AI Comes of Age

Ellen Pearlman

Not since Philip Glass and Robert Wilson premiered *Einstein on the Beach* at the Avignon Festival in France in 1976 has a new work highlighted such a profound shift in the zeitgeist—in this case, the twenty-first century's *Discrete Figures*. Glass's hypnotic minimalism soundscape complimented Wilson's spare stage sets, while Einstein's opening chorus intoned the sequential numbers 1-2-3-4-5-6-7-8. That combination, an unintentional presaging of the rise of 8-bit binary computer code accompanied by Lucinda Childs's repetitive, linear choreography, mimicked the signal routing of then relatively unknown computer circuit boards.

Discrete Figures, an interactive dance piece, explores the relationship between performing arts, math, the human body, and its simulated body. It is a line in the sand from which there is no turning back in terms of the use of machine learning (ML) and artificial intelligence (AI) in performance. Created by Tokyo-based artist, interaction designer, programmer, and DJ, Daito Manabe (Rhizomatics Research), and Kyle McDonald, an artist and coder, the piece was choreographed by "intrinsically Japanese" (her words) MIKIKO, with dancers from the Japan-based dance troupe ELEVENPLAY. After having its U.S. premiere at San Francisco's Gray Area/Grand Theater on April 19–21, 2018, the performance moved to New York City, where it opened at the New York Live Arts theatre on May 8–11, 2019.

Manabe had e-mailed McDonald, asking if he wanted to work on an new idea—"Dance x Math (ML)." The objective was to use computers to incorporate computer vision algorithms that are typically used for surveillance of the human body. McDonald agreed, saying he wanted to "explore the possibilities of training a machine learning system to generate dances" that complemented an individual dancer's unique style. He focused on creating two sections of *Discrete Figures*, nicknamed the "debug" and "AI dancer" scenes.

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AI, MACHINE LEARNING, AND ALGORITHMS

Artificial Intelligence is a complex term: it's so vast, it can even include the idea of consciousness, or sentience, in machines. For the purposes of this article, it is simpler to emphasize the term *machine learning* when thinking about AI. In machine learning, an algorithm, or set of commands in computer code, learns to build upon a well-defined task by repeating that task again and again. It does this based on a complex mathematical calculation, or algorithm. Most machine learning currently uses more nuanced sets of commands called "deep learning." Deep learning draws upon vast sets of electronic data sorted into hierarchies. Some of these hierarchies mimic the flow of information in a manner that resembles how neurons function in the brain. Because of deep learning's network structure, these hierarchies are also referred to as "neural nets." The information in these neural nets flows at very rapid rates. If you imagine the human brain as containing vast data banks (memory, both cognitive and muscle), and algorithms as the predetermined structure or characteristic of the brain (different parts of the brain), then you can think of deep learning as the types of things the brain does based on a hierarchy of what is most important at any one moment. In a computer, this means a superfast automation of many tasks that were traditionally not automated. For *Discrete Figures*, five dancers interact with cubes of images and light, drones, cameras, and machine learning algorithms that emulate them in live time.

HOW THEY DID IT

Discrete Figures incorporated a Vicon motion-capture system that collected two-and-a-half hours of data during forty separate recording sessions, a type of intensive setup traditionally used for creating complex gaming applications. Dancers improvised, and instead of using the movements to generate an end-product, like characters in a game, the motion capture was used to explore differences between the dancers and their own unique movement styles. The coding team created a special network called dance2dance. It was based on neural network architecture for sequential modeling from motion capture, modified to handle complex mathematical data. The data was based on predictive patterns. A predictive pattern explores the probability that a specific motion, word, character, rotation, or position leads to a unique outcome when combined together.

Without deploying special neural networks, a predictive model can copy only the exact data it has been fed. This means it averages data out to a modulated and smoothed whole that is not terribly dynamic. Think of the process as feeding hundreds of images of people doing nothing but bending their knees (not very interesting). With the addition of neural networks, a prediction algorithm

could be added that shows someone with a bended knee, and the next action they perform could be sitting on the ground, jumping up, or rolling around—all possible predictive outcomes.

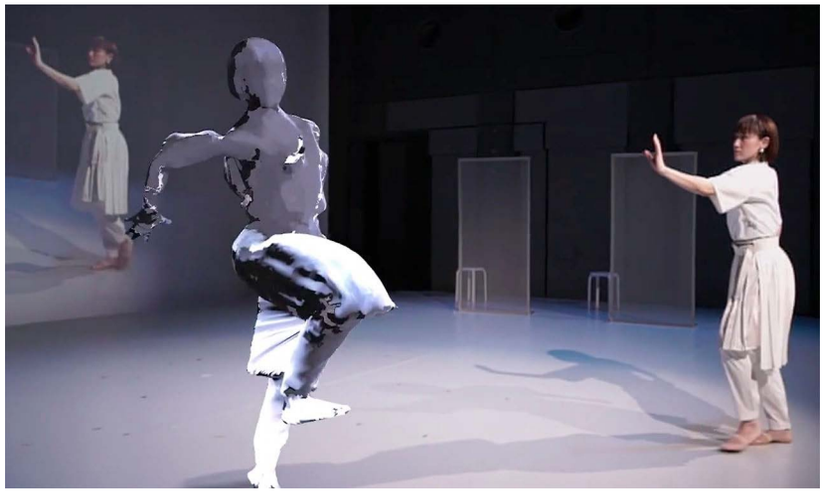
Musical rhythms and their relation to an individual dancer's styles were also studied. This is important, because standard motion capture data starts with a pre-composed structure that uses fixed limb lengths. This means an average is used to indicate the distance from the shoulder to the elbow, and then from the wrist to the finger joints, or from the hip joint to the knee, ankle, and toes. These measurements are stored in a special format called BVH that encodes rotations of a skeleton in time and space. Incorporating an algorithmic neural net means that new files could overlay standard data files to recreate specialized 3D models of a virtual dancer. These new models combine mathematical, temporal, and spatial data, developed in relation to the image of motion in the previously recorded motion-capture frame.

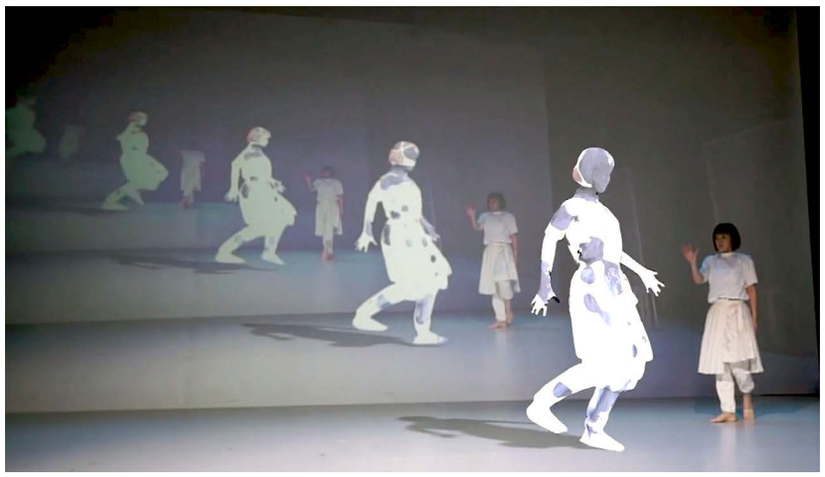
The most important machine learning moment in *Discrete Figures* occurs when a camera projects a performer's avatar, which appears as a shiny blob. The "blob" learns through live time algorithmic processing of the dancer's movements to simulate, and eventually becomes the exact replica of the dancer. The two engage together and this duet births a live simulacra running in tandem with its human originator. The avatar emerges from algorithmic processes that come into being in front of the audience. It creates a displayed virtual self in motion with an actuated self unique each time it is enacted.

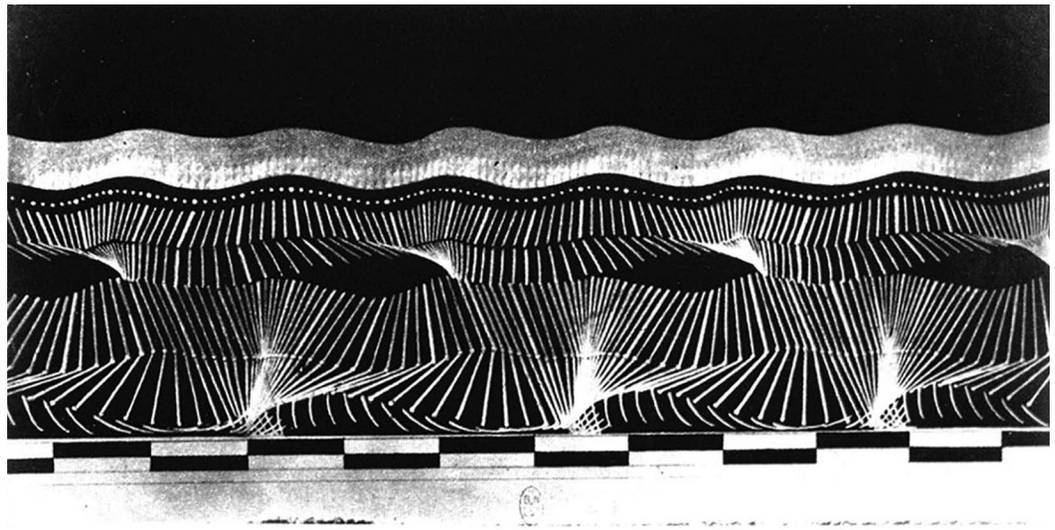
The dancer who interacts the most with the avatar was Masako Maruyama, or "Maru." McDonald states that Maru's duet with her double is the "transformation of human movement passed through a neural network once again embodied by a dancer." This generated motion mixes with the choreography between Maru and her AI avatar. The rigged 3D model takes on the look and feel of the real dancer as they begin sharing aspects of one another. At the end of the scene Maru departs by backing up towards an exit and the AI, who no longer has data to draw from transforms back to its original state—a silvery blob.

A SHORT HISTORY OF THE EVOLUTION OF IMAGERY LEADS TO MACHINE LEARNING BREAKTHROUGHS

Manabe and his research production team Rhizomatics posses an encyclopedic knowledge of the history of the human pose in space, grounded in centuries of research on art, literature, and science. He generously logs his influences for the public, sharing them on his website.[1] These investigations begin in the mid-1700s with *French Letters to a German Princess, On Different Subjects in Physics and*







Geometric Chronophotograph of The Man in the Black Suit, 1883 Photo: E.J. Marey.

Facing page: (top) Dancer Maru first meets her machine learning avatar; (center) Dancer Maru dances a duet with her machine-learning avatar; (bottom) Dancer Maru bids goodbye to her machine-learning avatar. *Discrete Figures*, 2018–2019. Photos: Courtesy Rhizomatics Research.

Philosophy by Leonhard Euler, a series of 234 handwritten letters from Euler to a German Princess and her younger sister. It instructs the royal sisters on the phases of the moon, the tides, history, physics, optics, logic, music, electricity, theology, and magnetism.

Manabe's website also looks at the work of Dr. Etienne-Jules Marey. In the 1880s, Marey described the human body as an animate machine run by the circulation and hydraulics of the blood, breath, and muscle. Deeply influenced by Eadweard Muybridge's 1879 motion study photographs published in the journal *La Nature*, Marey went and built his own motion capture camera apparatus using a technique called Chronophotography. That technique could record the flight of a pigeon at sixty frames per second—a result so astonishing it directly influenced the Wright Brothers in their pursuit of flight. Marey's geometric chronophotograph of *The man in the black suit replete with white striping and points* (1883) led to the 1914 publication of his motion Chronophotographs in "The Human Body in Action" for *Scientific American*. Marey also investigated motion capture using a sequence of photos of a man descending an inclined plane. These studies directly inspired Marcel Duchamp's famous painting, *Nude Descending a Staircase, No. 2* (1912).

Though Manabe delved into the roots of human form represented in photographic images, he also incorporated Bauhaus-affiliated art such as Oskar Schlemmer's *Man With Slanting Bars* (1930) and Wassily Kandinsky's *Dance Curves: On the Dances of Palucca* (1926). He even included futuristic machines such as Nicolas Schöffer's *CYSP-1* (1959), a cybernetic robot sculpture. Next on his list were the digital breakthroughs made by Michael Noll of Bell Telephone Labs. Noll had made the first *Computer Generated Ballet* in 1974, inspired by his viewing a performance of Igor Stravinsky's ballet *Apollo*. *Computer Generated Ballet* was a mathematically precise computer-animated rendering of male and female stick figures, uploaded to magnetic tape and displayed on a cathode ray tube. Though clunky and childlike, it represented a state-of-the-art innovation at the time, and was a first to show ballet movement generated by computer code.

The video artist Nam June Paik learned computer art, animation, and the early computer language FORTRAN from Noll, who in turn visited Paik's studio on Canal Street in Manhattan. By 1967, Paik was capable enough to program his own computer animations. Manabe also cites the works of the Open Ended Group with Merce Cunningham's *Biped* (1999), which an abstract generated from the Cunningham Foundation calls "an exploration of the possibilities of the animation technology of motion capture."

Japanese aesthetics, including the work of Masahiko Sato and the 2011 collaborative piece *EUPHRATES*, referred to as a "ballet rotoscope," also influenced Manabe.

It shows a ballerina dancing while her body joints are traced by a computer generated rotoscope animation technique. This technique was originally invented in the early twentieth century by the renowned animator Max Fleischer, who also created *Koko the Clown*, *Betty Boop*, and *Popeye the Sailor Man*.

McDonald also had his own repertoire of art historical and artist-engineer collaborations to draw from. These included dancer and filmmaker Yvonne Rainer's *Carriage Discreteness* (1966), from the legendary *9 Evenings* series at the Park Avenue Armory. In that performance, dancers interacted with projections, lighting design, and automated mechanics in conceptually new ways. McDonald studied digital toolkit developers who worked with software-user communities, like Mark Coniglio's 1989 software program Isadora, and Frieder Weisse's 1993 software programs Kalypso and EyeCon. He also looked at both the OpenEnded Group, which used a graphics programming environment called Field, and *chor-mn*, a 2016 research project by Luka and Louise Crnkovic-Friis. The latter used a dancer's motion-capture data, tracking it with a Kinect v2 for five hours. The resulting images were compiled into sequences, as opposed to one image at a time. From this block of sequential data, a stick figure appeared that could, in essence, dance all by itself, a simple but essential breakthrough. These are just a few of the historical references that shaped the algorithmic presentation of *Discrete Figures*.

CONTROVERSY

The New York premiere of *Discrete Figures* also included an after-performance panel discussion. Some in the audience attacked the performance as trite and conventional, saying it was nothing more than Japanese female dancers in skirts manipulated by men (Japanese and Caucasian). The men pulled all the strings behind the scenes by using technology to manipulate the female body. That view, though in line with certain aspects of contemporary critical discourse, did not fully consider the true implications of the performance. One audience member stated, "I do not understand the language of the Internet and I am proud of it . . . the sensibilities of the Internet, I try and censure it." This view, though understandable, is essentially akin to saying that mobile technology, the Internet, and other technological advances are irrelevant, and will continue to be irrelevant to artistic practice.

Discrete Figures is about machine learning algorithms constructing from their human counterparts simulations of themselves in order to imitate, collaborate, and perhaps one day surpass them. As part of the panel, Manabe stated that the theme of the work is AI, framed by the history of math, people, the body, and numbers. McDonald added that he was asked by Manabe to build a virtual dancer, and to incubate it with machines. He stated, "Gender is not something

I think about. It (the performance) is a symbolic use of the body . . . (through) reductive skeletal bodies." MIHIKO, who also sat on the panel, added, "Wearing the same costume actually brings out their (dancers) individuality."

From this rich array of art historical and engineering influences, Manabe and McDonald clearly situate their use of machine learning and artificial intelligence within the context of art and technology practices spanning well over a century. In retrospect, *Discrete Figures* will be understood as the Sisyphean grappling of a generation not birthed into technology now confronted with accelerated technological developments of a type it could not have imagined. It is up to the next wave of creative practitioners to take these lessons from the past and to incorporate them into current developments to forge a new horizon.

NOTE

1. See https://scrapbox.io/artresearch/human-pose.

ELLEN PEARLMAN is a New York-based new media artist, writer, critic, and curator. A senior research assistant professor at RISEBA University in Latvia, she is on faculty at Parsons/The New School University. An EU 2020 Vertigo STARTS Laureate artist, she premiered her AI brainwave opera *AIBO* at the Estonian Academy of Music in Tallinn. Pearlman is a *PAJ* contributing editor.