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PAULINA TARARA

ART CREATING ART

Creative machines?

ABSTRACT

In the first part of the article I am going to present the definition and the onset of generative art, based on the example of Harold Cohen's AARON and Simon Colton's The Painting Fool. In the second part, I am going to describe the contemporary trends in generative art, based on the example of the machine imitating Rembrandt and Elgammal's Adversarial Network.

KEYWORDS

Berlyne Daniel Ellis ; Cohen Harold ; Colton Simon ; Elgammal Ahmed ; algorithm ; CAN (Creative Adversarial Networks) ; CNN (Convolutional Neural Networks) ; discriminator ; GAN (Generative Adversarial Networks) ; generator ; meta-algorithm ; global approach ; local approach ; feedback system ; generative art ; machine vision ; AARON ; The Painting Fool ; The Next Rembrandt

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Art creating art

Creative machines?

Introduction

Art has been accompanying humans since the beginning of times. Creating is inseparably a part of the development of our species. Without creating, neither art, nor inventions would exist. Creativity results in the shifting of borders, gaining new areas of knowledge and using them in practice, in everyday life. It all started inconspicuously, nevertheless, over time simple rock tools transformed into contemporary supercomputers. In this article I would like to outline the new perspectives which open up before us, as creators: creating objects that are able to create. Based on the example of Harold Cohen's AARON and Simon Colton's The Painting Fool, I am going to present the first steps taken towards the creation and the development of "creative" machines. In the further part, while describing GAN and The Next Rembrandt project, I am going to point to the new tendencies in the use of algorithms inspired by biology (evolution, neural networks, adversarial systems) in the creation of art that creates art. The article presents these matters with taking into consideration various types of algorithms applied as the source of the "creativity" of machines.

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Generative art

Generative art is art which refers to artistic practice that applies a system (a set of rules). The elements which may be those rules include a natural language, a computer program, a machine or another invention that uses procedures. This system also has "some degree of autonomy contributing to or resulting in a completed work of art"[1]. An important element of generative art is the randomness in which the autonomy of its process is expressed. It may be defined in various ways: based on probability (e.g. on a generator of random numbers with constant or varying probability) or a chaotic system (which may make the impression of one that is completely unpredictable, however, there is rationale for the existence of short term cause and effect relationships, as it happens in forecasting the weather from one day to the next).

Generative art may be considered as weak or strong[2]. The first category includes the works in which the artist prevails and the role of the system is limited to being a tool - even when this tool has a high dose of freedom and inspires or supports the implementation - the final outcome mainly depends on human and his or her decisions. In the second category, it is the system that has high autonomy, and the role of human ends on writing the code, creating the device which gives birth to art.

Such a definition of generative art is independent of whether it was produced with the use of highly developed technology or not. Nevertheless, in this article, I want to concentrate on the practice which applies a computer as the environment for creative algorithms. I understand artificial intelligence, the examples of which I am going to present in the text, as programs whose output data is not the result of numerical transformations of algorithms, but of the constant correction of algorithms under the influence of feedback (the feedback system). In case of AARON and The Painting Fool, the creators of the program play the role of the active feedback system correcting the algorithm. In the other cases mentioned by me, the feedback system are other algorithms.

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[1] Definition according to: P. Galanter, What is Generative Art? Complexity Theory as a Context for Art Theory, p. 4, http:// www.philipgalanter.com/downloads/ga2003_paper.pdf [accessed on: 25 July 2020]..

[2] *Ten Questions Concerning Generative Computer Art, ed. McCormack J. et al., 2012, p. 2, http:// jonmccormack.info/wp-content/uploads/2012/10/TenQuestionsV3.pdf [accessed on: 25 July 2020].*

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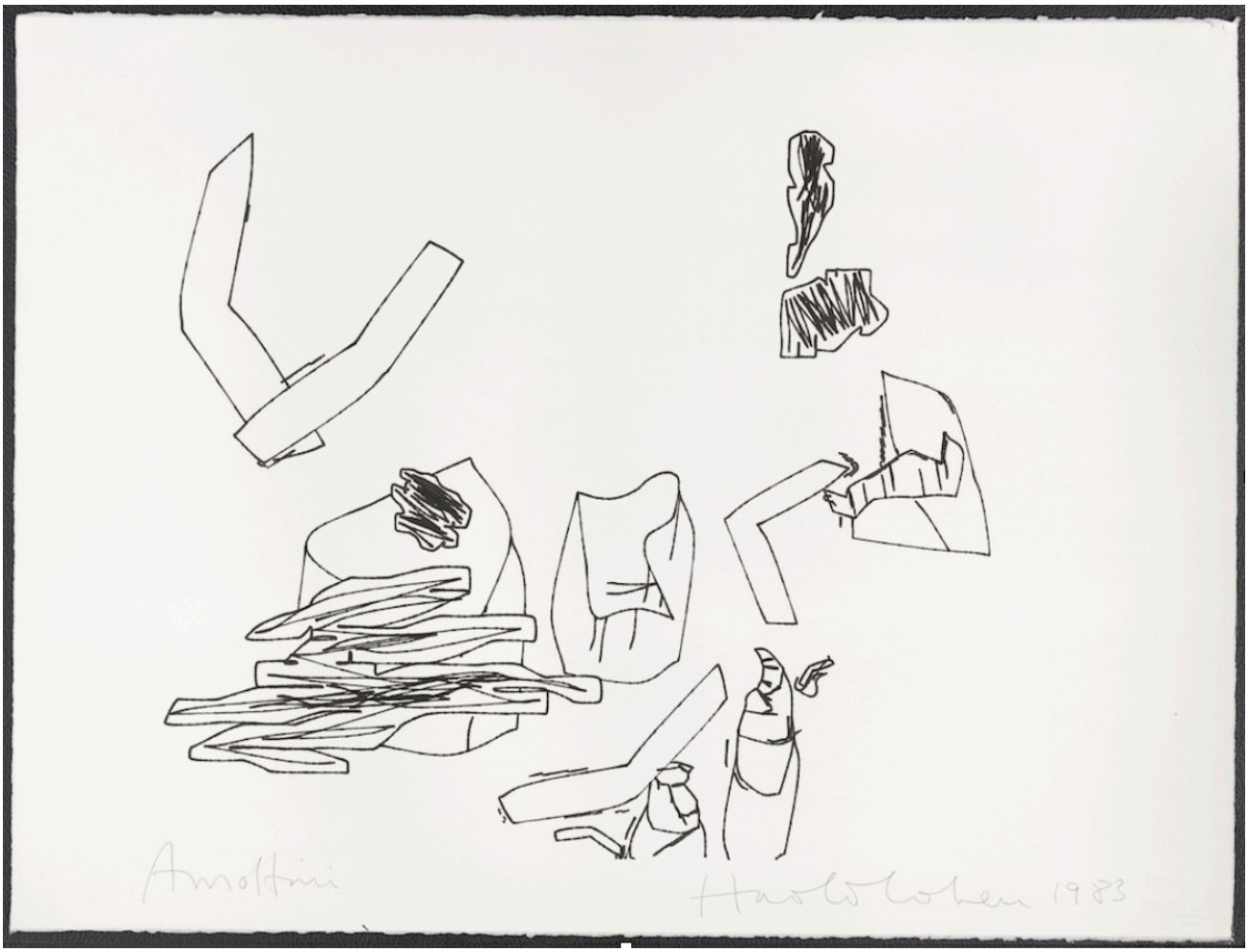
Harold Cohen, a plotter drawing, ink on paper, 57 cm × 76 cm, 1983.



Source: https://www.nytimes.com/2016/05/07/arts/design/harold-cohen-a-pioneer-of-computer-generated-art-dies-at-87.html [accessed on: 28 July 2020].

Weak generative art

AARON

Harold Cohen was the first artist to create artificial intelligence used for drawing, named AARON. AARON's works evolved over the years: from abstract images inspired by the petroglyphs of native Americans and early childhood drawings to figurative representations. The, initially, black and white drawings evolved into colourful images. AARON's code was created by Harold Cohen specially for

the needs of that project (today we have the possibility to use *open source* software, to implement it into the projects that are being created and to actively modify them). The program was being developed for the artist's whole life, for over 40 years, starting from 1972 when the machine and its art were presented at an exhibition at the Los Angeles County Museum of Art.

The data (image) entered into a computer, subjected to processing and returned as a result, was insufficient. It lacked a feedback system which the result could be subjected to, similarly as it takes place during the process of creation performed by human. Cohen understood art as the sum of decision processes that are subject to assessment and modification[3]. He tried to understand what set of signs is considered a complete image. He equipped his machine in that knowledge. It was the reflection of how Cohen understood art and the process of creation.

AARON's code is a code of a global type[4]. This means, that there is a set of instructions based on the function "if..., then...". The algorithm does not learn by itself. It is limited by the accuracy of its creator - by the number of situations that can be foreseen by the programmer that, step by step, implements the instructions according to which the algorithm lives. Every image created by AARON was different and was not based on the already existing resources. The program was only based on the set of rules that Cohen equipped it with. In order for the process of image creation to be to some degree autonomous, and in order for the images not to repeat, the author used a random number generator[5]. Initially, the program was only composed of basic rules referring to the types of lines and shapes, their proximity, permeation, composition. For years Cohen was gradually supplementing them with everyday objects, biological forms: humans, animals, plants. Until the end of his life he was modifying the program and he was its only "coach" and feedback system.

When, for instance, AARON was supposed to paint a human, it started from points on a flat area, subsequently it joined all the points together in accordance with the set rules, for example, the hand

[3] G.D. Taylor, When the Machine Made Art. The Troubled History of Computer Art (published online: Bloomsbery, 2014), p. 128.

[4] M. du Sautoy, Kod kreatywności. Sztuka i innowacje w epoce sztucznej inteligencji [The Creativity Code: Art and Innovation in the Age of AI], translated into Polish by T. Chawziuk, Kraków 2020, p. 130.

[5] M. du Sautoy, Kod kreatywności. Sztuka i innowacje w epoce sztucznej inteligencji [The Creativity Code: Art and Innovation in the Age of AI], translated into Polish by T. Chawziuk, Kraków 2020, p. 130.

Harold Cohen and AARON at work

Source: https://dam-gallery.de/haroldcohen-preview/?lang=en [accessed on: 28 July 2020]

is connected with the body, two hands can overlap one another due to the perspective, but cannot ever connect because in three-dimensional space they are in different planes etc.[6]

Cohen perceived art as a series of actions after which, every time, there is critical analysis, and on the basis of this analysis the decision regarding the subsequent action steps is made. Such a system is also used in machine learning. In machine vision, when, for example, we teach artificial intelligence to recognize dogs in images, the machine makes the decision: "this is a dog", which it subsequently compares with earlier results obtained during training. After this activity it may turn out that in the image there is no dog after all, and a correction is made in reference to the result. This is a feedback system. Thanks to it, it is possible to introduce corrections, improve the object of action and generate better results. In case of AARON, it was Cohen who accepted or rejected the images produced by the

[6] H. Cohen, The Further Exploits of AARON, Painter, 1994, p. 6, https://pdfs.semanticscholar.org/171f/19892e6c50293390791d377f0750e41df21f.pdf [accessed on: 28 July 2020].

machine. He played the role of a meta-algorithm which, in the contemporarily created artificial intelligences, on its own modifies the algorithms subordinate to it during training and learning.

If we look from the perspective of the program autonomy, AARON was never fully independent from its creator (weak generative art). Cohen, himself, did not consider AARON a fully autonomous machine:

> Over the years of what Cohen called a "mutual" relationship with his "other half," he and Aaron created both realist and abstract paintings[7].

He created a machine with which he cohabited in creative symbiosis. Initially, he painted AARON's linear drawings and over time he gave the machine more and more space for independent action. In result, it was a continuous creative cycle in which the machine inspired Cohen and these inspirations were translated into the machine's feedback system which was the artist himself; this had an impact on AARON's further art. I consider AARON's example important because the artist kept improving the algorithm until the end of his life, thanks to which the program kept constantly evolving, achieving very interesting and important effects, thus opening a discussion about the possibilities for creating a creative machine.

The Painting Fool

The Painting Fool belongs to Computational Creative software[8]. This means that the program has got a certain degree of autonomy and, within the scope of this autonomy, it makes decisions in the course of action. The project was initiated by Simon Colton in 2001, and subsequently it was developed at the Computational Creativity Research Group at Goldsmiths College in London. In 2006 Simon Colton named his program The Painting Fool for the first time. The author of the project wants the program to - thanks to training and improvement (also through becoming familiar with human creativity) - go beyond the contemporarily existing generative art projects: to show the ability of self-

[7] E. Callen, The True Potential of Computational Creativity: Technology and Humanity, https://www.30secondstofly.com/ai-software/harold-cohen-and-computational-creativity/ [accessed on: 28 July 2020].

[8] S. Colton, The Painting Fool: Stories from Building an Automated Painter, [in:] J. McCormack, M. d'Inverno, Computers and Creativity, Berlin 2012, p. 28.

Zmęczony i rozemocjonowany [Tired and emotional], Machine Intelligence Competition, Peterhouse, Cambridge, December 2007.

Source: http://www.thepaintingfool.com [accessed on: 29 July 2020].

criticism and be able to place itself in a broader cultural context. Its aim is not being the artist's tool which helps to create, but to one day become a fully autonomous artist painter[9].

In contrast to AARON, in case of which only one person, the author of the algorithm, was the feedback system and its only coach, the authors of The Painting Fool decided to collaborate with artists who became teachers. The Facebook community was also engaged in the assessment of the works presented by the machine. The analysis refers to both, images that were assessed positively as

[9] S. Colton, The Painting Fool: Stories from Building an Automated Painter, [in:] J. McCormack, M. d'Inverno, Computers and Creativity, Berlin 2012, p. 31.

well as negatively, in order for The Painting Fool to be able to make critical decisions referring to its works on its own in the future.

Colton believes that one of the important aspects of being an artist painter is the aware selection of the painting style. In order to simulate that, with taking portraits as the starting point, the author decided to assign appropriate painting styles to particular feelings reflected in the face, in order to underline the emotions of the person whose portrait is being painted. The source selected by Colton were the stills from the film *Fabuleux Destin d'Amélie Poulain,* presenting the main actress in various emotional states. Applying the trial and error method, manually assigning painting styles to particular emotions, he created portraits that were satisfying for him. This way, a base of about 100 painting styles assigned to particular amotions was formed. A part of them were generated by The Painting Fool randomly, however, all of them were assessed by the author who acted as a feedback system[10].

In order to create the impression of internal life that is possessed by every human, and from which artists draw inspiration, the author of the algorithm decided to make the emotional mood of The Painting Fool dependent on articles published in "The Guardian" on a given day. This experiment took place during the first edition of the Festival of Computational Creativity in Paris in July 2013. The program scanned the issue of the newspaper, looking for key phrases which then influenced the emotional state of The Painting Fool on a particular day. This is more strongly embedded in the reality of the world surrounding us than a generator of random numbers, and it still demonstrates an element of unpredictability. When the articles read by the algorithm are very negative, the program is even able to refuse to paint, giving the most negative phrase from the saddest article as the reason. When the articles are positive, The Painting Fool chooses from among nine pleasant words defined earlier, such as: "colourful", "happy" etc. and it paints a portrait in the style defined earlier, associated with the pleasant mood[11].

Both, The Painting Fool and AARON, belong to global algorithms and they are examples of weak generative art. Without authors who are responsible for the critical analysis and who react, changing

[10] The effects of the project may be viewed at the website: http://www.thepaintingfool.com/galleries/amelies_progress/ index.html.

[11] S. Colton, You Can't Know my Mind: A Festival of Computational Creativity, http://www.thepaintingfool.com/galleries/you_cant_know_my_mind/ICCC_YCKMM.pdf [accessed on: 29 July 2020].

its code, the machine would not be able to learn, adjust to the problems it is confronted with and improve its works. The creativity of machines is based on the creativity of the author.

Strong generative art

In the previous examples, human was not only the creator of the algorithm, the person pressing the "start" button, but also he or she actively participated in the decision making process as the feedback system. Human improved the algorithm, simply by changing the code or writing its further lines, trying to foresee all the possible situations which the machine would have to face. Human's role was inevitable in the process of the algorithm's functioning. The author could track the written code, he or she precisely knew what its particular parts were responsible for. This holistic approach is referred to as global. Currently, the code itself does not tell us everything about the functioning of artificial intelligence. Machine learning is based on the constant correction of algorithms under the influence of the feedback information until the moment of obtaining satisfying results. In this case, the feedback system is not human – the author of the algorithm – but another algorithm. Such auto-analysis of results is referred to as local approach. The decision tree which is, to a certain degree, possible to be tracked, does not always give clear presumptions referring to the path that was chosen by the algorithm for the purpose of achieving the defined target. For example, in machine vision (when we want to teach the program to recognize dogs) the algorithm asks the image a lot of questions, for example, whether the animal in the image has four legs. However, these questions evolve as the algorithm learns, and we cannot know what set of questions it uses to achieve its target. Especially that, while learning, the algorithm asks less and less of these questions because it uses the already gained experience and it learns from its mistakes.

We can observe the way in which machines make decisions on the following website: https://quickdraw.withgoogle.com. It is a simple game of charades, in which we draw and the artificial intelligence guesses what we have drawn. In the beginning of the game, we get the topic of the drawing. My task was to draw a scorpion.

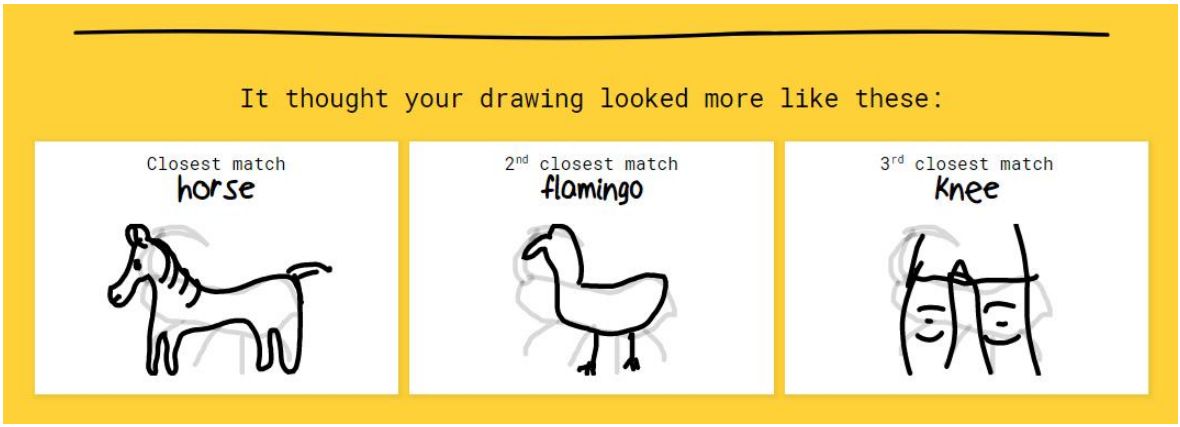
Unfortunately, my scorpion was not perfect and the algorithm did not guess what kind of animal it was. After finishing the game, one can ask the program to explain its track of thought. The nearest association in this case was a horse. The second and the third one were, respectively: a flamingo and, surprisingly, knees. As we can see, the associations of the algorithm and human associations are not completely identical.

My scorpion looked like this:

How the author of the article sees a scorpion

Source: https://quickdraw.withgoogle.com [accessed on: 30 July 2020].

How Google's artificial intelligence sees the author's drawing



Source: https://quickdraw.withgoogle.com [accessed on: 30 July 2020]

Currently, more and more initiatives associated with artificial intelligence in the world of art are being created. In the further part, I will show two examples of projects in which the authors based the artistic activity of their algorithms on machine learning. These are examples of strong generative art .

CAN vs Art Basel[12]

In this project the authors based on a theory saying that art is not created from nothing, it is the result of the artist's constant exposure to past and contemporary generations of authors and their works. Additionally, newly created art cannot be identical or strongly similar to one which already exists (the allegation is a lack of creativity), nor differ too strongly from the current standards (it is rejected by broader audience and treated as strange). The ideal artificial intelligence creating art is supposed to find balance between the old and the new, its works have to fit within the limits of what is currently accepted as manifestations of art. According to D.E. Berlyne:

> the most important aesthetic properties are novelty, surprise, complexity, polysemy and forcing to asking questions. Art is based on achieving novelty and surprise without so strongly differing from what may be expected that interest turns into revulsion because the outcome seems bizarre[13].

In order to achieve that, the starting point for the program created by Ahmed Elgammal and his team are the established and commonly accepted existing norms and styles, so as to, on their basis, broaden the existing borders and search for new methods of expression, this way achieving something surprising and (not too) new. Despite the fact that the network which they created is based on existing movements, it creates art which does not belong to those movements, art which attempts to balance on their borders.

From the technical point of view, in order to cope with this task, Ahmed Elgammal used Creative Adversarial Networks (CAN). It is a variation of Generative Adversarial Networks (GAN) which were the basis for creating CAN by Elgammal. In both cases it is a system of two networks: the generator and the discriminator. The generator is a creative part and it creates images from random

[12] Based on: A. Elgammal et al., CAN: Creative Adversarial Networks Generating "Art" by Learning About Styles and Deviating from Style Norms, June 2017, https://arxiv.org/pdf/1706.07068.pdf [accessed on: 30 July 2020].

[13] M. du Sautoy, Kod kreatywności. Sztuka i innowacje w epoce sztucznej inteligencji [The Creativity Code: Art and Innovation in the Age of AI], translated into Polish by T. Chawziuk, Kraków 2020, p. 153.

input data, without having access to existing works of art. The discriminator, in turn, in this particular case has got access to images from the publicly available base WikiArt (art from the 15th-20th century). It is a critical partner of the generator, it assesses the outcome and it plays the role of a feedback system. Thanks to the discriminator, the generator learns and, by changing the parameters of the algorithm, it may improve its works. In GAN there is one assessment step: the discriminator receives a generated image and it defines whether the image belongs to the training set (in this case - the WikiArt base) or not. In the case when the discriminator is not able to differentiate the work of the generator from the training set, the game ends. Unfortunately, this does not force the generator to create anything that would go beyond the existing art canons and would be at least in a small degree innovative, original. In order to achieve that, the second step of the discriminator assessment was designed. This is the way that the CAN networks function, basing their action on two steps of assessment, as distinct from GAN where there is only one. In the second step, the

Examples of images generated by the GAN networks

Source: Elgammal A., Liu B., Elhoseiny M., Mazzone M., CAN: Creative Adversarial Networks Generating „Art" by Learning About Styles and Deviating from Style Norms, June 2017, https://arxiv.org/pdf/1706.07068.pdf [accessed on: 30 July 2020].

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Images presented in the Art Basel art fair in 2017

Source: Elgammal A., Liu B., Elhoseiny M., Mazzone M., CAN: Creative Adversarial Networks Generating „Art" by Learning About Styles and Deviating from Style Norms, June 2017, https://arxiv.org/pdf/1706.07068.pdf [accessed on: 30 July 2020].

discriminator attempts to match the image to an art style. This principle of operation may be perceived as a game between these two networks. On one hand, the generator tries to convince the discriminator that its work is an already existing artwork, on the other - it tries to mislead it in reference to the style in which this work has been created. The discriminator, in turn, tries to guess which art movement the image belongs to, thus forcing the generator to create images of best possible quality. Thanks to the balance of both networks, it is possible to achieve satisfying results. The existence of two steps of assessment, which are used by the discriminator, results in the fact that the generator is forced to discover new areas of art, without going too far away from existing standards and movements.

The results were subjected to assessment. Scientists juxtaposed groups of images: paintings of abstract painters from the years 1945-2007, paintings of authors presenting their works at Art Basel 2016 and the set created by the algorithm (CAN and GAN). The aim was to check the ability of those

surveyed to differentiate whether a given work of art was created by human or by a machine. The aim is reached when the differentiation is not possible. The results were surprising. Those surveyed much more frequently considered the images created by CAN (53%) to have been created by human than in case of the paintings presented at Art Basel (41%).

The above described creative networks have the ability to constantly learn based on the information about the existing painting styles delivered to them. It is one of the experiments that were successful and well received by recipients. In contrary to global algorithms, there is greater autonomy here (we are not always able to accurately track the way which the algorithm followed to achieve the desired result), and above all, the ability to learn and to adapt to the set external conditions (the fields of art and the standards currently applicable in them).

The Next Rembrandt

This project aimed at bringing one of the greatest Old Masters back to life, in order for him to create one more painting after more than 300 years. The team wanted to investigate what is hidden behind the artistic genius of the master. For that purpose, 346 paintings were collected and scanned in high definition. Due to the fact that this task involved various institutions, the definition of the scanned paintings was not the same. In order to create a uniform database, each of them was enlarged and the definition was increased by 300%. The noise was also reduced, thus retrieving data which was digitally renovated in case of paintings which were not preserved in perfect condition. The size of all the collected material was over 150 GB of data. That was the starting point for discovering the genius hidden behind the paintings.

During his whole life, Rembrandt was interested in various topics: from landscapes, through still life to biblical scenes. However, what fascinated him most were portraits. Due to this fact, it was decided that precisely a portrait would be the new work of the resurrected Rembrandt. The selected period was between the years 1632 and 1642. The paintings were analysed in terms of various aspects: the colour of the eyes, gestures, the location of facial elements, the lighting, with the use of Convolutional Neural Networks (CNN).

For us, humans, recognizing objects is one of the first things we learn. While looking at a cat, we know that it is a cat and the enormous number of breeds and colorations is of no significance here. Also a cat that lost its ear, tail or a paw in an accident, unquestionably remains a cat for us. This

ability comes naturally to us, which cannot be said in case of algorithms. They have to learn what makes a cat a cat. This is where CNN comes to help. It is a collection of layers which we can understand as filters. Each filter brings out the desired features and characteristic elements form the image. The inspiration for creating them was the visual cortex, because some of its fragments are sensitive to horizontal elements and other - to vertical ones. And this architecture of specialized components performing only specific tasks was used in networks responsible for machine vision. Subsequently, characteristic features are grouped and analysed, and the result is the classification of an element in the image. The algorithm is able to indicate the probability of a given element's belonging to a particular label, for example: 81% for the earlier mentioned cat, 13% for a llama and 6% for a dog. The more training data, the greater the probability with which neural networks provide results.

Visualisation of the functioning of CNN filters

Source: https://medium.com/@apiltamang/a-gentle-dive-into-the-anatomy-
of-a-convolution-layer-6f1024339aca [accessed on: 10 August 2020].

The same mechanism was used by the team working on The Next Rembrandt project for recognizing the style of the great master: the composition that was turned into a geometrical pattern, the texture, the brushstrokes, the colour palette. The elements which were also analysed included the age of the people in the portraits, the direction towards which they were looking, the characteristic points of the face and typical proportions present in the paintings.

In the final stage of the work, the topic of the new painting of the algorithm master was selected: a 30-40 year old man, with a beard and moustache, looking towards the right, dressed in a black suit, with a white collar and a hat. What is important, the face of the painted person was not supposed to be the sum of all the faces painted by Rembrandt. In order for the master to be resurrected, the algorithm had to create a completely new face. In order to faithfully recreate the masterful brushstrokes, two types of algorithms were used, which analysed the texture and the way the paint was distributed on the canvas. The effect of the long work was composed of 148 million pixels on the screen and 13 layers of paint printed on canvas using a special plotter.

Rembrandt's new painting generated by artificial intelligence (on the left), layers of paint during printing (on the right)

Source: https://www.nextrembrandt.com [accessed on: 6 August 2020]

In this case, instead of broadening the current limits in art, the authors decided to teach a machine the style of one of the masters. The machine learned the master's style in 18 months, starting from the basics. The effect was the creation of a completely new work, bringing to mind Rembrandt's works. Was that a creative task?

The painting was commented in "The Guardian" by a British art critic, Jonathan Jones:

> What a horrible, tasteless, insensitive and soulless travesty of all that is creative in human nature [...]. You cannot, I repeat, cannot, replicate the genius of Rembrandt van Rijn. His art is not a set of algorithms or stylistic tics that can be recreated by a human or mechanical imitator. He can only be faked - and a fake is a dead, dull thing with none of the life of the original[14].

The aim of the project was not to create a new painting style, but only to repeat the style of the master. However interesting its outcome is, it is not creative. It does not broaden the adopted borders, it is not innovative, it only imitates, although it does it perfectly. Imitating is moving in the beaten paths, it is the opposite of creativity which goes beyond the generally accepted standards.

Conclusions

> Creativity is a mode of solving problems, which was created in order to break through the routine patterns in the moment when analytical thinking stops being effective[15].

Analytical thinking is thinking that is similar to an algorithm - with a specific selected path of action. The brain has to have the possibility to freely "have its head in the clouds", in order to create something creative and innovative. It is precisely the strange thoughts which seemingly do not fit to the topic at all, or mistakes, that give rise to innovation and creation, which differentiates the human way of creation from the machine one.

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[14] J. Jones, The digital Rembrandt: a new way to mock art, made by fools, „The Guardian", https://www.theguardian.com/artanddesign/jonathanjonesblog/2016/apr/06/ digital-rembrandt-mock-art-fools [accessed on: 6 August 2020].

[15] H. Beck, Mózg się myli. Dlaczego błędy mózgu są naszą siłą [Scatterbrain: How the Mind's Mistakes Make Humans Creative, Innovative, and Successful], translated into Polish by U. Szymanderska, Łódź 2017, p. 282.

In the latter one, the networks are set to solving the task in an actually quite defined way. The "creativity" of machines must not be mistaken for human creativity. The role of algorithms or neural networks is solving tasks efficiently and effectively, while creativity is something opposite: it is the resultant of mistakes, coincidence, poor efficiency, thinking outside the box. As for now, machines have no possibility to go beyond the path arbitrarily selected by the programmer. In contrary to the human brain which does not have one specific way of solving a given task. Creativity does not have to be logical or reasonable, because it is associated with breaking the established rules of procedure, which cannot be done by a machine[16].

By designing creative machines, we obtain new information about how our creativity functions. Many of the applied solutions draw straight from our biology and the perception of the world: neural networks designed in imitation of the cells in the human brain, evolutionary algorithms based on Darwin's theory of evolution or a feedback system which, also in our case, is an internal critic of our creative actions. However, despite the interesting and promising works of machines, machines are not autonomous. They are still unable to go beyond the frames imposed on them from the outside by their creators. We are the ones who provide them appropriate material for learning, in advance limiting the access to information, we push the "start" button and we decide whether the obtained outcome is worth of our interest. "Creative" machines still remain tools in the hands of creative people.

[16] H. Beck, Mózg się myli. Dlaczego błędy mózgu są naszą siłą [Scatterbrain: How the Mind's Mistakes Make Humans Creative, Innovative, and Successful], translated into Polish by U. Szymanderska, Łódź 2017, p. 271

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