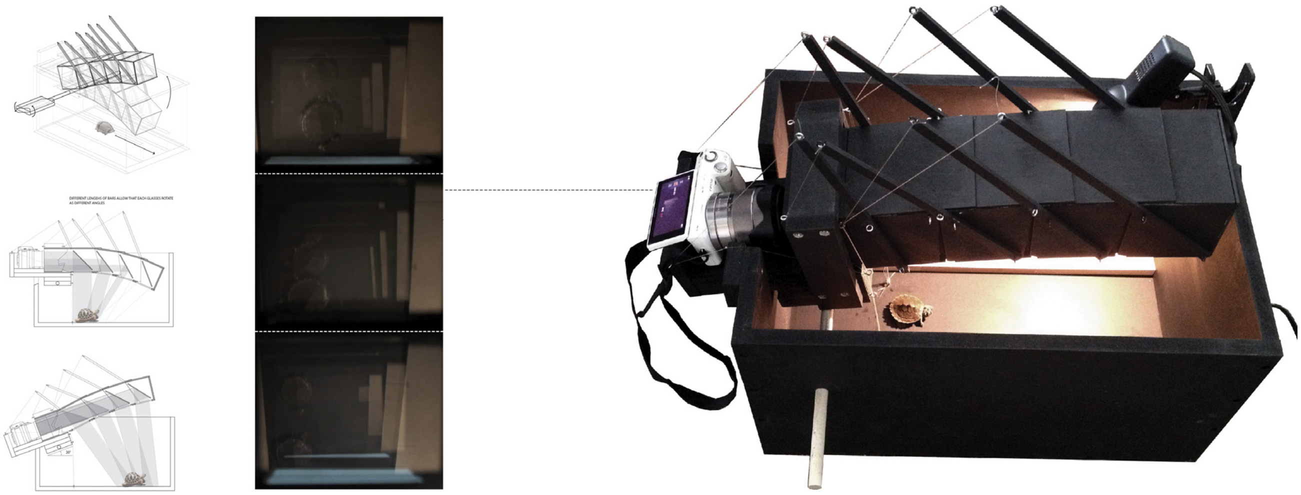

Figure 4. *Shared Recognition Machine* by Janghwa Park, project from Atmospheric Animations seminar, Spring 2014. Diagram edited by author.

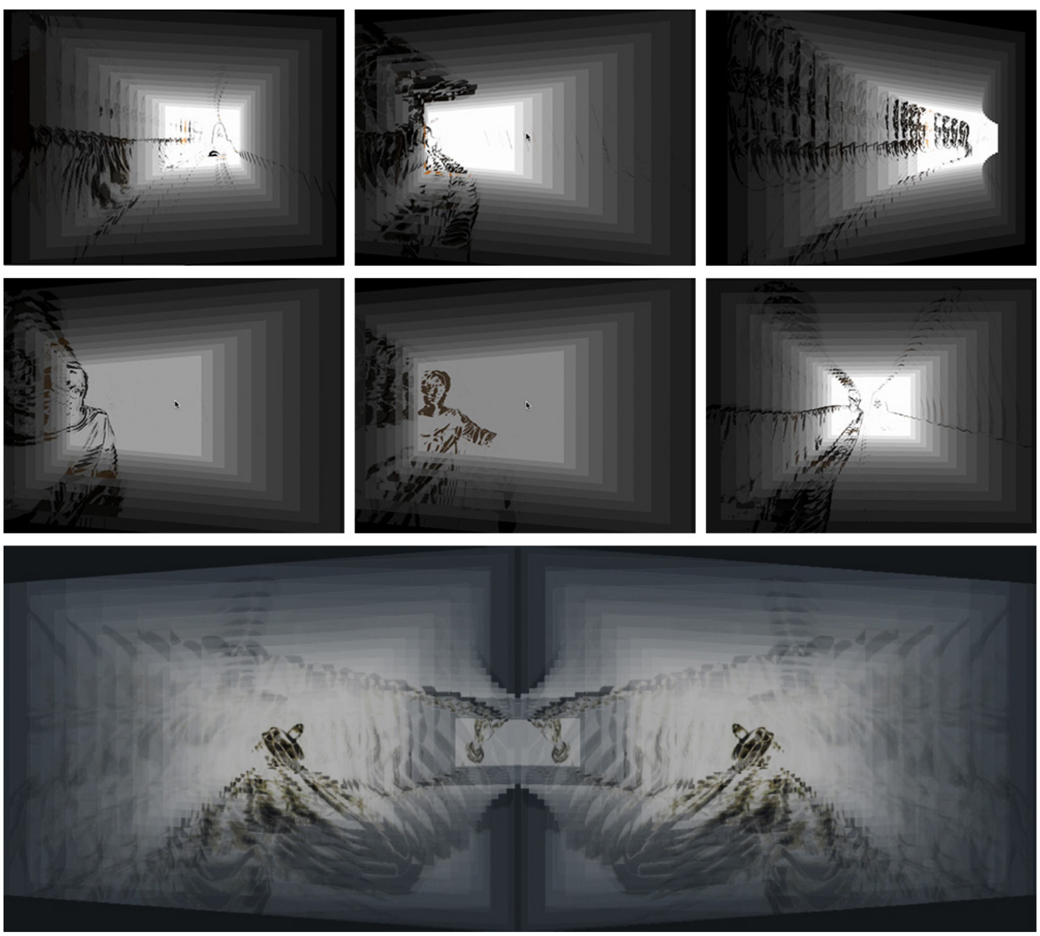

Figure 5. Frames extracted from *Record Mirror.* An Experiment with live video feed and frame differencing. Controlled by various hand positions, number of frames, etc. Project by author in collaboration with Davis Owen.

this light input through expandable linkages, translating the linear motion into an array of rotation of the lenses. Each of the lens components consists of three mirrors— precisely positioned— reflecting the input laser beams perpendicularly towards a flat screen which located on the other side of the lens. A light dot is turned into dash lines in the projected pattern, being extended horizontally as the number of lens increases.

Shared Recognition Machine (Figure 4) utilizes the principle of bullet time with a different approach. Constructed as an extension of a digital camera, it arrays linearly the image being captured in real time. Four pieces of mirrors are assembled with levers connecting to a central handle with cables. As one turns the handle, the whole set of mirrors will tilt upwards or downwards, with the angle between each simultaneously varied with the overall movement. Four images present at the same time of a turtle moving. The slight different angles of the images offer opportunities for our brain to recognize the three-dimensional information by stitching the separate 2D images together.

Designed as operable pieces responding to the movements of small-size animals, these devices and the visual patterns being created are scalable. They are essentially tracing machines that suggest the potential of becoming architectural systems that transforming motion patterns at human scale and beyond.

PIXEL MIRRORS

Moving from experiments on lenses towards pixels, *Record Mirror* (Figure 5) is developed as an interactive projection installation that assembles real time and delayed time into a spatial organization. Captured from a webcam, frames are selectively stored in a data structure, which are then displayed with a reconstructed time frame. Newly captured pairs of video frames - processed through frame differencing algorithm to identify the movements between the frames through pixel intensity comparison— are layered on top the processed old pairs, proportionally scaled down towards the center. As the current frame becomes the past one, it appears to move outwards. The newest frame— one in the real time— maintains the smallest size at the center of the screen. Illusion of depth is perceived as motion being generated from the furthest plane. A visual promenade is created virtually.

The capacity of recognizing each pixel, and giving it a new identity, allows various spatial configurations spanning different length of time periods to be constructed. The number of frames sampled from live video feed per second directly controls the amount of delay. And the reading of depth is affected by both the overall number of video frames stored in the computer program, and a size factor that determines the proportion of two adjacent frames being displayed. The center shifts with hand motion as input, creating perspectival distortion.

PROTO-DIGITAL TO POST-DIGITAL

Marey condemned time-based media by claiming that they “produces only what the eye can see in any case”, but “the real character of a scientific method is to supplant the insufficiency of our senses and correct their errors”. Exploring the representation of time incarnating in physical movements in space, a shared mechanism built upon smallest optical and digital units as well as their assemblies has traced the visual and the design potential of timescape from proto-digital to post-digital context through this scientific approach.

ENDNOTES

1 Sean Cubitt, *The Practice of Light: A Genealogy of Visual Technology from Prints to Pixels* (Cambridge, MA: MIT Press, 2014).

2 Cubitt, *The Practice of Light*.

3 The J. Paul Getty Museum . *Photography: Discovery and Invention* (Getty Publications, 1990).

4 Mary Ann Doane, *The Emergence of Cinematic Time: Modernity, Contingency, the Archive* (Cambridge, MA: Harvard University Press, 2002).

5 François Dagognet, *Etienne-Jules Marey: A Passion for the Trace* (New York, NY: Zone Books,1992).

6 Doane. *The Emergence of Cinematic Time*.

7 Ibid.

8 Mark B. N. Hansen, *Seeing with the Body: The Digital Image in Postphotography*, in Diacritics, Vol. 31, No. 4 (Winter, 2001), pp. 54-84 (Baltimore, Maryland: The Johns Hopkins University Press, 2001).