23
ALGORHYTHMICS
A Diffractive Approach for Understanding Computation

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Knowing how to use, program, and deploy software is a key skill in today's society. It comprises the core of curricula in so-called STEM (science, technology, engineering, and mathematics) disciplines. This chapter offers a critical, humanities-based approach to software that engages the growing importance of algorithms without resorting to wholly affirmative or wholly negative interpretations. I consider this approach "diffractive," instead of reflective, a distinction which I explain further below.

The entry into a critical understanding of digital media, algorithms, and their growing cultural impact often takes place by studying the visible aspects of media aesthetics (Manovich 2013; Bruno 2014; Cubitt 2014). Other approaches examine social networks and their properties through data visualization (Rogers 2013), or they concentrate on alphanumeric code (Cox 2012; Montfort et al. 2012). Similarly, approaches in digital humanities are often focused on textual methods (Berry 2012; Jones 2013; Gardiner & Musto 2015), which are based in visual perception. However, this chapter argues that, for a comprehensive understanding of algorithms and computational culture, it is important to train a nonvisual sensitivity toward information technology. To cultivate this sensitivity, I developed a method called, "algorhythmics," which arose after a playful, heuristic synthesis of *algorithm* with *rhythm* (Miyazaki 2012, 2013a).

Focusing on algorhythmics, this chapter is divided into four sections: the first offers brief definitions and explanations of algorhythmics as a diffractive approach to computational culture; the second presents methods and discusses some benefits of algorhythmics via case studies; the third describes another case study and further addresses the framework required for doing algorhythmics; and the final section offers some recommendations for future directions and extensions.

Algorhythm = Algorithm + Rhythm

"Algorithm" is a term used in computer science that means a finite sequence of step-by-step instructions active in computers as core modules of software. They are procedures mostly for solving a problem or task. Prior to the existence of either computer science or algorithms, Plato defined "rhythm" as a time-based order of movement (1967–1968: 664e–665a), where movement is a material process that can be measured by a technical instrument. Rhythm, then, is an effect of ordering and measurement (Miyazaki 2013a: 136–141). By extension, "algorhythmics" are time-based, technological processes, which occur when matter is modulated by symbolic and logical structures, such as instructions written as code. Algorhythms are the timing effects of computation. Such processes are micro-events, which operate on scales and levels that are usually below or beyond our perceptual threshold. Still, they are ubiquitous and operate across all aspects of our life. They are—as I show below—highly influential, especially in cases where they become dysfunctional.

The synthesis of algorithm with rhythm does not merely merge materialism with immaterialism, signals in circuits with text-based code, the real world with the symbolic world, or physics with mathematics. Rather, it is to be understood as a kind of diffraction or interference pattern (Barad 2007: 71). One easy way to generate such patterns or wave phenomena is by dropping two stones in a pond and observing the resulting ripples on the water surface. They interfere and mix into each other in interesting ways. Similarly, the research fields of algorithmics and rhythmics could positively interfere with each other, still maintaining their specificity and characteristics.

According to Karen Barad and Donna Haraway, diffraction is an alternative to reflection, which is the common term used in conjunction with critical inquiry or critical thinking (Barad 2014: 172). Diffraction happens when moving waves encounter an obstacle or slit that is a size close to their wavelength. The disturbed waves then create new patterns. While a reflective inquiry is based on a change of direction—a returning and mirroring of the thing under study—a diffractive inquiry transforms and bends its subject to create a range of alternative approaches for studying a subject, object, or process (Barad 2007: 89). As a diffractive approach for understanding computational culture, algorhythmics not only looks for interesting patterns across computer science (algorithms) and real-world phenomena (rhythms), but also includes thinking about how to render these often unperceivable processes into sensible phenomena. In this way, it involves bridging research fields where technical measurements are essential with those where human perception and cultures are examined. Algorhythmics is thus more than a recommendation to cultivate a time-based sensitivity toward processes where computation and data are involved; it demands skills and methods to quite literally *make sense* of these processes.

Algorhythmic Sensitivity

Methods of media transformation between the senses are important for practicing algorhythmics. Turning a selection of alphanumeric values (data) into an audible stream of sound (sonification), or transforming these into visible structures on a flat plane (visualization), demonstrates simple procedures of media transformation, which equips and augments human sensitivity with machines and media. In a project called *Algorhythmic Sorting* (2010–11), I collaborated with programmer, Michael T. Chinen, to make a piece of software that let us aurally and visually compare the efficiency and performance of different algorithms while ordering and sorting randomly generated numbers. We could see and listen to "bubble," "merge," "quick," "insertion," "shell," and "heap sort" algorithms. Each generated distinct audible rhythms and visible patterns (see Figure 23.1). This experiment acted as a proof of concept for algorhythmics, since it allows even nonprofessionals to quickly understand how algorithms perform differently, or how algorithms are bound to time and embody different types of timing. Understanding the efficiency and performance of algorithms is crucial to also understanding the sociopolitical and economical aspects of digital cultures, because algorithms are now common components of most infrastructures.

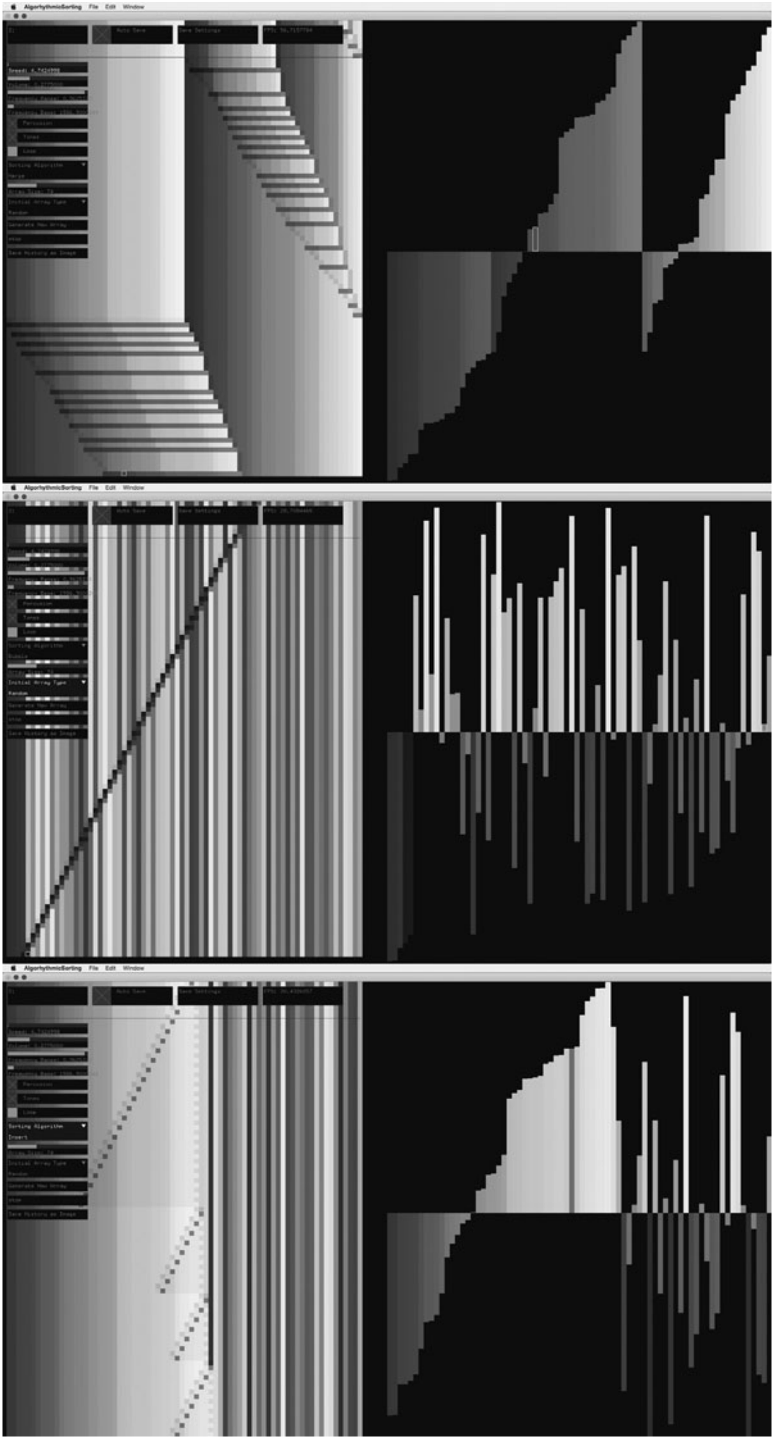

Figure 23.1 Screenshots of *Algorhythmic Sorting* (2010–11) with merge sort, bubble sort, and insert sort (from top to bottom) done by the author.

For another proof of concept, I transformed electromagnetic emissions of operating computing machinery into audible sounds (audification) by amplifying signals coming from long cables and electromagnetic coils. This simple trick lets you hear the material processes of computers and other digital gadgets. Placing a coil connected to an amplifier and loudspeaker near the central processing unit (CPU) of a MacBook Pro reveals a lot of interesting sounds. After loading the desktop, you are able to hear noisy buzzes connected to mouse movements as well as sounds connected to window loading, program starting, and other processes. All these processes correspond with the CPU. The micro-units inside the CPU chip emit small electromagnetic waves, which get transmitted to the coil or wire. These get amplified, and then drive the membrane of the loudspeaker. The movement of the speaker creates pressure differences in the air that we hear as sounds. Most of these fluctuations are too fast to be heard, but some are slow enough that they generate distinguishable rhythms of noise and melody.

In fact, this simple trick was practiced from the late 1940s until the early 1960s during the era of electronic mainframe computing, when the speed of computation was still in the realm of hundreds of kilohertz. Instead of a coil, engineers and programmers directly connected some part of the computer—mostly data busses or parts of storage—to amplifiers and loudspeakers. It was a quick-and-dirty way to get perceivable feedback from otherwise silent machinery (Miyazaki 2012, 2015). Other examples where audible feedback was produced from otherwise silent media include audiocassettes for data storage (1970s), acoustic coupled modems in the early age of preinternet networks (1960s and 1970s), and dial-up internet and telefaxing (1990s). Even the transmission of presumably silent ethernet communication protocols can be turned into streams of algorhythms (Miyazaki 2013a). Also, wireless communications (via Wi-Fi, Bluetooth, GSM, and UMTS) have specific rhythms and fluctuations, which we can listen to with some minor technical effort (Miyazaki 2013b). This is quite useful to understand the coverage of digital wireless networks in urban environments.

In short, algorhythmic sensitivity allows people to experience and understand the structures of a wide variety of key media operations, their fundamental principles, and their timings. This implies a sensorial, nonlinguistic approach to the inner workings of computational gadgetry. Since algorithms operate throughout all levels of data storage, transmission, and processing, algorhythmics builds aesthetic, cultural, and technical competences in areas of computational culture and digital humanities. This is especially important because most of the processes in this realm are usually imperceivable. Algorhythmic sensitivity as a mental state of inquiry might afford new links and reconfigure the understanding of an object under examination, since it provides an alternative to its text-based description. Including these nonlinguistic aspects of digital humanities is highly important for a critical analysis of algorithmic cultures.

Understanding Media with Other Media

Algorithms usually act on hidden micro-levels. Bulks and networks of algorithmic procedures build our technological unconscious (Thrift 2004). Algorithms are involved in management, business, finance, supply chains, logistics, postal systems, air traffic, war, media entertainment, telecommunication, and knowledge production, but they are typically hidden and unimportant—mere tools, services, and means of human control.

The significance of the algorithmic micro-world is often only learned through technological breakdowns with massively hazardous consequences. Crashes of financial markets, e-commerce, communication networks, or power-grids show us that a small mistake in calculation, timing, scheduling, or routing can lead to unforeseen malfunctions. For instance, on January 15, 1990, AT&T's long-distance telephone network in North America crashed and was disabled for 9 hours. The reason for the crash was a small programming mistake implemented via a software update for line-switching computers across the country (Miyazaki 2016). The mistake was written in the programming language, C. The update did not act in the intended way, and the timing of the network's operations were thus slightly out of order. The resulting algorhythmics were a sort of stuttering. Rhythms not usually detected by self-monitoring operating systems became effective during the updating process, when the routing maps of a station were actualized. When this happened, the automated shutdown procedure was initialized, and a station would go offline. The first station went offline for unknown reasons. It sent a "go offline now" message to all its neighboring computers. Receiving this message, neighboring stations crashed as well, because they needed to update their routing maps. After a short break of four to six seconds, they would be online again and communicate with neighboring computers. This again caused crashes, as even more computers would update their routing maps. In this way, the crashing and shutdown of the line-switching computers repeated rhythmically, cascading over the entire long-distance telephone network for nearly 9 hours.

This crash is just one example of thousands of algorithmically caused breakdowns one can find in common information sources. Whenever scholars equipped with an algorhythmic sensitivity learn that algorithms were involved in such malfunctions, they might determine which algorithms were responsible and ask themselves how the overall orchestration of these events would sound. Would it have a rhythm? Would it be repetitive? An open and sensitive mindset, which regards things as constantly in flux and also emphasizes the importance of making the unperceivable sensible, might be productive, since it pushes humanities scholars beyond common methodologies framed by reading and writing. Doing algorhythmics involves an interest in understanding media phenomena with different media. Listening to electronic signals via a loudspeaker or making them visible with either an oscilloscope or LEDs are examples of such very basic operations. How would a digital image sound? What does a sound recording look like? What does browsing the net sound like? Even though being sensitive to some aspects of a process—here, timing and rhythms—inevitably reduces or eclipses other modes of perception, such a reduction does not imply that some forms of perception or inquiry are superior to others.

Again, algorhythmics is a diffractive practice, which is open for interferences between low-level re-engineering, technical measurement, and hardware tinkering on one side and critical theory, musicology, theater or film studies, and art history on the other. It is a scholarly gesture of bridging and thus includes both tentative and speculative elements, but also some kind of engagement with the materiality, technicality, and performativity of the matter under study.

Beyond Algorhythmics

The theoretical framework for algorhythmics was strongly influenced by the work of Wolfgang Ernst and his method of media archaeology (Ernst 2011, 2013), but is as well informed by different approaches within media studies, including media ecology, political ecology, and ecological history (Fuller 2005; Bennett 2010; Parikka 2013). As my example of the AT&T crash demonstrates, it is not only crucial to grasp the workings, effects, and rhythms of one algorithm. It is also important to get an idea of the relations and feedback loops involved, such as when algorithms start to interact with each other in unintended ways.

An aesthetics of technological ecosystems—a techno-aesthetics of the twenty-first century—is required, one that does not forget that today's systems consist of millions of interconnected, algorhythmic micro-worlds. The growing ecosystem of intelligent machines and small invisible devices, which are connected to our smart phones, tablets, and laptops, generate a never-ending stream of algorhythmic effects that may influence processes on a planetary level. How do agents affect each other in such ecosystems? How does a trend spread across them? How can we hear and see such trends? How do complex timings and behaviors evolve and emerge in ecosystems? What are the habits of our data-driven society? How do we study their trajectories?

Using algorhythmics to understand computing and grasp how deeply these micro-operations are built into almost all aspects of society might be an important milestone during general education of the future. Equally essential to learn are the ecological consequences of "bad" algorhythmics. A future scenario for education might include a cabinet of curiosities with various algorhythmic models, which explain different layers, levels, and spheres of computation, including their benefits and dangers. Students could use these media to understand other media as well as the relationships between media. We have created a continuously expanding and evolving, heterogeneous new world based on algorithmic structures. To understand its wonders, dangers, futures, and histories is a never-ending, but surely rewarding, task.

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