

21st Century Wundermaschinen: Mechanical Art Practice in Open Source Culture

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Abstract

This article discusses the implications of open source culture within new media art practice from a practitioner's perspective of view. This article firstly discusses contemporary scholars' work on the notion of 'computer code as magic incantation'. This interlinks digital media with the pre-modern esoteric experience to provide a research context. This discussion is followed by the description of artists' advantages of working within an open source society which includes the efficient solution of technical and conceptual problems. Further, the thesis focuses on the new challenges the code sharing culture has brought to the artists: while the mysterious cover of techniques were revealed, how do the artists discard the conventional notion of 'skill pioneer' and 'technique creator', and further produce art work with unique qualities? In order to provide a possible solution to these questions, the author would like to introduce the notion of 'Zombie media', an approach of applying media archaeology into artistic methodology advocated by media archaeologist Jussi Parriks. This discussion illustrates contemporary machine prototyping with the reuse, re-exploration and circuit bending of old media. This method proposes a depunctualization of media and the opening, understanding and hacking of concealed or blackboxed systems. It also suggests that media never dies: it decays, rots, reforms, remixes, gets historicized and reinterpreted. Finally, this article illustrates how this method of coded magic merging with zombie media can be applied by individuals to create unique experience, and how art practice corresponds with open source culture.

Key words

Wundermaschine, media archaeology, open source, zombie media, digital art practice

Introduction

Open source is a development model that promotes a universal access to the developers' computer codes and design blueprints. These sources are free to download and improved by any other developers. The artwork/ design can therefore be used and modified by the general public and have the potential to be developed collaboratively. However, several expectable issues are raised: What is the art technique in open source culture? Is there a method the artists can apply in practice, to develop digital artwork that is unique and novel while working open-sourcely? This thesis looks at the influence and impact of open source culture on contemporary developers and aims to provide an insight of art making in open source culture. A practical experiment that supports the argument will be provided.

Coded Magic and Magical Code: Computer Coding as Artistic Technique

In digital artwork, computer programming (also as coding) is often used by the artist as a technique to give instructions to their interface (or machine, artifact, etc.) to perform, display or to create experiences. The interface embedded with the written instructions, becomes able to perform the artist's concept to the audience. In this sense, the art work, an assemblage of various instructed commands, can be taken as the artist's agent. Recently, cultural theorist Kevin LaGrandeur examines the parallel between the “magical codes” of the Renaissance occult science and the “coded magic” written by the contemporary computer scientists. He suggests that both use the power of words to effect changes in nature, express universal physical laws via metaphorical correspondence and pursue the hidden connection between words and reality (Yates, 1967; LaGrandeur, 2013). Some scholars start to excavate the metaphorical meaning of computer coding and consider the practice of experience design through digital means, such as digital art and interactive design, can be considered as the “*persistence of pre-modern occult ideas*”¹. That is to say, there is an interesting parallel between the modern intention of creating aesthetic experience through programming language and the pre-modern occult scientists' (including magician and alchemist) practice of coding/ decoding natural phenomena.

In “*Androids and Intelligent Networks in Early Modern Literature and Culture: Artificial Slaves*” (2013), LaGrandeur discusses about this analogy. He illustrates the influence of magic

¹ LaGrandeur, K. (2013). *Magical Code and Coded Magic: The Persistence of Occult Ideas in Modern Gaming and Computing*. Paper presented at PostNatural: Conference of the Society for Literature, Science and the Arts, University of Notre Dame, USA

and esoteric literature on science and technology in Renaissance. And further, in *Magical Code and Coded Magic: The Persistence of Occult Ideas in Modern Gaming and Computing*, he argues:

“The reason that magical spells that derive from occult knowledge were the first methods that Renaissance occult scientists resorted to when trying to create and control their artificial servants (examples of which include the golem, the homunculus, and various talking brass heads and proto-robots) is because the belief in spells was part of a general belief among humanists and occultists in the power of words to effect changes in nature. This principle stemmed from their idea that humans in the Garden of Eden had spoken the original language that God had used to create the world, and that it was recoverable and usable by humans again under the proper circumstances.” (LaGrandeur, 2013:1)

According to LaGrandeur, the practice of language, engineering and myth of contemporary artists can be traced back to pre-modern alchemical science. Since the alchemists not only have paved the way for a modern understanding of chemical action and reaction, they were also dedicated to the science of the artificial in that they strove to “transmute” natural substances from one form into another. The occult language existed in Renaissance thinking and was considered to be influential upon nature. Cultural historian Jonathan Sawday (2007) quote English playwright Ben Jonson’s work *The Alchemist* (1612), to discuss the relationship between esoteric literature and science:

“The power of the alchemist lay in his ability to convince his credulous audience that art (by which Jonson means human imitative skill) might, eventually, be able to transplant nature... It is a brilliant manipulation of words, not things.” (Sawday, 2007: 176)

Moreover, many recent discussion of how machine language is influential on human society², can also find its parallel in pre-modern literatures. For example, in 17th century, to the savants of the Royal Society, the reform of language and the promotion of the mechanical philosophy were seen as allied endeavors. The belief system of the “Clockwork Universe”³ urges the scientist/chemist to question: if machines/ clockworks had no need of rhetoric in their operation, then why should language, which was a token of the presence of the universal instrument of human reason, deploy such strategies? Some suggested that language, too, had to operate mechanically with mathematical regularity and precision. Thomas Sprat, in his

² Modern scholars start to see computer program’s potential in social, economical and political organization. For example, in *Insect Media* (2010), Parikka reminds us the power of non-human aspect of communication and intelligence.

³ An idea originated in 13th century that compares the universe to a mechanical clock. The cosmos continues ticking along as a regular machine (after God’s creation) with its gears governed by the laws of physics, making every aspect of the heavenly system predictable.

History of the Royal Society: for the Improving of Natural Knowledge (1667) proclaimed the advent of a new kind of language: one which would ‘*separate the knowledge of Nature, from the colours of Rhetorick, the devices of Fancy, or the delightful deceits of Fables.*’ (Sprat, 1667:62) This “mechanical language” should operate like an “admirable instrument”, as though language was itself an artificial device or mechanism. This mechanical language would, so it was hoped, result in a recovered purity of speech and understanding: a close, naked, natural way of speaking; positive expressions; clear senses, a native easiness, and bringing all things as near the mathematical plainness as they can. The pursuit of a precise, while at the same time, secret language, and the practice of clockwork analogy and universal metaphors are common in pre-modern science experiments. According to Sawday, it is the search of mechanical language that greatly influences the development of the literature, arts and modern technology.

That is to say, the contemporary artists’ intention of exploring the relationship between language and experience, and engaging sensory perception through coding, can be linked to earlier human occult activities. Contemporary scholar’s discussion on digital materiality also seems to respond to this notion. German media theorist Friedrich Kittler suggests to concern programming with a micro perspective. He argues that “*written texts ... do not exist anymore in perceivable time and space but in a computer memory’s transistor cells*”. (Kittler, 1995) The common idea about software, that is, executable codes should disappear if we go through the architectures and abstractions of the computer. What the programmers understand as languages, are basically representational metaphors of machine operations that manipulate the voltage in silicon circuitry. As Kittler says: ‘*all code operations, despite their metaphoric faculties such as ‘call’ or ‘return’, come down to absolutely local string manipulations and that is, I am afraid, to signifiers of voltage differences*’ (Kittler, 1995). Kittler correlates the metaphoric faculties with the material characteristic and suggests that coding has the ability to transmute natural substances from one form into another. This notion of considering computer chips as “transmutable material” find its resonance to Jane Bennett’s “*vibrant matter*”⁴ and “*Transmateriality*”⁵ proposed by Australian artist-writer Mitchel Whitelaw.

These contextual reviews support intentions to consider “coding” as art techniques in open source culture. Coding is neither an informational process nor mathematical equations; rather, it is a direct engagement in materiality as well as domination of cultural metaphors. Coding works on connecting objects, transmuting materials and generating experiences. In this sense, we could locate several questions: While the secret language of coding is shared online, what

⁴ See Bennett, J. (2009). *Vibrant matter: A political ecology of things*. Duke University Press.

⁵ See Whitelaw, M. (2010). After the screen: array aesthetics and transmateriality. *Transdisciplinary research: at the intersections between art, science and culture*, 5-6.

is the technique the artist is holding privately? What challenges have been brought to the artists, if the mythical quality of technique is necessary for the aesthetic perception of the work?

The Uncovered Techniques in Open source Cultures: Advantages or Challenges?

Mexican artist Leslie Garcia shares her “*Pulsu(m) Plantae*” project on LessNullVoid⁶ website and Github⁷ archive, which includes details of how to turn the plant into a bio-sensor by detecting the micro-voltage from the plant with operational-amplifiers. Sound feedback designed to show different stimulus reaction were also illustrated step-by-step online. Swedish artist- Ph.D. researcher Mods Hobyesh shares how he develops a touch-sensitive interface by measuring the capacitance between objects and human bodies on Instructables⁸, an online community. He listed all components and tools, uploaded programming codes and wrote a clear follow up steps for other developers to produce exactly the same result. These online resources enable all amateurs with basic electronic knowledge to be able to recreate and even improve the design. The open source community thus allows the amateur to collaborate and communicate with each other across international and cultural boundaries. They quickly learn from the artist and designer’s experience, such as to predict technical problems or even reduce expense for prototyping. However, while everyone possesses these advantages, what is the unique quality the artists can create in their work or design?

Many artworks are made with an intimate integration between technique and concept. For example, Jackson Pollock made his drip paintings by harden brushes, sticks and basting syringes as paint applicators. The technique of pouring and dripping paint is thought to be the origins of the term “action painting”⁹. With this technique, Pollock was able to achieve a more immediate means of creating art. The resulting work often emphasizes the physical act of painting itself as an essential aspect of the finished work or concern of its artist. That is, the technique itself is (becomes) the artist’s concept on canvas. As the Pollocksaid:

⁶ LessNullVoid website by Leslie Garcia. <http://lessnullvoid.cc/content/>

⁷ <https://github.com/Lessnullvoid/Pulsum-Plantae/tree/master/pcb>

⁸ Instructables was created by Eric Wilhelm and Saul Griffith, both graduates from the Media Lab at MIT in 2005. The user can upload DIY projects which other users can comment on and rate for quality.

⁹ See Rosenberg, H., “*The American Action Painters*”. [Online]. Available from:

<http://www.poetrymagazines.org.uk/magazine/record.asp?id=9798> [Accessed 13 Feb 2015]

*“When I am in my painting, I'm not aware of what I'm doing. It is only after a sort of 'get acquainted' period that I see what I have been about. I have no fears about making changes, destroying the image, etc., because the painting has a life of its own. I try to let it come through. It is only when I lose contact with the painting that the result is a mess. Otherwise there is pure harmony, an easy give and take, and the painting comes out well.”*¹⁰

If Pollock see technique as a mean to present his concept on canvas, what is the connection between technique (coding) and the concepts of design in open source culture? While the artists program with Arduino boards, Processing and OpenFrameworks, or reuse the hardware developed by others to realize their design, what is exactly the quality the artists are searching for? Considering the “reuse” of ready-made and the intention of “collage”, it seems the various art methods of the early avant-garde in the early 20th century are worth addressing. From Pablo Picasso and Georges Braque’s work with found newspapers around 1912 to Marcel Duchamp’s Bicycle Wheel of 1913, and Nam June Paik’s rewired televisions as early as 1963, the artists have moved to working with and exploring daily objects, electronics, household gadgets to display abstract, minimalist shapes. Instead of using electronics to explore or develop cutting-edge technologies, this approach embodies the spirit of assemblage and collage, using “trailing edge” everyday and obsolete technologies as its key resource. Interestingly, on recent discussion of how media archaeology can be applied as art methodology, we can identify a similar notion toward art making in DIY and open-source culture.

Zombe Media: Media Archaeology as Art Methodology

Media archaeology is becoming ubiquitous in media studies¹¹. It explores how the “dig” of historical media can be applied in cultural study to discover hidden narratives in linear histories. It reveals the cultural and technological layers of previous media – their impossible desires, alternative past, representation, expansion and unrealized dreams.

Media archaeologists often referred this term to Michel Foucault’s notion of the *Archaeology of Knowledge* (1970). Media is itself an “archive” in the Foucauldian sense, as a condition of knowledge, but also as a condition of perceptions, sensations, memory and time. In other words, this media-as-archive is not only a place for systematic keeping of documents, but is itself a condition of knowledge. Media archaeology can be seen as a method to excavate the

¹⁰ See Barbara Rose (editor), *Pollock: Painting*, Agrinde Publications Ltd.: New York (1980), page 97.

¹¹ For example, an archaeology of compositing (Manovich, 2002), an archaeology of television (Muller, 2000), and an archaeology of peep media (Huhtamo, 2006).

ontology of things, to dig out how a media, manifesto, discourse or trend can be produced, adopted and persisted. Friedrich A. Kittler took Foucault's ideas and applied them specifically to media studies: what if we started to read media technology in a similar way, focusing in particular on how it was created and made accessible in certain settings? Such strategies enable us to view past, present and future as interrelated, as well as helping us to construct alternative histories of the media.

For example, a closer examination of the historical significations of the mechanical clockwork as a symbolical or allegorical device can reveal that at least three contradictory significations of this "master medium" can be found in different historical settings. In mid-century scholastic teachings, the clockwork was seen as God's intervention bringing divine regularity to the erratic flow of earthly existence. In Cartesian terms, the clockwork was reconfigured into a conceptual model of the heavens and of animal and human bodies. There it became a testimony to the strength of human invention and discovery and the power of the human mind to assert control over nature. As such it was seen primarily as an "extension of human agency". Under the condition of large scale industrialization, the same mechanical clockwork transformed into a symbol of inhuman oppression, something Andreas Huyssen has called a "*blindly functioning world-machine*¹²." (Huhtamo & Parikka, 2011. 49-50) How can we accommodate such completely contradictory significations of a machine that has been central to human development for almost six centuries? Media archaeology engages with this question following a discursive approach. It is not concerned with an excavation of apparatuses or the construction of lineages of these apparatuses. Instead, it uncovers the heterogeneity and multiplicity of its object. Unlike traditional archaeology which restricted to material excavation, media archaeology further intends to influence future media practice.

Recently, media theorist Jussi Parikka further argues that media archaeology can not only be considered as a theory and methodology, but should be "practice oriented"¹³. That is to say, we should not only record the past and store it away in an archive, but look at how that past impacts the present. This can be achieved in several ways: through the production of artistic works that engage with historical themes; establishing alternative histories that deconstruct what we understand by the relationship between past, present, and future; finding a way of using so-called 'obsolescent' materials to engage with emerging media cultures; and integrating machines with contemporary artistic and cultural practices.

12 Huyssen, A. (1986). "The Vamp and the Machine: Fritz Lang's *Metropolis*." In *After the Great Divide*. Macmillan, London.

13 See Hertz, G., & Parikka, J. (2012). *Zombie media: Circuit bending media archaeology into an art method*. *Leonardo*, 45(5), 424-430.

In *Zombie media: Circuit bending media archaeology into an art method*¹⁴ (2012), Parikka and Hertz extend this historiographically oriented field of media theory into a methodology for contemporary artistic practice. According to Parikka and Hertz, the practice of *Zombie Media* is:

“close to Do-It-Yourself (DIY) culture, circuit bending, hardware hacking and other exercises that are closely related to the political economy of information technology. Media in its various layers embodies memory: not only human memory, but also the memory of things, of objects, of chemicals and of circuits.” (Hertz and Parikka, 2012 : 425)

In other words, instead of using electronics to explore or develop cutting-edge technologies, this approach also uses everyday and obsolete technologies as its key resource. As a manifesto, five points of *Zombie Media* was proposed in Parikka's blog *Machinology*¹⁵:

- 1. We believe that media never dies. It decays, rots, reforms, remixes, and gets historicized, reinterpreted and collected.*
- 2. We oppose planned obsolescence. As one corner stone in the mental ecology of circulation of desires, planned obsolescence maintains ecologically unsupportable death drive that is destroying our milieus of living.*
- 3. We propose a depunctualization of media and the opening, understanding and hacking of concealed or blackboxed systems: whether as consumer products or historical archives.*
- 4. We propose media archaeology as an artistic methodology that follows in the traditions of appropriation, collage and remixing of materials and archives. Media archaeology has been successful in excavating histories of dead media, forgotten ideas, sidekicks and minor narratives, but now its time to develop it from a textual method into a material methodology that takes into account the political economy of contemporary media culture.*
- 5. We propose that reuse is an important dynamic of contemporary culture, especially within the context of electronic waste.*

The idea of zombie media reminds us that the code sharing, re-using and hardware hacking in open source culture may be considered the reinterpretation of “memory of things”. The artwork can be constructed by circuit bending, other ways of re-using and reintroducing dead media into a new cycle of life. Such materials become zombies that carry with them histories but are also reminders of the non-human temporalities involved in technical media.

¹⁴ Ibid.

¹⁵ See Parikka's blog *Machinology* at <http://jussiparikka.net/>

The Notion of 21st Century Wundermaschinen: Machines of Wonder

In previous sections, we recognize a new perspective of art developing in open source culture. By reusing, remixing and circuit bending the memory of things, we can play with the function and cultural metaphors of a dead media. In Ph.D. thesis, the author considered the artwork created by means of recalling dead machines or referencing obsolete mechanical metaphors as “21st Century Wundermaschinen”. Wundermaschine is a German word that implies the “miracle automata” built by mechanical means between 16th to 19th century. For example, the “Miracle Writing Automata”¹⁶ by German mechanic Friedrich von Knaus in 1760, the “Speaking Machine”¹⁷ by Wolfgang von Kempelen in 1790 and the “Digesting Duck”¹⁸ by Jacques de Vaucanson in 1739. These automata was produced to create wonder and for purpose of collection. As Sawday (2007) suggests, they are also automata created for “poetic resonance” of nature (Sawday, 2007:122). In digital era, the prototyping of Wundermaschinen is to reflect contemporary technical media: how the digital embodies the human and the nature, the occult and the scientific? What are the poetic, imaginary qualities electronic artefact could generate?

***Botanical Universe* (2014): An Experimental Project of Re-purposing Clockwork in Contemporary Art**

Botanical Universe (2014) (fig. 1) explores how historically oriented studies of “astronomical clock” can be applied in the design, conceptual formation and expression of an imaginary machine: a “*bio-timekeeper*“. It was developed open-source with Adafruit Servo Driver and PWM/Servo library online. The developing process was documented on personal website¹⁹ and the Arduino codes were also uploaded to an open Github archive²⁰. The title of this project intimates “Mechanical Universe”, an idea originated in 13th century that

¹⁶ See Voskuhl, A. (2013). *Androids in the Enlightenment: Mechanics, Artisans, and Cultures of the Self*. University of Chicago Press. p:31

¹⁷ See Dudley, Homer & Tarnoczy, T.H., (1950) *The Speaking Machine of Wolfgang Von Kempelen*. The Journal of the Acoustical Society of America, Vol 22, No 2: pp 151-166.

¹⁸ See Riskin, J. (2003) *The defecating duck, or, the ambiguous origins of artificial life*. *Critical Inquiry* 29, no. 4 : 599-633.

¹⁹ See <http://www.pingyehli.com/DM/2014/11/29/exhibition-botanical-universe/>

²⁰ <https://github.com/pingyehli/BotanicalClock>

compares the universe to a mechanical clock. By paralleling the function, expression and belief system of pre-modern automata with a reflection of contemporary bio-tech oriented utopia in pop culture, this practice questions how alternative qualities of machine, such as wonder, poetic and imagination can be embodied in the practice of electronic artefact. The design of the installation intimates the mechanical clocks in mid centuries with laser-cutted wooden hands, meters, structure and wheels. However differently, an ivy plant and a sensor system replace the “escapement”²¹ used in the past to drive the mechanical clock. The Ivy is installed in the center of structure with four environmental sensors which monitors the temperature, light, air humidity and soil humidity of the space. These environmental readings are compared to ivy's best growing condition (based on botanical data) to understand how well the ivy is living in the space. A mechanism with 16 ticking hands is designed to display how well the ivy's is living by different moving pattern and speed. Generally, the better the plant is growing, the faster and more rhythmic the hands are ticking.

In order to create a more immersive experience, the design of sound is taken as an important part of the installation. A pair of contact microphones and amplifiers is attached on the wooden structure to directly transmit the vibration caused by eight ticking motors. The outcome is an organic resonance from the noise of gears as well as a crafty sound from the friction of contacting wooden boards. The sound is amplified without synthesizing to simply bring back the mechanical noises of pre-modern clockwork. Interestingly, from the audience feedback, the sound is thought to create some kind of temporal illusion which guides the viewers' imagination. This feedback will be further explored in future development of this project.

²¹ In mechanical clocks, an escapement is a device that transfers energy to the timekeeping element and allows the number of its oscillations to be counted.



fig. 1 Botanical Universe (2014) displayed at Space 5, Culture Lab, Newcastle University, U.K.
Materials: Plant, laser-cutted MDF, contact microphones, amplifier, speaker, Arduino UNO R3, Adafruit Servo Driver, temperature sensor, humidity sensor, soil humidity sensor, light sensor and wires.

Conclusion

The developers as well as artists can now obtain more sources for creation online. However, while the technical solution and conceptual blueprints can be gained easily, it becomes even more challenging for the individual to develop work that is creative and unique. This thesis provides a practical method by bridging the intention of “media archaeology as art methodology” and “coding as art technique” in open source and DIY culture. It adopts the idea that media never dies and recognize the potential of re-using “zombie media” in the context of contemporary art. By circuit bending, hardware hacking and prototype sharing, the developers/ artists can resurrect and reinterpret the artefact’s memory and cultural metaphors. By adapting an approach that is half-innovational and half-archaeological, the artists are able to reveal the media’s hidden past, cast the media’s future and reflect on contemporary ecological problems and aesthetic quality of information technologies.

References

- Bennett, J. (2009). *Vibrant matter: A political ecology of things*. Duke University Press. Durham.
- Dudley, Homer & Tarnoczy, T.H., (1950) The Speaking Machine of Wolfgang Von Kempelen. *The Journal of the Acoustical Society of America*, Vol 22, No 2: pp 151-166.
- Foucault, M. (1972). *The Archaeology of Knowledge: Translated from the French by AM Sheridan Smith*. Pantheon Books.
- Huysen, A. (1986). "The Vamp and the Machine: Fritz Lang's Metropolis." In *After the Great Divide*. Macmillan, London.
- Jennings, H. (2012). *Pandaemonium 1660-1886*. Icon books, London.
- LaGrandeur, K. (2013). *Magical Code and Coded Magic: The Persistence of Occult Ideas in Modern Gaming and Computing*. Paper presented at PostNatural: Conference of the Society for Literature, Science and the Arts, University of Notre Dame, USA
- LaGrandeur, K. (2013). *Androids and Intelligent Networks in Early Modern Literature and Culture: Artificial Slaves*. Routledge, UK.
- Parikka, J. (2010). *Insect media: An archaeology of animals and technology*. U of Minnesota Press.
- Parikka, J. (2012). *Zombie Media in Leonardo*. Retrieved December 16, 2014, from <http://jussiparikka.net/2012/09/05/zombie-media-in-leonardo/>
- Parikka, J. (2013). *What is media archaeology*. Polity Press, Cambridge.
- Riskin, J. (2003) The defecating duck, or, the ambiguous origins of artificial life. *Critical Inquiry* 29, no. 4 : 599-633.
- Sawday, J. (2007). *Engines of the Imagination – Renaissance culture and the rise of the machine*. Routledge, New York.
- Voskuhl, A. (2013). *Androids in the Enlightenment: Mechanics, Artisans, and Cultures of the Self*. University of Chicago Press.
- Whitelaw, M. (2013). *Transmateriality: Presence Aesthetics and the Media Arts*. Throughout: Art and Culture Emerging with Ubiquitous Computing, 223.
- Whitelaw, M. (2011). *After the Screen: Array Aesthetics and Transmateriality*. Retrieved December 16, 2014, from <http://teemingvoid.blogspot.tw/2011/04/after-screen-array-aesthetics-and.html>
- Yates, F. A. (1967). *The hermetic tradition in Renaissance science* (pp. 255-274). na.
- Huhtamo, E. and Parikka, J., (2011). *Media Archaeology – Approaches, Applications, and Implications*. University of California, London.
- Hertz, G. and Parikka, J., (2012). *Zombie Media: Circuit bending media archaeology into an art method*. *Leonardo*, 45(5), 424-430.
- Kluitenberg, E., Zielinski, S., Sterling, B., Huhtamo, E., Carels, E., Beloff, Z., ... and Akomfrah, J. (2007). *The Book of Imaginary Media: Excavating the Dream of the*

Ultimate Communication Medium. NAI Publishers.