Living Images: Images Supported by Living Things

Kazuhiro Jo[1, 3], Juppo Yokokawa[2], Nobuhiro Masuda[1]

jo@jp.org

[1]Faculty of Design, Kyushu University
[2]Art Media Center, Tokyo University of the Arts
[3]Yamaguchi Center for Arts and Media (YCAM)

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ABSTRACT

We propose the notion of "Living Images" by reviewing the historical background from early color photography through germ paintings with microbes to recent artworks include our audiovisual work Chromatophony. We aim to highlight the link between digital and living images and initiate discussions on future forms of display.

1 INTRODUCTION

In this talk, we propose the notion of "Living Images," images supported by living things. In recent decades, bioart [1], [2] has become a popular form of art that transcends the dichotomy between analog and digital. These practices often foreground a visual aspect as a part of their expressions. From the perspective of a display, we could see such imagery practices supported by living things as "living images." We present the historical background from the Lumière brothers' autochrome [3] and Alexander Fleming's microbial paintings [4] to labyrinth solving by Physarum polycephalum [5] and DNA-Encoded movies [6] with recent practices in bioart/design. To examine the details of living images, we will introduce our audiovisual work *Chromatophony* (2018) made with squid chromatophores. We will discuss the potential of living images as a display by comparing pixels of digital images and living cells of living images. We also consider the friction of two cultures [7], science and humanities, that has emerged from living images in terms of bioethics.

2 BACKGROUND

In this section, to provide a genealogy of living images, we will consider the historical context of how living things are used in the practice of image-making and provide an overview of recent works in bioart.

2.1 Autochrome

In 1904, Louis Lumière, one of the inventors of cinema, presented the autochrome, an early color photographic process [3]. In this process, a mosaic of translucent potato starch granules additively recreates the color of the original scenes. Each granule is dyed either orange, violet, or green, and exposed to transmitted light from the original scene with colored filters. With a density of 8000–9000 elements per square millimeter (Fig. 1), there are approximately 200 million grains on the original 13×18 cm glass plate (Fig. 2). To achieve the required grain size (less than 15 μm across), Lumière tested various tubercles and rhizomes, inventing a way to collect grains with "great regularity" by mixing them in water. The autochrome started with a glass plate and was replaced with film in 1931. Although the dominance of the autochrome declined quickly due to the emergence of higher sensitivity, higher resolution subtractive chromogenic color film, developed by Agfa and Kodak in 1935, we could regard its invention of additive color synthesis as a precursor to existing color display systems.

2.2 Germ Art

One day in 1928, Alexander Fleming discovered the antibiotic properties of penicillin from his left petri dish. He was not only a noble-prized scientist but a self-taught painter, working in the medium of living organisms. He painted everyday scenes with various growing microbes as pigments to produce different colors (Fig. 3). A petri dish with agar was an organic medium, either as artistic or biological supports, inoculated with varying spices using a wire tool. The painting required a particular time to mature the species and existed a few moments when one species grew into the others [4]. Successors of his paintings, several contemporary artists are still working with microbes. Some of them have produced a collection of bacteria and fungi to serve as a palette of different hues, textures, and effects [8]. Others have organized a competition [9] for the burgeoning range of techniques and artistic styles in the field. The constant change, the death of bacteria, and the unpredictability is part of the work [10]

2.3 Labyrinth Solving

Nakagaki et al. discovered that the plasmodium of the slime mold *Physarum polycephalum* can find "spontaneously/intentionally" the minimum-length solution between two points in a labyrinth [5]. They put a plasmodium in a maze on an agar surface and placed food at the laryinth's start and endpoint (Fig. 4a). Gradually, the plasmodium filled the four possible routes (α1, α2, β1, β2) (Fig. 4b) and found the minimum length (Fig. 4c). As the researchers argued, we could regard the experiment as a cellular computational process with primitive intelligence. However, from the perspective of imagery, we could also find similarity in the semi-automated movement of the result (i.e., the minimum length) and a record of painting, such as *Le Mystère Picasso* [11] in terms of their unveiling of the intertwine process.

2.4 DNA Encoding

In 2017, the Harvard Medical School team encoded the very first motion picture of a moving horse filmed by Edward Muybridge in 1887 [6]. They first assigned each pixel in the a GIF-version of the black-and-white film to corresponding DNA code with A, T, C, and G. They then put the information for each frame into the genomes of a population of living bacteria by using the CRISPR-Cas system. The bacteria preserved the information in each new generation of progeny. For decoding, they read the DNA and extracted pixels and frames from the living storage system (Fig. 5). It is now possible, as the authors argue, to “create living organisms that capture, store, and propagate information over time [6].”

2.5 Works in Bioart

Among others, there are several works in which images are supported by living things. One example is *Living Images* (same name but different practice) by Johanna Rotko [12] a series of “yeastograms” or images made with living yeast cells. The artist used ultraviolet (UV) light to expose raster images printed on a film onto cultivated yeast. The UV light killed the exposed yeast cells, and while the yeast sheltered under the black parts of the film formed the image on the growth medium (Fig. 6). The image evolves through different states of growth and is eventually covered by molds and other species.

Another case is *[ir]reverent: Miracles on Demand* by Adam W. BROWN [13] (Fig. 7). First, a thin slice of bread with “PX” (symbolizing Christ’s name) inscribed on it is placed in the oculus. Then, a strain *of Serratia marcescens*, a microorganism that produces a viscous liquid similar to blood, is dropped onto the bread. The incubated microorganism eventually produces viscous red fluid causing the bread to “bleed." According to a review, "We no longer need gods to perform miracles for us; we can now produce our own. However, we still need a little help from the true rulers of this planet: the bacteria." [14]

3 Chromatophony

As a last example for examining living images in detail, we introduce our audiovisual work *Chromatophony* (2018), which allows for vivid color expressions by inputting audio signals as electrical stimuli to squid chromatophores [15] (Fig. 8). Squids are known to change their body color rapidly to “display” patterns for purposes of intimidation or camouflage. This color change is made possible by a set of organelles called chromatophores through the relaxation and contraction of muscle cells controlled by electrical stimulation from neurons. This property makes it possible to artificially stimulate the chromatophores using an external electrical signal. Backyard Brains described an experiment wherein music was used as the electrical stimulus to move a squid's chromatophores [16].

Based on the work by Backyard Brains, we investigated the relationship between the response of chromatophores to a sound signal while adjusting its frequency (Fig. 9). The results suggested that the squid's chromatophores responded best to sound with a frequency of approximately 90 Hz and barely responded to sound with frequencies greater than 800 Hz (Fig. 10). Based on these results, we produced music and recorded the chromatophores’ reaction to the music on video using a digital microscope. Because chromatophores stop moving after four or five hours of activity, it was necessary to use a fresh squid specimen for the work.

4 DISCUSSION

The six examples we have examined so far, from the beginning of the last century to the present, are characterized by attempts to produce images that are alive using living things as material supports. Each attempt, of course, is different in term of its original aim, from a commercial application (Lumière) and scientific projects (*Physarum polycephalum*, DNA) to a hobby (Fleming) and means of artistic expression (Rotko, Brown). However, reconsideration from the historical perspective of visual display, it is possible to examine these practices as a genealogy of exhibiting the living images that have been passed down through science and humanities. In fact, some theorists have recently related the discrete nature of pixels, a primary element of digital display, to not only Autochrome Lumière, but also to the pointillism of Impressionist paintings of the same period [17], [18]. To clarify this point, we will conclude by examining our latest case study, *Chromatophony*, in comparison to the characteristics of digital displays (or their primary element, the pixel) (Table 1).

Table 1. Comparison of pixels and chromatophores

	Pixels	Chromatophores
Temporal	Stable	Instable
Spatial	Homogeneity	Specificity
Control	Central	Peripheral

Temporally, it can be said that pixels maintain their quality for a long time, whereas chromatophores exhibit rapid temporal changes (i.e., growth and decomposition). Second, spatially, pixels are interchangeable and homogeneous and require accurate color reproduction between displays, whereas chromatophores show differences at multiple levels, such as between individual squid samples and different cephalopod species. Finally, while the pixels in digital images are completely passive and centrally controlled by a control unit, a squid's chromatophores are said to have their own photoreceptor function, and most of the neurons in cephalopods are distributed not in the brain but in the arms. These characteristics pointed out in Chromatophores should not be seen as negative for their inconveniences or uselessness, but rather as indicative of what a display would be sustainable in this age of the Anthropocene.

5 CONCLUSION

More than half a century ago, C.P. Snow described the divide between the natural sciences and humanities as "two cultures" [7]. To this day, each of these fields are withdrawn into their respective domains, and the issue of their division has yet to be fully resolved. However, we believe that digital display provides an efficient medium to act as a device bridging the two cultures, nature and art. As a cross-disciplinary approach, the concept of "living images" identified here can serve as a powerful catalyst toward the development of mutual understanding between science and the humanities. In this regard, it is interesting to note that in the case of Fleming mentioned earlier, it has been suggested that germ painting is not just a hobby but an important step towards the achievement of discovering penicillin [4]. Regardless of this anecdote's veracity, within the buried histories of the practice of living images, we could find some significant clues for the future forms of the display.

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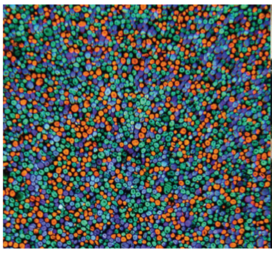
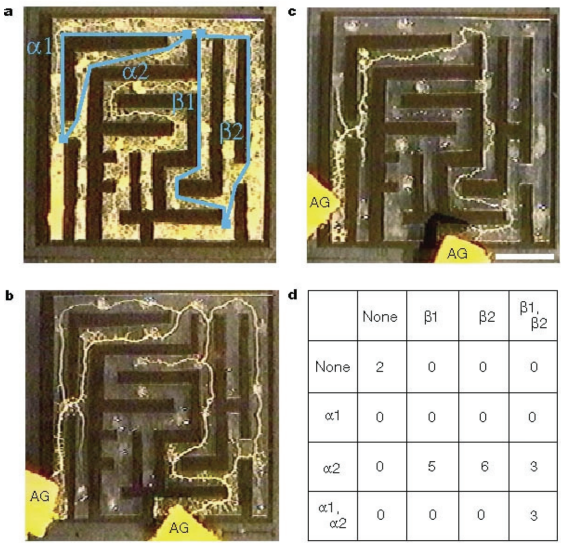


Fig. 1(left) The colored starch grains in an Autochrome plate., Fig. 2(right) House in Stockholm, Autochrome, 1930.

Fig. 3 (left) Fleming's bacteria paintings [4]



	None	β1	β2	β1, β2
None	2	0	0	0
α1	0	0	0	0
α2	0	5	6	3
α1, α2	0	0	0	3

Fig. 4 (right) Maze-solving by Physarum polycephalum [5]

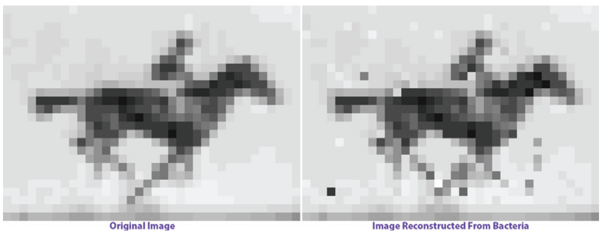


Fig. 5 The original image (left) and the image reconstructed from bacteria (right) [6]

Fig. 6(left) *Living Images* by Johanna Rotko (2020), Fig. 7(right) [ir]reverent: Miracles on Demand by Adam W. BROWN (2019)

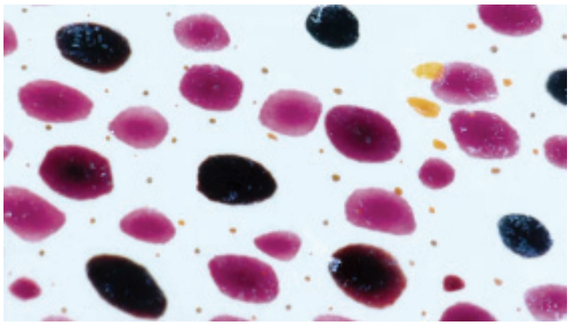


Fig. 8 Screen capture of "Chromatophony (2018)" by Juppo Yokokawa and Haruki Muta

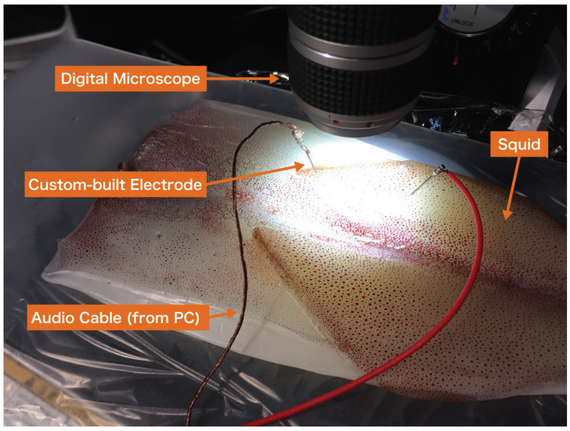


Fig. 9 The way to investigate the relationship between the response of chromatophores and the sound signal.

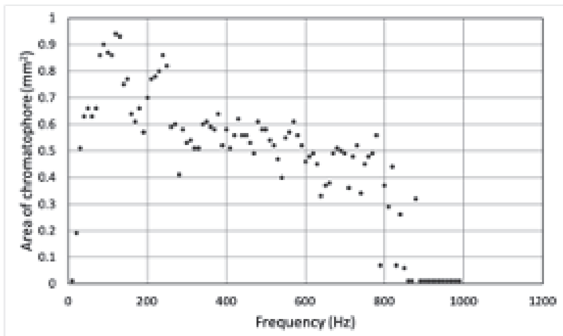


Fig. 10 Area of chromatophores at different frequencies.