Artificial Aesthetics

A critical guide to AI, media and design

Lev Manovich & Emanuele Arielli

Chapter 2

Who is an artist in software era?

Preface

Suppose you are a designer, an architect, a photographer, a video maker, a musician, a writer, an artist, or a professional or student in any other creative field. Or perhaps you are a digital creator making content in multiple media.

You may be wondering how AI will affect your professional area in general and your work and career. This book does not aim to predict the future or tell you exactly what will happen. Instead, we want to offer you a set of intellectual tools to help you better navigate any changes that may come along.

These tools come from several different fields: aesthetics, philosophy of art and psychology of art (Emanuele), and media theory, digital culture studies, and data science (Lev). As far as we know, our book is the first to bring together all these different perspectives in thinking about creative AI.

We started the work on the book in summer 2019, exchanging numerous messages, commenting on each other ideas, and sharing drafts of sections. The final book is a result of this process. Although each chapter is written by one author, it reflects the discussions we had over 27 months.

The book is released one chapter at a time on manovich.net, academia.edu, and medium.com.

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Chapter 2
Lev Manovich

Who is an "Artist" in Software Era?

Turing test for artistic AI

What would be the equivalent of the Turing test for an AI system capable of creating new songs, games, music, visual art, design, architecture, films? This looks like a simple question with an easy answer. If a system can automatically create new works in each media or genre and we cannot tell the difference between those works and those created by humans, it passes the Turing test.

The same or similar answers have been common in many discussions about AI and artistic creativity. For example, Margaret Boden, a well-known academic researcher in the field of computational creativity, has proposed the following criteria for such a test: a program has to produce an artwork that is "indistinguishable from one produced by a human being and/or was seen as having as much aesthetic value as produced by a human being."[1] Between 2015 and 2018, a group of researchers at Dartmouth College ran "Turing Tests in the Creative Arts, "an annual competition series that tested "if machines are capable of generating sonnets, short stories, or dance music that is **indistinguishable from human-generated works**."[2] (You can learn about the winning programs on the project website.[3])

Such interpretation of Turing test has been used in many publications discussing art-generating computer systems. Already in 1966 Michael Noll reported the following experiment in a psychology journal:

> A digital computer and microfilm plotter were used to produce a semi-random picture similar in composition to Piet Mondrian's painting "Composition with Lines" (1917). Reproductions of both pictures were then presented to 100 subjects whose tasks were to identify the computer picture and to indicate which picture they preferred. Only 28% of the Ss were able to correctly identify the computer-generated picture, while 59% of the Ss preferred the computer-generated picture.[4]

Are we now done with answering our question about a Turing test for the arts? Not quite.

If we think further, we quickly realize that this is more complex. To even begin to answer it, we may need to consider ideas from several fields such as philosophical aesthetics, experimental psychology of the arts, histories of the arts, media theory, and software studies. Discussions about a Turing test for artistic creativity have not used perspectives from the last two fields much, and yet in my view they are very important for thinking about AI and creativity questions. This chapters explores **the challenges of defining a test for artistic AI in our era** when human creators routinely rely on digital assets and creative software which already has been offering AI-type support for long time. In other worlds: what would it mean for "genuine artistic AI" to compete with contemporary artists who already implicitly use AI implemented in their standard tools (operating in *Photoshop*, *Premiere*, *After Effects*, *Blender*, *Unreal* and so on behind the scene)?

A black and white drawing based on 1917 Mondrian painting (left) and computer generated Mondrian-like composition (right) used by Michael Noll in his experiment. (Illustrations from the original 1966 publication.)

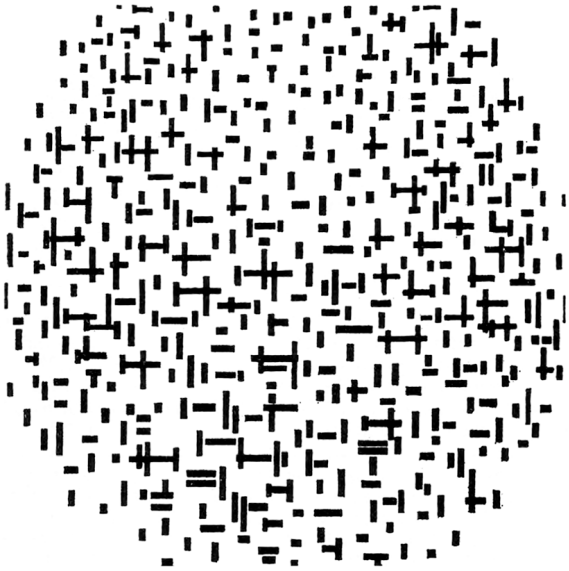


Fig. 1 "Composition With Lines" (1917) by Piet Mondrian. (Reproduced with permission of Rijkmuseum Kröller-Müller, Otterlo, The Netherlands, © Rijkmuseum Kröller-Müller.)

Fig. 3 "Computer Composition With Lines" (1964) by the author in association with an IBM 7094 digital computer and a General Dynamics SC-4020 microfilm plotter. (© A. Michael Noll 1965).

How to define a test for artistic AI in the era when human creators routinely rely on creative software?

Creativity in Software Era

To begin, we need to consider the fact that all creative work in media and design today takes place in a digital environment - i.e., it involves use of appropriate software, services, and online resources. Creators have instant access to numerous works made by others via social media and specialized sites for sharing art, photography, video, and music (e.g., *DeviantArt*, *ArtStation*, *Behance*, *SoundCloud*), as well as to websites with stock media, templates, and effects (e.g., *Shutterstock*, *Adobe Stock* and endless others.) They can watch how other creators accomplish tasks and access their project media files, which can even be viewed in the application that was used by the creator. For instance, Photoshop allows you to see all the modification layers in another person's project. You can also directly apply the creative choices and decisions made by another creator (for example, color and tone modifications) to your project.

When creators write code to make interactive, generative or animated works, such method is even more important. Both students and professionals often start by copying somebody else computer code and then proceeding to change it. Tutorials for popular programming languages and libraries for cre-

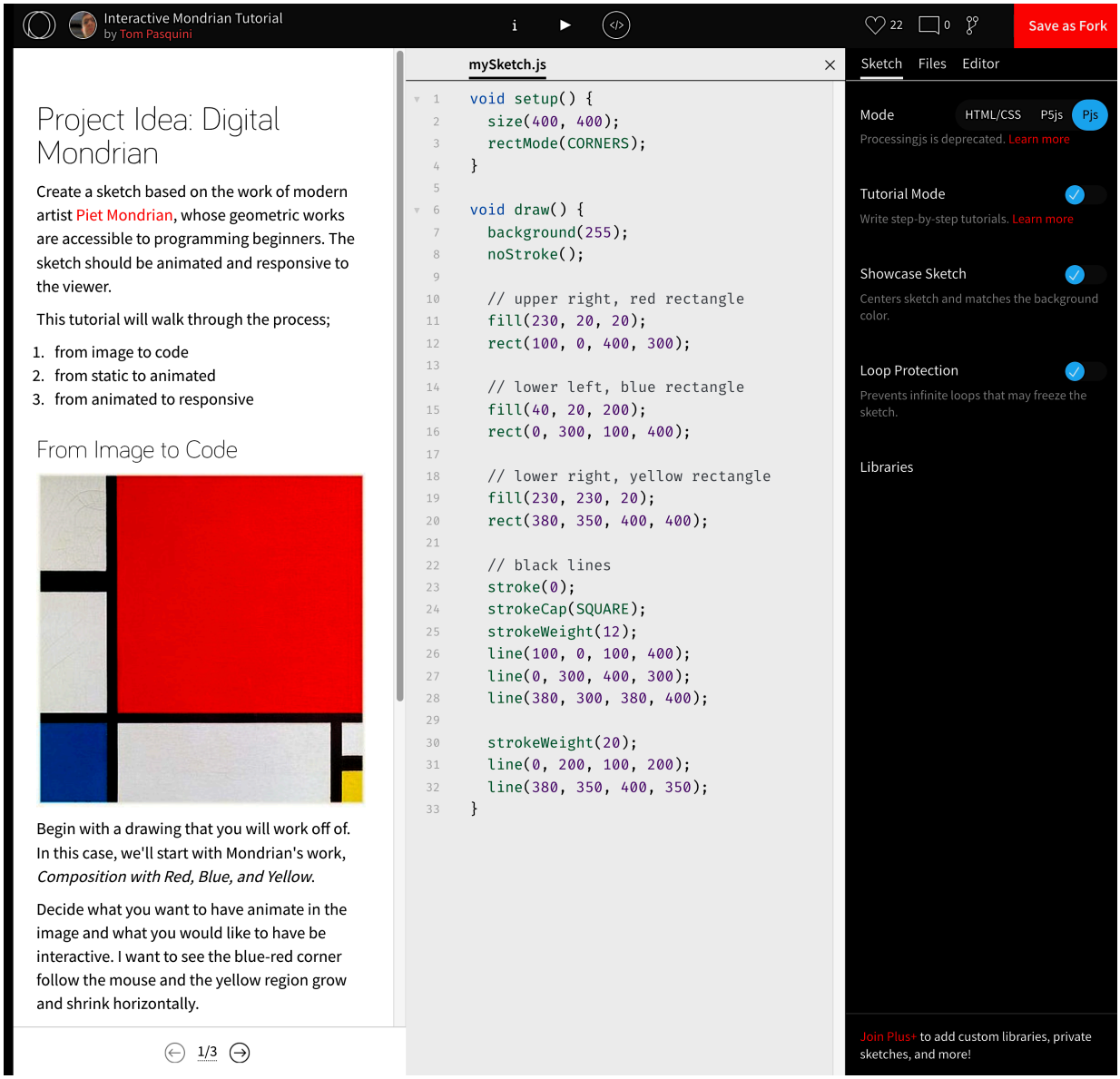
ative applications such as *Processing* may provide examples of code to accomplish various tasks and asks the learners to modify them.

Digital media externalizes and reformulates creative process as a sequence of discrete operations with numerical parameters

While traditional art and crafts education was also based on copying the works of other masters, **digital media** changes this practice qualitatively. It **externalizes** person's thinking and creative process turning it into **a sequence of discrete operations with numerical parameters** defining their details. (For instance, "increase saturation by 5%" or "apply Gaussian blur filter with 30% strength and 3-pixel radius", etc.) Every action is saved by software separately and you can study these actions and apply them in your own work. And even when digital media simulates physical art materials such as "painting" with various "brushes," these seemingly continuous creation process becomes discrete - for example, some painting programs keep track of every brushstroke allowing you to undo them one by one.[5]

If you do creative coding, you can similarly copy, examine and then modify another person's thinking incapsulated in the program she wrote. For instance, website https://openprocessing.org invites you to "Join 100,000 creative coders and follow their work." You can run each program that manipulates or generates images, text, camera inputs, sounds (these programs are called Sketches in Processing community), examine its full code, and also instantly "fork" it, i.e. make a copy and start modifying it.

Tom Pasquini, Interactive Mondrian Tutorial, https://openprocessing.org/sketch/843344/, accessed January 15, 2022. An example of one of many online tutorial for learning Processing. In this tutorial (left frame), you are taught how to write code that generates animated interactive image in the style of Mondrian. The frame in the center displays code you can directly modify, run and see a new image. The right frame displays all forks (new versions) of this sketch created by other members of openprocessing.org.

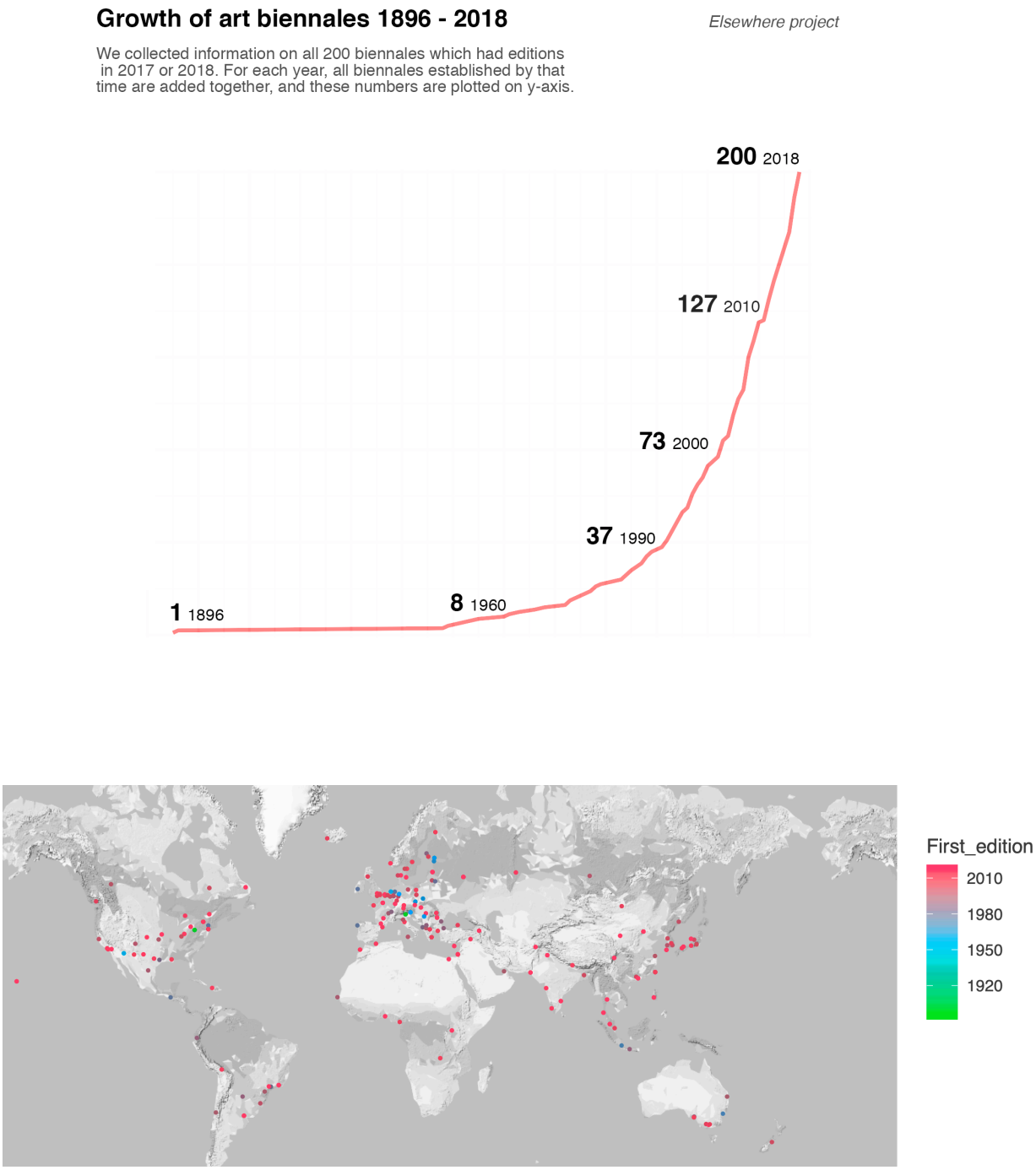


(While today the common method for teaching computer to make artworks is to train it on a large dataset of existing artworks which provides the computer only with results of creative process, it could be better to instead use sequence of actions which led to final artworks. So rather than only learning to blindly simulate the outputs, a computer could be taught to think like a human creator - thus acquiring real artistic intelligence.)

Let's continue listing the ways digital media changed artistic process. Contemporary creators have technologies that can create many visual, sonic, spatial, multimedia, and interactive "effects" that were not possible with earlier arts and media technologies. Examples include the use of projection mapping for videos in space, particle systems for animation, robotics in performance and installations, or new materials in architecture. Even **when new technologies use older technologies, these are qualitatively different from their earlier versions**. Think about taking a video on your phone at 8k resolution - the resolution of such video is about 50 times higher than what was available to filmmakers 100 years ago. Although we refer to both analog films from the 1920s and digital films made using a phone today as "films," these are different types of visual media.

We also need to consider **the new scale of creation** in photography, art, media, design, digital art and other creative areas in the 21st century. As an example of the scale of photography production, consider these statistics: According to one 2021 estimate, "The creative industries generate around 30m jobs and account for 3% of global GDP, employing more young people (aged 15-29) than any other sector."[6] And if we look at non-professionals making objects such as photos, the scale is astonishing: in November 2020, "Google announced that more than 4 trillion photos are stored in Google Photos, and every week 28 billion new photos and videos are uploaded."[7]

Example of new new scale of creative industries in the 21st century.[8]: growth of number of new art biennales. Top: cumulative number of new biennales (y) per year (x). Bottom: new biennales on a map, with color indicating year of first edition.



Who shall AI compete with?

This new digital environment, which I have only described in brief, poses crucial questions that need to be considered when defining a Turing test for "creative machines":

What does it mean to "**create" today** when countless stock visual and audio media, templates, filters, effects, styles, and tutorials are available to both casual and professional creators? Shall we try simulate this contemporary "digital creativity"? Or do we want to match the artistic achievements and creative processes of a pre-digital, pre-software and pre-network era?

Do we want AI in our test to be able to generate new works from scratch **while only having access** to examples of works from a particular historical period, place, type of media, or genre? Could it have access to all digitized human cultural heritage? (Today supervised machine learning only uses very specific datasets of cultural artifacts, so it's the first situation.) Or maybe it can also use all the affordances of the digital cultural environment available to human creators today? In other words: **do we want to simulate an artist from the 19th, 20th or 21st century?**

Do we want human artists to complete with an AI system that can make a complete work from beginning to end? Or should we be testing **AI assistants** as well? Today *AI assistance* or *AI augmentation* of human creative process has become the norm. Here are a few examples of these tools that are used by tens of millions of people every day: "auto enhancement" of photos (available in Lightroom, Apple Photos, Google Photos and endless other photo editing apps); automatic selection of human faces, figures, and other objects in photos and video so that they can be edited differently from the background (offered by Photoshop, Premiere, etc.); automatic selection of a user's best photos from her media library (Lightroom); simulation of camera movement and parallax using a single photo (Google Photos); automatic rearrangement and editing of design elements to generate new layouts (Adobe

Spark). (These examples cover only a few very popular software applications; the described functions are also available in many other apps.)

Do we want AI to simulate an artist from the 19th, 20th or 21st century?

In the original Turing test scenario, a human has a conversation with an entity that she cannot see. This entity can be either another human or a computer. The test **does not assume that the human has any expertise or skill**. Human beings have very sophisticated perception and cognition abilities and making a computer with similar capabilities was seen as the goal of AI research since the field emergence in the 1950s.

In other words, researchers wanted AI to be able to do what all normal humans can do: understand information captured by their senses, generate sentences and bodies of text that are grammatically correct and semantically meaningful, understand what other humans are saying, employ basic logic and reasoning, and make plans to achieve goals.

(In psychology, linguistics and cognitive science, **researchers debate whether a particular human cognitive ability has a biological or cultural origin** - in other words, are we born with it, or do we learn by interacting with our environment and other people? This question is important for our topic, but we will leave it for another discussion elsewhere.)

If we want to compare AI creators and human creators, we can't simply invite any human to act "creatively" and "make art" in one room," and then ask another human in another room to judge whether the works were created by this human or a computer. We are not born with the fully formed ability to draw, compose music, write poetry, weave cloths with color patterns, carve human figures and faces, or create intricate decorations and ornaments from

different materials. (We also know that certain individuals in every traditional human culture from the past 7000 years were able to develop very good skills in all these arts. How did they arrived at these skills, before tradition of apprenticeships developed? Why this happened in every traditional culture?)

Psychological research supports **the hypothesis that only some children have talents** that helps them later becoming very skilled at some things:

> Talents that selectively facilitate the acquisition of high levels of skill are said to be present in some children but not others. The evidence for this includes biological correlates of specific abilities, certain rare abilities in autistic savants, and the seemingly spontaneous emergence of exceptional abilities in young children, but there is also contrary evidence indicating an absence of early precursors of high skill levels.[9]

Psychologists also discovered that genes have strong influence on young children's skills in figure drawing. They have tested these skills for thousands of 4-year-old and 14-year-old children and found that at both ages, genetics is correlated with the accuracy of figure drawing.[10]

These and other studies suggest that in its artistic skills acquisition, a human brain is not a tabula rasa. If not all human adults naturally develop good artistic skills, this means that **AI programmed to have such artistic skills** is not simulating universal cognitive abilities. Instead, it is **simulating skills that have been learnt**, whether this is by imitating examples seen elsewhere, undergoing formal training or apprenticeship, following online tutorials, or in some other way.

Many people can easily acquire some creative skills such as dancing. With proper training methods, they can also learn to draw, sing, and deploy rhetoric. However, not everybody can become an accomplished an opera singer or skilled craftsperson.

Who are the "Professionals"?

What is the level of artistic skills we want the machine to simulate? Is it the average ability of any human who received certain training? Or gifted children? Or do we want it to compete with an art professional?

But **how do we decide who counts as a professional?** Do we select people who have received a diploma after years of studying at university or art school? Or should these people already have received a certain amount of recognition in their field? However, recognition depends on many factors and does not necessarily correlate with the levels of talent and artistic skill. In some art fields such as classical music, this correlation can be quite strong, while in other fields such as contemporary art, it can be much weaker. The reason is that in the first case, there are several criteria shared by members of the classical music world (performers, teachers, critics, competition juries) and used to evaluate everybody. But in the second case, there are no shared agreed on criteria. Consequently, somebody can acquire a reputation as an important artist because she/he is shown and promoted by influential galleries and museums, does work that fits a particular ideological agenda currently in favored, graduated from one of the most prestigious art schools, and so on.

If the reputations of the creators in high culture and their individual works do not always correlate to their levels of skill and talent but instead are shaped by economic and ideological factors, it becomes difficult to administer a test for artistic AI using such works. What if we instead consider different more democratic mechanisms of aesthetic evaluation in contemporary culture? I am thinking about creators today who don't have formal training in the arts, publish their creations on various social media platforms and portfolio sites such as Behance, ArtStation, deviantArt, and others, and receive recognition from online audiences for these creations in the form of likes, shares, "appreciations", comments, and so on.

Perhaps the people who have accumulated the most signs of appreciations (which can be called likes, favorites, claps, votes, etc. depending on the plat-

form) are the most skilled creative professionals today, and AI needs to compete with them? A similar question applies to people with in-depth arts training who make a living as photographers, film editors, song writers, web designers, and so on and who publish their works on portfolio sites where others can vote for them. These sites such as Behance feature millions of creative projects in dozens of fields by professionals of this type. Do their projects with the most likes represent the highest possible level of achievement in each field today?

In the late 2000s computer scientists started using data from early sites such as dpchallenge.com and photo.net where photo enthusiasts and professionals shared their photos and other photographers judged the aesthetic quality of these photos.[11] Analyzing scores for hundreds of thousands of photos they discovered that the judgements of very weak photos and strongest photos (1-3, and 7-10 on a 1-10 scale) very mostly similar. In other words, different photographers agreed about worst and best photos, but the photos in the middle of the scale received many different scores. This study suggests that averaging evaluations on any social or professional network is not the best method for selecting works for an artistic AI test.

Perhaps it would be better to use the artworks that have received awards from the top international competitions and awards ceremonies that exist for many creative fields, such as film festivals or literature prizes. However, since there are now millions of professional creators, who generate billions of works every year, we can be sure that these awards are also not the best evaluation method. Often participants must pay to be judged in a competition, and the cost of entry prohibits many from applying.

Regardless of how we define them, the number of arts professionals has increased dramatically in the 21st century. They have many mechanisms and platforms for sharing their work and receiving appreciation. **No single evaluation mechanism that is available today** - be it likes, awards in competitions, the judgments of other professionals, or academic experts - **can encompass enough works and be sufficiently objective**. In short, if we want an AI creator

to compete with the best creative works made today, it is challenging to define what is the "best."

What if we limit our creative AI Turing test to only the masterpieces of the past, i.e., the works that are outstanding achievements in human cultural history? But this is also somewhat arbitrary. Scholars who study canons in the arts - the authors and works from the past thought to represent the highest artistic achievement of humanity - reveal how these canons change significantly over time. Whole historical periods can be considered as uninteresting, unimportant, or decadent at one time, before later being regarded with admiration. Some of the most basic concepts in European cultural history, such as the *Middle Ages* and the *Baroque* are good examples of how our evaluation of a historical culture can change dramatically over time.

Relying on historical canons of "best" artists, composers, writers, and so on, or the lists of particular "masterpieces" of these creators is problematic. Reputations of individual creators have been changing over time and continue to change today. The creators that were famous at some point may fade into oblivion, while others who were not considered great or were simply unknown can enter the canons decades or centuries later. The similar changes may happen with artworks themselves.

For example, in *Impressionism and its Canon* (2006)[12], James Cunning have meticulously analyzed the formation of the canon of French Impressionism paintings over the whole 20th century years. Canon in this case refers to the works of Impressionist artists that are most often reproduced and discussed in art history books. **13** Impressionist artists are estimated to have produced approximately **11,600** paintings and pastels during their lives. Cunning selected 95 art history books from Cornell University library that include discussions of Impressionism. He and his students found that out of all these 11,600 images, only 1,400 appear in these 95 at least once, and only 138 appear more than 10 times. In other words, **only 1.1%** of the works created by Impressionists are reproduced often enough, thus forming what we call "Impressionism canon." His book demonstrates that it is naive to think that these most frequently reproduced works are objectively better many other paint-

ings or pastels of these artists; instead, canon formation took place over decades and included many different events, without any single one dominating this process.

Lovelace tests for artistic AI

I make all these points not because I want to slow down the developers of creative AI tools. On the contrary, the goal of this presentation is to help building better AI tools for media, design and the arts. To create more creative artificial intelligence, we must understand the nuances, meanings and histories of concepts such as *creativity, artist*, *professional*, *masterpiece*, *expert* judgements and *canon* formation. (I will discuss a few of these concepts in another chapter.)

We should not take for granted contemporary understandings of these concepts or the judgments and canons that are commonplace today. This would be the equivalent of simulating very selective and narrow examples of human cognition, only to claim that we have simulated all human cognitive abilities.

Although the Turing test is well-known, it is not the only test that has been devised for evaluating artificial intelligence.[13] In 2001, researchers published a paper in *Minds and Machines journal* suggesting a test named in honor of Ada Lovelace (1815-1852). A daughter of poet Lord Byron, Ada was the English mathematician known today for her work with Charles Babbage's *Analytic Language* and the insight that computers have much greater potential than mere calculation. She wrote: "Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent."[14]

Today computers pass Turing test for artistic AI billions of time per day

The inventors of the Lovelace test summarized one of her arguments in this way: "Computers can't create anything. For creation requires, minimally, originating something. But computers originate nothing; they merely do that which we order them, via programs, to do."[15] The Lovelace test is defined by the authors in the following way: "*an artificial agent designed by a human outputs something (for example, a short story); this agent can repeat this process; the human who designed this agent can't explain how the agent produced this something.*"

In 2014, another researcher proposed a different version of Lovelace test.[16] In this new 2.0 version, an artificial agent needs to create an artifact of particular type (e.g., "paintings, poetry, stories, etc.") that conforms to a set of constraints "expressible in natural language." A human evaluator confirms that this artifact is a valid instance of this type and meets the defined constraints. Additionally, a human referee confirms that the combination of type and constraints "to not be unrealistic for an average human."

As I discussed earlier, an "average human" can't create artifacts of many types without special training or apprenticeship. This is one problem with such a test. The second problem is the idea of constraints that have to be expressed in natural language. How would you express in English or Russian exact constraints in a complex abstract painting? Or the presumed "system" of brushstrokes in a figurative painting? Although researchers have analyzed every brushstrokes in some paintings of a few famous artists, the descriptions they produced are mathematical (algebraic or statistical) as opposed to a text in any human language. And in the paradigm of using supervised machine training to teach computer styles of artists or composers, a "description" a neural network produces is even more removed from something we can ex-

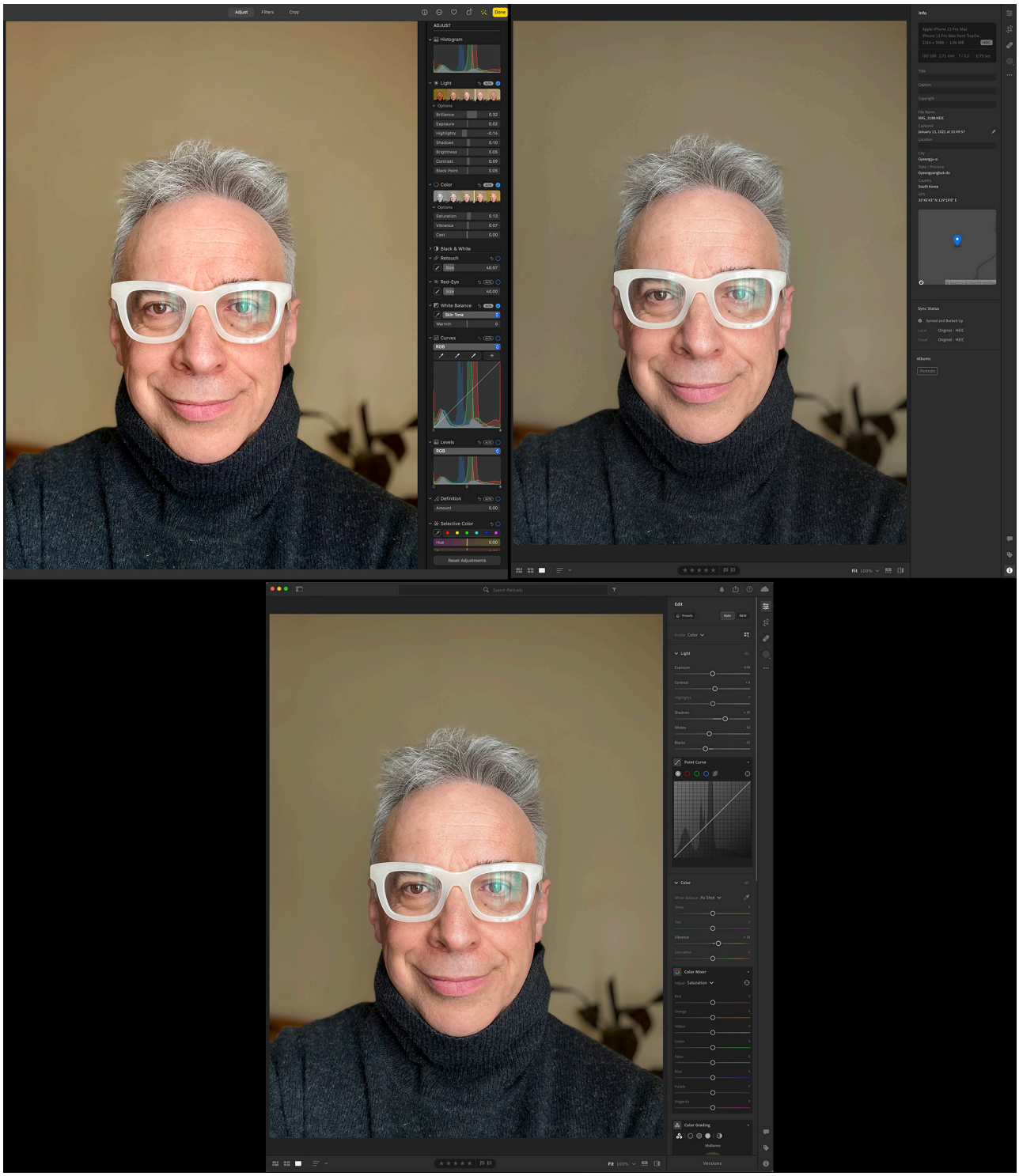
press as written sentences. Instead, this description is distributed across millions or billions of connections between artificial neurons each with its numerical weights (i.e. parameters) learned by the network. (The GPT-3 network created in 2020 has 175 billion parameters, and the next generation GPT-4 is projected to have 100 trillion parameters.[17])

Turing Test for artistic AI is too easy

As we saw, the idea of a Turing test for artistic AI and also the proposed alternatives raise many questions and appear to have serious problems. However, I am yet to mention the main problem: computers making art passed this test a long time ago. Already in 1966, an experiment organized by Michael Noll I have already described earlier found that people preferred a computer-generated, Mondrian-like drawing to an original Mondrian. (To be fair, we should note that the experiment used not a color reproduction of Mondrian painting, but a black and white drawing made after the artist's painting.)

Today our computational media devices successfully pass Turing test billions of times every day. Did you notice that over a period of a few years - approximately 2013-2018 - the quality of images captured by cameras in mobile phones improved dramatically? Partly it was due to the increase of sensor resolution, hardware improvements, and the addition of multiple lenses to phone cameras. But it was also partly due to the addition of AI to these the cameras. Looking at my photos from the early 2010s, I find that most of them are unusable. But by approximately 2020, it became actively difficult to take an unusable photo. In practically any situation, the photo has perfect exposure (i.e., enough details in the dark, medium, and light parts), and the main subject is in focus.

Apple iPhone Pro 13 Max, selfie camera (12 MP). Upper right: original photo. Upper left: Apple Photo automatic enhance. Bottom: Lightroom automatic photo enhance.



As professional photo cameras today don't have the same software as cameras in phones, I often struggle to take a decent picture with one of these devices. Even if I spend a couple of minutes trying various settings, it does not work. But when I shoot with my phone, almost all the photos are usable. This means that every time I take a photo with my phone, it passes the Turing test. In fact, it performs much better than any human - I simply can't capture as many good photos with my "less smart" expensive camera as I can with my "smarter" phone camera. (For example, the latter can instantly take a few photos, automatically select best exposed parts from each photo and seamlessly combine these parts.)

I could add further examples but these two are already sufficient. Between 1966 and today, computer devices that generate, edit, or capture media passed the Turing test countless times. So, using the Turing test for artistic AI does not work. We need a different test.

The traditional tests used to judge progress in artificial intelligence may be appropriate when we want to simulate basic human cognitive functions, but the world of art, design, film, architecture, and so on calls for something different. Lovelace test is one such possibility, but in my view, it is still too easy (although it probably made sense in 2001, before recent advances in AI.)

We must come with a harder test. After thinking about this challenge for some time, I have some ideas of what such test can be - and I will present them in a later chapter.

[1] Margaret A. Boden, "The Turing Test and Artistic Creativity," *Kybernetes* 39, no. 3 (2010): 409-413, https://www.researchgate.net/publication/220626152_The_Turing_test_and_artistic_creativity.

[2] Michael Casey and Daniel Rockmore, "Looking for Art in Artificial Intelligence," *The Conversation*, May 3, 2016, https://theconversation.com/looking-for-art-in-artificial-intelligence-56335.

[3] Neukom Institute Turing Tests in the Creative Arts, accessed October 6, 2021, http://bregman.dartmouth.edu/turingtests/.

[4] Michael A. Noll, "Human or Machine: A Subjective Comparison of Piet Mondrian's 'Composition with Lines' and a Computer-Generated Picture," *The Psychological Record* 16, no. 1 (1966): 1-10, http://noll.uscannenberg.org/Art%20Papers/Mondrian.pdf.

[5] For the detailed analysis of creative software including Photoshop and After Effects, see my 2003 book *Software Takes Command* (Bloomsbury Academic, 2013).

[6] Economist Intelligence Unit, *Trade challenges and opportunities in the post-pandemic world,* https://impact.economist.com/perspectives/sites/default/files/eiu_dit_creative_industries_2021.pdf.

[7] Ben-Yair, Shimrit "Updating Google Photos' storage policy to build for the future". *The Keyword Google Blog,* November 11, 2020.

[8] For details, see Lev Manovich, *Culture in the pandemics era? Examining the growth of art biennales from 1895 to 2019,* December 14, 2021, http://manovich.net/index.php/projects/culture-in-the-pandemics-era-examining-the-growth-of-art-biennales-from-1895-to-2019.

[9] MJ Howe, JW Davidson, JA Sloboda, "Innate talents: reality or myth?" *Behavioral Brain Science* (1998), 21(3): 399-407, doi: 10.1017/s0140525x9800123x, PMID: 10097018, https://www.researchgate.net/publication/13194220_Innate_talents_Reality_or_myth.

[10] Rosalind Arden et al., "Genes influence young children's human figure drawings and their association with intelligence a decade later." *Psychological science* vol. 25,10 (2014): 1843-50, doi:10.1177/0956797614540686, https://www.researchgate.net/publication/264939641_Genes_Influence_Young_Children's_Human_Figure_Drawings_and_Their_Association_With_Intelligence_a_Decade_Later.

[11] For the examples of early and more recent publication on this topic, see Ritendra Datta, Dhiraj Joshi, Jia Li, and James Z. Wang, "Studying Aesthetics in Photographic Images Using a Computational Approach," *2006 European conference on computer vision* (Springer, 2006), https://www.researchgate.net/publication/221304720_Studying_Aesthetics_in_Photographic_Images_Using_a_Computational_Approach; Won-Hee Kim, Jun-Ho Choi, and Jong-Seok Lee, "Objectivity and Subjectivity in Aesthetic Quality Assessment of Digital Photographs," *IEEE Transactions On Affective Computing*, Vol. 11, No. 3, July-September 2020, https://ieeexplore.ieee.org/document/8302852.

[12] James Cunning, *Impressionism and its Canon (*University Press of America, 2005).

[13] Selmer Bringsjord, Paul Bello, and David Ferrucci, "Creativity, the Turing Test, and the (Better) Lovelace Test," *Mind and Machines* 11 (2001): 3—27, https://philpapers.org/rec/BRICTT-3.

[14] Quoted in Rowan Hooper, "Ada Lovelace: My Brain Is More Than Merely Mortal," *New Scientist*, October 15, 2012, https://institutions.newscientist.com/article/dn22385-ada-lovelace-my-brain-is-more-than-merely-mortal/.

[15] Selmer Bringsjord, Paul Bello, and David Ferrucci, 3.

[16] Mark O. Riedl, *The Lovelace 2.0 Test of Artificial Creativity and Intelligence*, arxive.org, December 22, 2014, https://arxiv.org/pdf/1410.6142.pdf.

[17] Will Knight, "A New Chip Cluster Will Make Massive AI Models Possible," Wired, August 24, 2021, https://www.wired.com/story/cerebras-chip-cluster-neural-networks-ai/.