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The Role of Art for the Future of Society

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Abstract

Advances in artificial intelligence technology are transforming society. Many people are anxious about the changes anticipated by this technological advancement. This paper describes the background and current status of the emergence of artificial intelligence and explains the advances in information technology that have brought about its emergence. Next, examples of art institutions, art events, and new art trends that link technology and art will be presented based on the results of a European survey. Finally, based on these examples, the role of art in the future development of technology will be discussed, considering the differences between the East and the West.

Keywords

Artificial intelligence, Technology, Transforming society, Technological advancement, Information technology, Art, Development

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Disclaimer

Initially, this project was intended to conduct a psychological experiment on the differences between Japanese and Western perceptions of AI. However, the COVID-19 pandemic has made this complex, and we have had to change our plans. We sincerely appreciate your understanding and support.

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1. Background

This study is based on advances in artificial intelligence (AI) technology, expected to bring significant societal changes. AI will also affect our employment and lives, and people are paying attention to these changes.[1]

As society undergoes significant transformation, there may be a way to predict and understand these changes by focusing on art. I set this hypothesis for this paper.

Although art has no technological underpinnings, it may be possible for artists to anticipate and express the significant changes that will take place in the future through their imagination. By paying attention to how artists perceive, utilize, and distance themselves from new technologies, it should be possible to predict subsequent societal changes.

This study aims to predict changes in society by examining the impact of new technologies in the art field. In addition, there is an interaction between technology and art, with technology facilitating the development of art and art, stimulating the growth of technology.

In particular, we focus on how art can alleviate social anxiety when such anxiety exists.

1.1. Advances in Artificial Intelligence Technology

Deep learning has continued to produce innovations since around 2012, with breakthroughs such as the dramatic performance improvement of nearly 10% in the 2012 ILSVRC image recognition contest and the accuracy of machine object recognition surpassing that of humans in February 2015. In other words, artificial intelligence can now judge objects more

[1] West, Darrell M., and John R. Allen. "How artificial intelligence is transforming the world." Report. April 24 (2018): 2018. Accessed May 10, 2023. https://www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/

accurately than humans, and this invention quickly spread to the industry, and object recognition startups became the new trend.[2]

In March 2016, AlphaGo defeated Lee Sedol. Because Go is more complex than chess or shogi, machines were thought not to beat humans in the foreseeable future.[3] However, the development of deep learning has been remarkable and far exceeded expectations, winning against human champions.

An essential concept for understanding deep learning is disentanglement.[4] Bengio and Goodfellow described prior knowledge for understanding deep learning with the keyword disentanglement. Human knowledge, such as image recognition or Go, cannot be expressed in simple mathematical formulas. Instead, it interacts with complex parameters that cannot be neatly described. Deep learning can unravel such complex intertwined parameters through deep hierarchies.

Deep learning can recognize images, and we can use it as reversed style to generate pictures with deep generative models called VAE [5]and GAN[6]. In particular, GANs can now create high-resolution images that humans cannot identify.

1.2. Impact of AI and Big Data on Society

AI through deep learning began to change the society around 2012, but even before that, Big Data, large amounts of data on the Internet, would significantly impact society.

Eli Pariser coined the term Filter Bubble to describe how personalized web searches limit the perspectives of individual users.[7] Later, Christian Rudder showed that large amounts of online data on social networking sites can reveal a person's behaviors, preferences, and opinions.[8]

Cathy O'Neil addressed the potential for large-scale data analysis and algorithms to deepen social inequality and amplify prejudice.[9] In particular, she noted the potential for algorithms to amplify prejudice and deepen social inequality. O'Neill calls the algorithms of big data "WMDs" (Weapons of Math Destruction) and argues that they have the following three characteristics.

1. Opacity: many algorithms are complicated for the public and those affected to understand, and their work lacks transparency.
2. Scale of Damage: These algorithms can have a significant impact on people's lives, including job opportunities, schooling, and insurance premiums.
3. Unfairness: these algorithms are often biased and may disadvantage certain people or groups.

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[2] Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." Advances in neural information processing systems 25 (2012): 1097-1105.
[3] Silver, David, et al. "Mastering the game of Go with deep neural networks and tree search." Nature 529.7587 (2016): 484-489.
[4] Bengio, Yoshua, Aaron Courville, and Pascal Vincent. "Representation learning: A review and new perspectives." IEEE transactions on pattern analysis and machine intelligence 35.8 (2013): 1798-1828.
[5] Kingma, Diederik P., and Max Welling. "Auto-encoding variational bayes." arXiv preprint arXiv:1312.6114 (2013).
[6] Goodfellow, Ian J., et al. "Generative adversarial networks." arXiv preprint arXiv:1406.2661 (2014).
[7] Pariser, Eli. "The filter bubble: What the Internet is hiding from you." Penguin UK, 2011.
[8] Rudder, Christian. "Dataclysm: Who we are (when we think no one's looking)." Random House Canada, 2014.
[9] O'neil, Cathy. "Weapons of math destruction: How big data increases inequality and threatens democracy." Crown, 2017.

O'Neill calls for increased regulation and transparency of algorithms to address these issues. However, this point made by O'Neill as of 2016 is still valid, and its need is growing.

Safiya Noble identifies the potential for web search engines to reinforce racism and unequal access to information.[10] Other researchers who have investigated such inequalities include Virginia Eubanks. She investigates how advanced technology affects people with low income.[11]

With the invention of deep learning, the combination of big data and algorithms has evolved into AI. Its social impact is only expanding: AI has spawned many innovations and many problems that accompany its evolution. In particular, dealing with the anxiety about the social changes brought about by artificial intelligence has become a major challenge.

EHESS is home to many researchers dealing with the social impact of digital technology and big data.

Valérie Beaudouin, for example, is developing a framework for designers and operators of machine learning algorithms to define the "right" level of accountability, combining technical, legal, and economic aspects, for example, when AI is required to be highly secure.[12]

Antonio Casilli studies user behavior on social media platforms.[13] He has analyzed vast amounts of behavioral data on people on social networking sites and published papers on how they are formed and mimicked. He is concerned that data collected without the consent of large numbers of people could be used to influence politics, such as commercials or election campaigns, and is researching ways to combat this.

1.3. Will Artificial Intelligence Surpass Humans?

How far will artificial intelligence (AI) develop? A futurological concept that attempts to answer this question is "Singularity."[14] This term refers to the point at which the capabilities of "some form of artificial intelligence" will continue to grow exponentially, surpassing human intelligence and the changes in the world that AI will bring about. After Singularity, AI will be able to program and improve itself and will be able to perform the entire process of AI development on its own. It is said that humans will be left behind in the eyes of AI.[15] While this vision of the future may sound frightening, the reality is that AI technology still faces many challenges. There is no guarantee that it will progress as hypothesized. Current artificial intelligence still faces many challenges. For example, highly accurate artificial intelligence has already been achieved in natural language processing and emotion recognition. On the other hand, occupations that utilize creativity and sensitivity are attracting attention as jobs that artificial intelligence cannot replace.

The development of artificial intelligence is expected to bring about significant changes in society and the economy. The labor market and employment environment will change

[10] Noble, Safiya Umoja. "Algorithms of oppression. Algorithms of oppression." New York University Press, 2018.
[11] Eubanks, Virginia. "Automating inequality: How high-tech tools profile, police, and punish the poor." St. Martin's Press, 2018.
[12] Beaudouin, Valérie, et al. "Flexible and context-specific AI explainability: a multidisciplinary approach." arXiv preprint arXiv:2003.07703 (2020).
[13] Tubaro, Paola, Antonio A. Casilli, and Yasaman Sarabi. "Against the hypothesis of the end of privacy: an agent-based modelling approach to social media." Springer Science & Business Media, 2013.
[14] Kurzweil, Ray. "The singularity is near: When humans transcend biology." Penguin, 2005.
[15] Brynjolfsson, Erik, and Andrew McAfee. "Race against the machine: How the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy." Brynjolfsson and McAfee, 2011.

drastically as artificial intelligence becomes widespread and various tasks are automated if artificial intelligence begins to replace human abilities.[16] Like Go, artificial intelligence will replace human jobs sooner or later. This is the idea behind the artificial intelligence threat theory.

While this view is understandable, many engineers involved in the development of AI are skeptical of such a view. Because artificial intelligence still has many technical challenges, and it isn't easy to believe such a situation will soon pass. Even today, computers already surpass humans in computing speed and storage capacity. However, few people believe that computers are taking away human jobs. The advent of computers has created many new jobs, and many people are aware of this. Even if machines replace skills we have mastered, it does not necessarily mean they will immediately take our jobs. The speed at which new tools are created and permeate society will have an impact here. On the other hand, both sides may or may not be able to take advantage of such a situation and enter new fields.

While artificial intelligence has already produced many innovations and is expected to continue to play an active role in various areas of society, there are also many problems associated with the evolution of artificial intelligence. In particular, a significant issue is dealing with anxiety about the societal changes artificial intelligence brings.

1.4. Differences in Views on Artificial Intelligence between East and West

Artificial intelligence may bring about different social changes in Japan and Europe.

In Japan and Europe, there is a difference in the psychological distance toward robots. In Japan, cartoons featuring robots such as "Astro Boy" and "Doraemon" are famous, and robot animation such as "Gundam" is widely watched.[17] With this background, Japanese people have little resistance to using robots daily.[18]

In terms of cultural background, it is possible that there is less aversion to creation by artificial intelligence in Japan. In Japan, there is a tendency not to actively distinguish between artificial and natural objects. For example, Japanese gardens are designed in such a way that the scenery in the back and the garden itself seem to be connected. This is called borrowed scenery, and the entire landscape is composed as one. Therefore, although the garden itself is artificial, it is accepted as something continuous with nature. This is one of the characteristics of Japanese culture.[19]

In Europe, on the other hand, there is a phenomenon known as the "Frankenstein syndrome": in Mary Shelley's novel "Frankenstein," published in 1818, there is a scene in which the "monster" takes revenge on its creator. Stories like this repeatedly appear in Western novels, in which a human-created life form avenges its creator. Science fiction writer Isaac Asimov named it the "Frankenstein Syndrome."[20]

This cultural context is believed to have been established by its recurring appearance in various films and novels. Ridley Scott's "Blade Runner" also depicts a story in which a creature

[16] Penrose, Roger, and N. David Mermin. "The emperor's new mind: Concerning computers, minds, and the laws of physics." (1990): 1214-1216.

[17] Alt, Matt. "Pure Invention: How Japan's Pop Culture Conquered the World." Constable, 2020.

[18] Murakami, Takashi, ed. "Little boy: The arts of Japan's exploding subculture." Yale University Press, 2005.

[19] Kato, Shuichi. Space and time in Japanese culture. Iwanami Shoten, 2007. (Kato, Shuichi. Le temps et l'espace dans la culture japonaise. CNRS Editions, 2009)

[20] D. S. Syrdal, T. Nomura, H. Hirai, and K. Dautenhahn, "Examining the Frankenstein Syndrome: An Open-Ended Cross-Cultural Survey." Social Robotics: Third International Conference, ICSR 2011.

kills its creator. [21]He hypothesizes that repeated depictions of such reports have led people to fear the artifacts they have created.

There is a close relationship between the novel Frankenstein and the birth of "programming."

The author, Mary Shelley, was invited by the poet Lord Byron to stay at a villa called Diodati on the shores of a lake in Switzerland. During a long rainstorm, the five people at the estate decided to write a "ghost story" together.

A recently discovered scientific principle became the topic of discussion. A phenomenon called galvanism has been found: when electricity is applied to frogs' legs, they move. The idea that an animal's body can be driven by electricity gave rise to the notion that if electricity is applied to a corpse, it might be brought back to life.

She turned the idea from this new scientific discovery into a story in "Frankenstein. Or, the Prometheus of our time". Novels with such a scientific background are now called Science Fiction (SF), and "Frankenstein" is considered the world's first SF.

The "Prometheus" in the subtitle is a figure from Greek mythology. He stole fire from the gods and learned to fly. However, he gets too close to the sun, his wings melt, and he falls. This myth appears in Greek mythology as a prototype for man's acquisition of "technology." This idea has taken root in Western culture today. Technology belonged to the gods, and humans acquired technology by stealing from the gods.

In his book "The Question Concerning Technology in China: An Essay in Cosmotechnics," the Chinese philosopher Yuk Hui describes the difference between Eastern and Western views of technology. In Western mythology, man acquired technology by stealing from the gods but suffered damage. Such episodes are repeatedly depicted not only in mythology. In contrast, there are no episodes in Eastern mythology, especially Chinese mythology, in which technology gets back at humans. He argues this is the difference between Western and Eastern views of technology.[22] Yuk Hui's argument is based on the long history of Western and Eastern philosophy. In the West, technology belongs to the realm of the gods, and man has made it his by stealing it from them. This remains the myth of Prometheus. In contrast, in the East, technology is considered one with cosmology (Dao).

> "In Chinese thinking, Dao is superior to any technical and instrumental thinking, and the goal of Dao is also to transcend the limitations of technical objects — that is, to let them be guided by Dao. In contrast, it seems that the ancient Greeks, had a rather instrumental concept of techne as a means to an end, at least this was the case for the Aristotelians."

Thus, to treat techne and Dao as one concept, he introduced the term "cosmotechnics".

Another figure who connected science and art is Augusta Ada Byron (formally Mrs. Lovelace; she was the daughter of the late Augusta Ada Byron). We will refer to her as Ada in this paper). Ada is the daughter of Lord Byron, the organizer of the Villa Diodati stay mentioned earlier. Her mother was a woman who excelled in mathematics. Ada descended from both parents, became a rare combination of her understanding of mathematics and her gift for words as a poet.[23]

Charles Babbage, a mathematician, invented the calculator, the world's prototype of computer. Babbage's graded difference engine could output value tables and logarithmic tables for sequences of numbers and polynomial functions. His next conception, the analytical engine,

[21] Shelley, Mary Wollstonecraft. "Frankenstein, or The Modern Prometheus" (1818). epubli, 2022.
[22] Hui, Yuk. "The question concerning technology in China: An essay in cosmotechnics." MIT Press, 2016.
[23] Woolley, Benjamin. "The Bride of Science: romance, reason and Byron's daughter." Pan Macmillan, 2015.

was thought to be able to handle various problems and algorithms by changing formulas and parameters. In practice, however, he never completed his analytical engine.

Babbage gave lectures on his analyzer idea at various venues. An Italian scholar named Menabrea, interested in Babbage's lecture, wrote a French paper based on it. Ada met Babbage at one of the social parties, learned of his ideas, and became intensely interested. She then offered to help him with his work. Ada suggested that he translate the French paper written by Menabrea into English and publish it.

At that time, women rarely published papers under their names. Ada translated the paper and added her text to it as annotations. The annotations were more than twice as long as the text of the paper. The annotations described how to instruct the analytical laboratories to perform the calculations. We understand this as the world's first program.

However, whether Ada created the world's first program is questionable. Ada wrote the paper in close communication with Babbage, and he wrote the part that instructs the calculation method. In short, Babbage also wrote the program part.[24]

Nevertheless, as part of her notes, she states that the development of the calculator should enable us to compose music and poetry in the future. She describes the possibility of artistic usage of it when Babbage, the inventor, was only thinking about doing calculations. Her prediction of the future of technology based on her sensitivity as an artist is truly outstanding. The brilliance and accuracy of her ideas are of immortal value.

Mary Shelley and Augusta Ada Byron were close friends. The presentation of the possibilities of linking science and art created by these two women continue to have a profound impact on contemporary society.

As an artist, Ada predicted the future of what machines could do. I am thinking about it in the same way. I would like to talk about the future that machines can realize from an artist's point of view.

1.5. Turing's comparison of human and machine intelligence

In 1950, Alan M. Turing wrote a paper entitled "Computing Machines and Intelligence." In this paper, he considers whether machines can be intelligent.[25]

Turing was one of the most important researchers who built the world of computers. He is best known for the Turing Machine, a universal computer that formed the most fundamental part of the theory of computation.

To define human intelligence, he devised a method called the "Turing Test." The generalized Turing Test is as follows. One room contains a human being, and the other a machine. The person in this room can only communicate with the person in the other room by text using teletype. The objective is to guess from the outside which room has a human and which room has a machine. If you perform this test several times and the percentage of correct answers is 50%, the machine has the same level of intelligence as a human.

His paper notes various objections and reactions to whether a machine can be intelligent. Among them was a rebuttal to Mrs. Lovelace's comments. She stated, "Machines can only do what they are taught and nothing new."

Turing writes a rebuttal to Mrs. Lovelace's comment. Indeed, machines can only do what they are taught. But it is not true that such directed work "never surprises" the person who instructed it. Even if the work is done as directed, the result may surprise those who see the

[24] Wolfram, Stephen. "Untangling the tale of Ada Lovelace." Stephen Wolfram Blog (2015).
[25] Turing, Alan M. "Computing Machinery and Intelligence." Mind 49: 433-460. 1950.

finished product. Thus, while agreeing with Ada's statement, he refutes the position that machines can be intelligent.

In the text, he expresses that machines can be intelligent or appear intelligent on the outside.

The year 1950 was about 100 years after Babbage's invention and the world's first program by Ada. It was 1946 when ENIAC, generally considered the world's first computer, became known. Despite this early date, the author argues convincingly and convincingly that machines can have intelligence. His description of how computers work and his predictions about how far they will evolve are remarkably accurate.

Turing predicted that it would not be possible to program a computer with a storage capacity of 10^9 until about 50 years from now, or the year 2000. Computers with 10^9 digits (≈1 gigabyte) of main memory were available then. This prediction of the future is incredibly accurate.

He predicted that computers 50 years from now would prevent the average questioner from making the right decision more than 70% of the time in a five-minute exchange. In fact, in 2000, computers capable of chatting, as he predicted, had not yet been realized. Still, about ten years later, in 2010, artificial intelligence capable of chatting with people had already been developed. Again, the accuracy of his predictions is remarkable.

This paper he left behind continues to influence many people, even today. The debate he advocated about the possibility of machines having intelligence continues today. Looking back to his 1950 paper predicting whether machines would be intelligent, we can confidently say that "machines can indeed be intelligent." But what would we predict if we were asked today to predict the future 50 years from now, in 2073? If Turing were alive, what kind of future would he have envisioned?

1.6. Making science and technology accessible through art

The 1950s was a time of remarkable technological progress when technology began to have a major impact on society in various ways. A new art field called "technological art" emerged during this period. Technology art encompasses various artistic activities that utilize technology in production. Examples include kinetic sculpture, sound art, and light art. A movement to explore the relationship between art and technology is emerging in various regions, focusing on using technology to create new forms of artistic expression.

Particularly relevant to this paper is the Exploratorium, established in San Francisco in 1969.

In 1968, physicist Frank Oppenheimer wrote "Theoretical Foundations of Science Museums." The document discusses the importance of literacy in science and technology, the shortcomings of existing educational methods, and the relationship between museums and industry. This text became a manifesto outlining the early concepts of the Exploratorium.

Frank Oppenheimer was the brother of Robert Oppenheimer, who led the Manhattan Project during World War II. Robert Oppenheimer is best known for successfully building the atomic bomb but later became vehemently opposed to developing the hydrogen bomb during the Cold War. As a result, he was considered a security risk. He was eventually stripped of his security clearance and removed from government positions during McCarthyism and anti-Communist hysteria in the United States.

Frank Oppenheimer was also removed from his position as professor of physics at the University of Colorado and blocked from many other academic positions. He became interested

in the importance of science education and museums and public institutions' role in making science education accessible and appealing to the general public.

In 1969, Frank Oppenheimer founded the Exploratorium in San Francisco. This science museum was designed as a public learning institution to help people of all ages become familiar with and interested in science. Based on Oppenheimer's belief that science education should be based on inquiry and exploration rather than passive memorization of facts, the Exploratorium is designed to encourage visitors to actively engage with scientific concepts and explore the world around them.[26]

One important aspect of the Exploratorium is the collaboration between scientists and artists. The Exploratorium's artist-in-residence program began in 1974 and allowed artists to work with scientists and educators to create new forms of art based on scientific inquiry. They provided artists with museum facilities and equipment and the opportunity to interact with staff and visitors. This allowed the artists to create interactive, engaging, and scientifically conceptual works of art.

The artist-in-residence program was successful, attracting artists from various backgrounds and disciplines. As a result, many of the works were highly innovative and influential in developing contemporary art. The program also led to a greater understanding of science. And its role in society demonstrated the potential for collaboration between artists and scientists.

Today, the Exploratorium continues to promote Frank Oppenheimer's vision of accessible and engaging science education for all as an important center for science education and outreach.

Another example of art and technology collaboration is the organization Experiments in Art and Technology (EAT), which scientist Billy Kluver founded while he was at Bell Labs. Mr. Kluver was tired of his mundane life as a scientist.

Tired of his mundane life as a scientist, he sought ways to collaborate with artists such as Robert Rauschenberg and Andy Warhol. After an exhibition in New York, EAT traveled around the West Coast, including to the Exploratorium.

For example, Warhol's "Silver Clouds features a room full of cloud-like silver balloons. Warhol conceived the idea for this work and brought the silver clouds to life with the help of scientists and engineers. The work was first exhibited in New York in 1966 and has been exhibited worldwide since then.

Computers have been used as a medium to connect people since approximately the 1980s. Since then, it has come to be called media art.[27]

I was greatly influenced by the Internet technology that emerged after the 1990s. I began my artistic activities in 1996 with "WebHopper," which visualizes users' Web browsing behavior on a world map and traces their virtual journey in real-time. This work was part of the "Sensorium" project, which won the Ars Electronica Grand Prix. In 2001 I participated in creating the exhibit "A Hands-on Model of the Internet" at the National Museum of Emerging Science and Innovation. The exhibit uses black and white balls to show the packet exchange process allowing users to create packets manually and see how they are transmitted over the Internet.

From 1996 to 2001, the Internet began to become popular. How can we explain the Internet, a cutting-edge technology that was emerging at the time, in a way that is easy for the general public to understand? It was from this perspective that I created these works.

Later, I became interested in collective intelligence on the Internet. Our team created Modulobe in 2005, a platform for creating complex 3D models that move like living creatures by

[26] Oppenheimer, Frank. "A rationale for a science museum." Curator 11.3 (1968): 206-209.
[27] Michael, R. "New Media in Art." Thames & Hudson, (2005).

combining simple shapes like matchsticks.[28] Users can use this application to create and submit a variety of models. As users influence each other, a variety of creations are created. In this way, we studied how collective intelligence is created on the Internet.

In 2011, we launched “NicoNicoGakkaiβ” as a place to promote user-participatory research.[29] In the world of the Internet, new media such as YouTube and Nico Nico Douga have emerged. Among them, there were people who posted videos of their research results. They are not professional researchers, but they are citizen researchers (we call them wild researchers).

Based on these experiences, this paper will consider art's role in positioning cutting-edge technology in society and making it more accessible to the general public.

1.7. Literature Review

There are already several pioneering studies on the relationship between AI and art.

In 2019, the MDPI journal Art published a special issue entitled The Machine as Artist.[30] The issue included 17 research papers exploring the interface between artificial intelligence and creative expression. The papers covered topics as diverse as philosophical questions about the nature of creativity and authorship in the context of machine-generated art and the use of AI in human-machine creative collaboration. Each paper provides valuable insights and perspectives into the field of machine-generated art.

In 2021, Associate Professor Nao Tokui of Keio University published a book for AI and Creation.[31] The book addresses the question, "How can we use AI to enhance human creativity?" This book aims to provide guidelines for using AI to enhance human creativity. It covers various topics related to the intersection of AI and creativity, including how to train AI models to recognize and generate artistic styles and use AI in the creative process. The potential of AI to stimulate new creativity.

In the same year, 2021, Professor Sofian Audley published his book.[32] The book traces the evolution of computer art from its origins in the 1950s to the present, exploring how machine learning algorithms have been used to generate new creative expressions. It also delves into contemporary debates about the role of technology in artistic practice, examining issues such as authorship, creativity, and the boundaries between human and machine-generated art.

Yuk Hui wrote a book that explores the cultural and philosophical differences between Eastern and Western approaches to technology.[33] The book analyzes the relationship between technology and culture by examining the historical development of technology in China and how cultural values and traditions have shaped technology. Particular attention is paid to the differences between Western and Chinese conceptions of technology, emphasizing the role of cultural and philosophical factors in shaping these differences.

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[28] Eto, Koichiro, et al. "Modulobe: A creation and sharing platform for articulated models with complex motion." Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology. 2008.

[29] Eto, Koichiro, Tom Hope, and Hideaki Takeda. "A pattern language for an open academic society with non-professional users." Proceedings of the 23rd Conference on Pattern Languages of Programs. 2014.

[30] Mazzone, Marian, and Ahmed Elgammal. "Art, creativity, and the potential of artificial intelligence." Arts. Vol. 8. No. 1. MDPI, 2019.

[31] Nao Tokui. "Creating with AI - Computational Creativity and Beyond." BNN, 2021.

[32] Audry, Sofian. "Art in the Age of machine learning." MIT Press, 2021.

[33] Hui, Yuk. op. cit., p. 89.

2. Research Questions

I want to identify how the future relationship between humans and AI will evolve across artificial intelligence and the creative field of art. To this end, I set the following research questions:

1. What are the most important capabilities in the coming AI age?
2. What can art do for the future of society?

I set these questions to reflect a growing interest in the intersection of art and technology and how creative expression can be enhanced or changed by AI.

3. Methodology

This study aimed to address the research questions through a qualitative approach comprehensively. To this end, I primarily conducted field research.

The field research included case studies of several art and technology institutions and interviews with artists. During this phase, we aimed to gain a deeper understanding of the topic and gain insights from experts in the field.

In addition, workshops were held with both artists and researchers to promote discussion and knowledge exchange. The goal was to fully understand the subject matter and gain a deeper understanding of the research questions.

In addition, the workshop considered the differences between Eastern and Western attitudes toward artificial intelligence. This allowed us to understand more comprehensively and draw conclusions relevant to the East and the West.

4. Case Studies

In Europe, the interface between art and technology is increasingly attracting attention, and many art institutions, events, and movements are incorporating technology into their creative activities. These movements often explore the impact of technology on society and question conventional notions of art and artistic expression. This section presents examples of such intersections of art and technology in Europe.

4.1 Ars Electronica

The Ars Electronica Center in Linz, Austria, has been at the forefront of the global digital art scene with its comprehensive range of festivals, centers, and awards since it launched the Ars Electronica Festival in 1979.[34]

Hans Leopold Söder, program director of the music department of the Austrian Broadcasting Corporation (ORF), music department proposed the concept of Ars Electronica. Söder recognized the potential of electronic media as a new form of artistic expression and wanted to create a platform to showcase the work of artists and musicians experimenting with these technologies. The first festival was held later that year as part of the International Bruckner Festival in Linz, Austria. Initially, the festival was held every two years, but since 1986 it has been held annually.

[34] Hirsch, Andreas J. "Creating the Future: A Brief History of Ars Electronica 1979-2019." Ars Electronica, 2019.

By bringing the general public to the festival, Ars Electronica sought to create a space for dialogue, exchange, and exploration, encouraging people to think creatively and critically about the role of technology and art in their lives. This approach reflects a larger trend in media arts to engage diverse audiences and involve them in the creative process. By fostering a culture of collaboration and co-creation, Ars Electronica democratizes access to cutting-edge art and technology. It paves the way for new forms of artistic expression and social participation.

In 1987, Prix Ars Electronica was established for the most outstanding work submitted yearly. Since then, it has been called the "Academy Award for Media Arts" and highly acclaimed. Initially, the focus was on electronic music, but the awards have since expanded to include computer graphics, interactive art, and many other fields.

Prix Ars Electronica has its judging criteria. That is, it is not limited to artworks created by artists. For example, Tim Berners-Lee, the inventor of the World Wide Web, received the award in 1995, and Linus Torvalds, the developer of Linux, received the award in 1999. Other winners have included initiatives such as Creative Commons, Processing, and Wikipedia. Thus, Ars Electronica continues to honor inventions that have changed the world in the context of art.

In 1996, the Ars Electronica Center was established as a museum and research facility to explore the interface between art, technology, and society. The center hosts exhibitions, workshops, and events showcasing the latest digital art and technology developments.

An overview of the Ars Electronica Center in Linz, Austria. Photo by the author.

The Futurelab, attached to the Ars Electronica Center, is a research and development center that produces interactive exhibitions, installations, and other digital artworks. The Futurelab also functions as a residence for artists and researchers. It also occasionally launches projects commissioned by companies or its projects.

In 2012, Horst Hertner, one of the founding members of the Ars Electronica Center, came up with the idea of using drones to paint pictures in the night sky: drones equipped with LED lights are flown into the night sky and kept aloft by computer control. Spaxel is a coined word that combines the words space and pixel.

Futurelab has developed a drone (quadcopter) equipped with a programmable LED system and a GPS-based autopilot. They programmed the drones to draw a specific picture. Then, the drones could create dynamic three-dimensional shapes in the night sky. To control the

deformation flight, they developed uniquely adapted swarm control software and a ground controller to control the deformation in flight.

In 2012, I observed a field flight experiment of this spaxel. At the time, they experimented with 7x7 drones. At night, 49 drones were floating in the air on the banks of the Danube River, drawing patterns of light. The lights were feeble. The pattern was unstable and shaky; 49 drones were floating in the air, painting a picture, but the dots of light were so few that they did not appear to be painting a picture. In 2012, I could never have predicted that they would paint as bright and precise a picture as we see now.[35]

The first flight test of 49 drones by the Ars Electronica Futurelab in 2012. The location was on the banks of the Danube River, in front of the Ars Electronica Center. Photo taken from Ars Electronica Web site.

The director, Horst Hörtner, published this experiment in his paper.[36] Futurelab then collaborated with Intel to fly 100 Spaxels simultaneously to form a 250-meter wide picture in November 2015. This experiment set a new world record in the category of "Most Unmanned Aerial Vehicles (UAVs) in the air at the same time" of the Guinness Book of Records.

On July 23, 2021, Intel will levitate 1,824 drones to draw the Olympic emblem at the Tokyo 2020 Olympic Games opening ceremony. Nine years later, FutureLab's vision of the future is now gracing the skies of Tokyo.

Why did the city of Linz, Austria, start Ars Electronica? Although the city now has the impression of being an art city represented by Ars Electronica, before that, Linz was a gray industrial city centered on the steel industry. The first attempt to change that city was the International Bruckner Music Festival. This eventually led to the establishment Ars Electronica Festival & Center, which incorporated technology and new media into artistic expression. The goal was to make Linz a destination for artists and researchers working at the intersection of art and technology, creating a dynamic community that would stimulate creativity and innovation. The festival has attracted increasing attention and continues to attract visitors from around the world.

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[35] Ars Electronica Futurelab, "Spaxels / Klangwolke – Quadrocopter." 2012. Accessed May 10, 2023. https://ars.electronica.art/futurelab/en/projects-spaxels-klangwolke-quadrocopter/

[36] Hörtner, Horst, et al. "Spaxels, Pixels in Space.-- A novel mode of spatial display" Proceedings of the International Conference on Signal Processing and Multimedia Applications and Wireless Information Networks and Systems. 2012.

The current co-director of the Ars Electronica Futurelab is Hideaki Ogawa, an artist, curator, and researcher who moved to Linz from Japan in 2007 and opened the center in 2009.

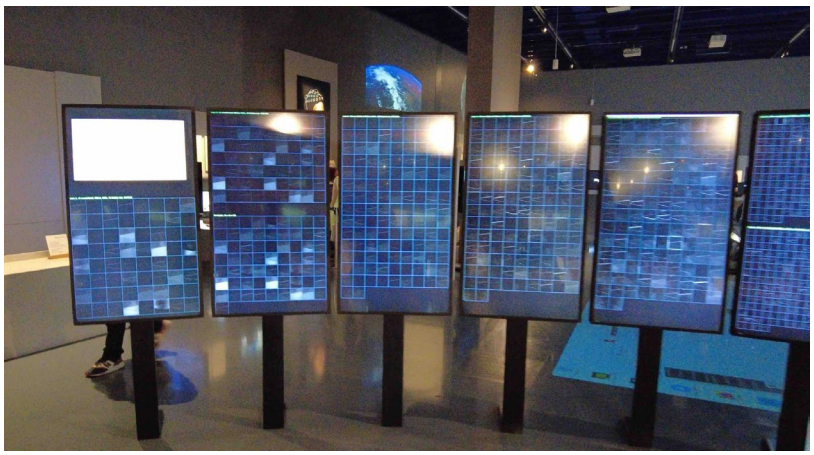
I had the opportunity to interview Ogawa this time.

The Ars Electronica Center originally started as part of the City of Linz but is now an independent public corporation. Another water infrastructure in Linz is also an independent public corporation. According to Ogawa at the Ars Electronica Center, the future comes out when you turn on the faucet, just as water comes out when you turn on the faucet. In other words, Ars Electronica is an infrastructure project for creating the future.

The Ars Electronica Festival is held annually, but in 2020 they will hold it online due to a pandemic. The following year, 2021, they held it in a hybrid format. The festival usually attracts hundreds of artists worldwide, but there was no turnout this year. Only three Japanese artists participated. The event was quieter and lonelier than in previous years.

The Ars Electronica Center had an interesting exhibit focused on AI and climate change: Deep Neural Networks (DNN) are the fundamental technology behind modern AI systems. This exhibit showed how the underlying technology works. The system first receives input from a camera. Visitors could place a model of a bell pepper or an African elephant in front of the camera. Then, the DNN receives input from the camera, performs layers of calculations, and returns the result of image recognition of what the image from the camera shows. Eleven monitors were lined up in front of us so that we could simultaneously view all the intermediate layers of the DNN in the calculation process.

Many intermediate layers compute DNNs, but the computation of so many layers is difficult even for engineers who use DNNs to understand. Therefore, with the simple idea of using multiple monitors to see all the layers simultaneously, the engineers showed visitors in an easy-to-understand manner that DNNs are composed of many layers and that layering layers perform calculations.[37]



This installation aims to explain Deep Neural Networks (DNN) in an easy-to-understand way, using Convolutional Neural Networks (CNN), in particular, the VGG16 network. Photo by the author.

[37] Ars Electronica Futurelab. "Understanding AI. Convolutional Neural Network." Ars Electronica Center, 2021. Accessed May 10, 2023. https://ars.electronica.art/futurelab/en/projects-understanding-ai/

4.2. "Les Machines de l'Ile" (The Machines of the Island of Nantes)

In the city of Nantes, France, there is a unique facility called "Les Machines de l'Ile de Nantes. It is famous for its giant elephant that moves, and people can walk around the city on its back.[38]

A giant elephant walks through the streets at Les Machines de l'Ile in Nantes, France. Photo by the author.

The city of Nantes is about two hours by TGV from Paris, and on the island of Nantes, sandwiched between two rivers, is "Les Machines," a former shipyard. This place is a factory producing artworks and a gallery for their models. Every day, a moving giant elephant carries people around the grounds of this spacious factory. There is also a merry-go-round on the premises that carries children every day.

Initially, their activities began with street performances in which they paraded around the city with moving giant dolls. The sight of the giant dolls moving around the city was so impressive that their videos became viral and well-known to many people. Since then, they have developed their project in various locations and have even performed in Yokohama. Their home base is in Nantes, France, where they have a permanent exhibition hall and a merry-go-round.

I visited Les Machines in Nantes City to inspect the site this time. The giant elephant is 12 meters high and weighs nearly 50 tons. With a lively gait, it moves slowly through the city of Nantes. What makes the elephant move like a living creature are its eyes. When I rode the elephant, I was fascinated by the movement of its eyes. The movement of the elephant's eyes makes people feel as if the machine were a living creature.

[38] The Machines of the Island of Nantes, 2023. Accessed May 10, 2023. https://www.lesmachines-nantes.fr/

A map showing the route of a giant elephant walking through the city. Taken from the company's Web page.[39]

This giant elephant is just one of several machines from the company. Various other creatures have also been made, including a giant spider, a minotaur, and a dragon. The machines are operated by a team of trained puppeteers and technicians using combined hydraulics and machinery. The performance is a theatrical piece with elaborate storytelling and music. The aim is to create an immersive experience that blurs the boundaries between reality and fantasy and transports the audience into another world.

Surprisingly, they never repeat themselves. Known for their models of humans, spiders, dragons, and elephants, they delve into one genre and then move on to another. Each time, they move forward with a completely new project. I see this as his obsession with him as an artist.

Currently, he is working on a project called "l'Arbre aux Hérons (The Blue Heron Tree)," which was conceived in 2002, with construction to begin in 2018 and completion scheduled for 2022, but has not yet been completed. At our visit, the initial prototype of the blue heron had been completed and was undergoing a test flight.

I interviewed the company's artistic director, François Delarozière.

They are committed to performing machine theater in public. They take the public place as a place of expression and go out to the people themselves. By deliberately entering into people's daily lives and routines, they create strong emotions in people.

The concept of "movement" is crucial in his work. He emphasizes how "moving" machines can exist in the public sphere, in the city. In this project, technology is used to create "movement." This is the object and purpose of this project.

The project focuses on making the "Eye" move among these. As a human habit, people go to their eyes to read emotions. Some dialogues can be made using the eyes. The movement of the eyeballs and the movement, color, and closure of the eyelids have meaning. They give sense to the eyeballs.

And movement is language. A language is a machine, a mechanical life form, a dance. The importance of finding such a language is assumed.

[39] The Machines of the Island of Nantes, "PLAN-PARC." Accessed May 10, 2023. https://www.lesmachines-nantes.fr/pratique/acces/plan-parc/

Usually, everyday elephants are moved by a single operator, but it shows a dedicated operator moves the eyes. He says special eye movement processing allows them to attract people's emotions intensely. This is one of the secrets.

Cities are generally composed of immovable objects. Buildings and roads are rooted, and only people and cars move. People prefer parks because of the greenery and the presence of some animals. People are intrinsically attracted to things that move. Trees, plants, animals, and other moving, flickering life forms give us peace.

Seeing a giant elephant walking through the streets is truly a fantasy. It evoked memories of prehistoric times when humans and animals coexisted. This experience may make us imagine a future in which we coexist with nature and animals.

Jules Verne (1828-1905), an 18th-century French science fiction novelist, influences their expressions. This city of Nantes is the birthplace of Jules Verne. The Jules Verne Museum is located nearby. Jules Verne was a writer known for works such as "20,000 Miles Under the Sea". He portrayed a vision of the future based on technology that was just emerging at the time, such as submarines and balloons. He succeeded in spreading his vision of the future of technology in the form of stories.[40]

The steam engine appeared in the early 18th century (said to be in 1698), but James Watt (1736-1819) improved the steam engine in the 1760s, and a spinning mill powered by a steam engine was in operation in Manchester in 1789. It took about 100 years from the invention of the steam engine to its practical application.[41]

The era in which Jules Verne lived was when such factories powered by steam engines began to operate. The industrial revolution arrived with the steam-powered revolution. He made a name for himself as a novelist who used science to depict the future based on the social changes brought about by the revolution brought about by steam engines.

The background of "La Machine" is the human society changed by the machines that Verne depicted. Although it was nearly 200 years ago from today's perspective, these social changes that occurred in the past and their effects remain as a culture and continue to be shown today.

4.3. Maker Faire

Maker Faire is an event that began in California in 2006 to celebrate people's creative craftsmanship.[42] It was initiated by Dale Dougherty and others at O'Reilly, a computer magazine publisher, and was first held in San Mateo, California. The first edition was held in San Mateo, California, and featured exhibits and workshops in various fields, from robotics to textiles. The event quickly gained popularity and expanded to cities worldwide, including New York, Paris, Tokyo, and Rome.

Makers' Fairs are held by different organizations in different venues, each with a different direction. One of the most poetic designs is the Nantes Maker Campus, first held in 2016 under the name Maker Faire Nantes and since 2018 under the name Nantes Maker Campus, held annually in early July. The event attracts thousands of visitors annually, with more than 300 vendors offering more than 40 workshops. Now in its sixth year, it is considered the largest gathering of the makers' community in France.

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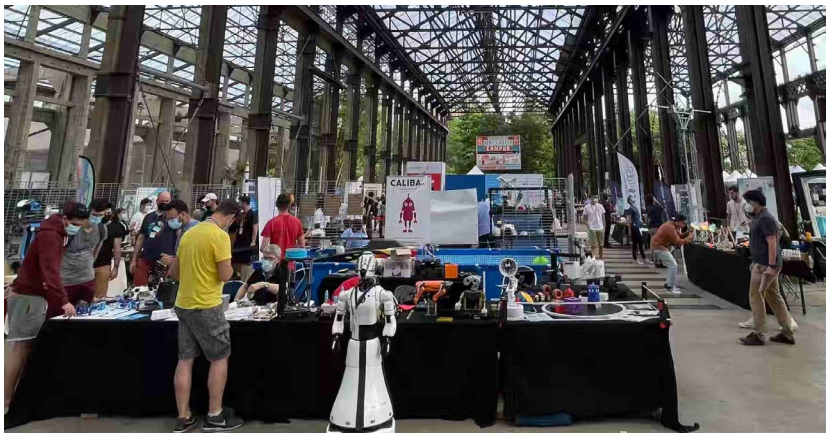
[40] Verne, Jules. "Twenty thousand leagues under the seas." Hetzel, 1871.
[41] Dickinson, Henry Winram. "A short history of the steam engine." Cambridge University Press, 2011.
[42] Maker Faire. 2023. Accessed May 10, 2023. https://makerfaire.com/



A view of the Nantes Maker Campus venue, a very large hall on the grounds of Les Machines de l'Ile. Photo by the author.

The venue is "Les Machines de l'Ile de Nantes" (The Machines of the Island of Nantes). The site is a former shipyard building repurposed to create a spacious, open event space. The venue is poetically designed, with an excellent presentation that combines beauty and nostalgia.

Although Maker Faire is sometimes called a celebration of science, it does not necessarily deal with cutting-edge science and technology. For example, at the Nantes Maker Campus, there is a booth where visitors can experience blacksmithing. Iron is clamped between pliers, softened by a hot flame, and shaped by hammering. It sounds simple in words, but not so many people have experienced it. Being able to experience such an ancient technique, which is the starting point of science and technology, is a sign of the direction of the Nantes Maker Campus.

I interviewed the event organizers, Jean-Baptiste Le Clec'h and Jean-Marc Méléard of Makeme, who split their roles between maker hunters (headhunters of interesting people) and management. They have always been active in music, and their taste reflects that. As for the criteria for selecting makers, it was apparent that he was choosing people with a particularly high artistic sense. Many of the works on display seemed to embody the fantasies of the Jules Verne era as they were.

Elsewhere in the city, I visited Rome's Maker Faire, the European Edition of Maker Faire Rome, a large-scale, pan-European event focused on innovation and sustainability. The Italian government and the city of Rome are the organizers of the event, which is publicly funded. As a state-sponsored event, advertisements could be seen everywhere in Rome, and even ordinary citizens were aware of the event's existence.

The exhibition comprised 11 spaces, six thematic areas, and approximately 250 exhibitors. Companies, schools, universities, and research institutes participated in the exhibition, focusing on innovative technologies and sustainability themes. The spotlight was particularly on emerging innovative companies. The venue, Gazometro Ostiense, is a former factory site renovated from an abandoned factory facility and turned into an exhibition venue. Outdoor facilities, such as the remains of gas tanks, were effectively reused to provide exhibition space.

It was interesting to note that while the traditional Maker Faire is an exhibition venue focused on individual craftsmanship, products, and research, presentations from various companies and universities were displayed side by side, combining exhibits from different directions into a single event.

They all have in common that they are creating mechanisms for innovation through citizen participation. They also have in common the creation of venues that reused factories.

4.4 Generative Art

Generative art is an artwork form that uses video or moving images created with relatively short scripts (programs).[43] It began with the efforts of cutting-edge media artists and designers such as Masaki Fujihata and John Maeda.

Masaki Fujihata used the term "algorithmic beauty"[44] to describe the appeal of the images created by the program.[45]

John Maeda pursued the possibilities of design created by programs and presented them as artworks.[46] From there, he argued that designer program themselves and design accordingly. 2001 saw the publication of a book by the same name.[47]

DBN was an extreme programming environment for beginners until then. First, DBN ran in a web browser designed to run in a Java applet, so one could simply view a particular web page and start programming.

In addition, he developed a new and cleaner programming language syntax. Traditional programming languages often required writing "spells," which were difficult to explain. For example, in C, you need to write "#include <stdio.h>" at the beginning. Once you get used to it, you understand what it means, but for non-specialists, it was sometimes frustrating to get to that point. Maeda prepared a thoroughly simplified syntax that he could not omit anymore.

What was revolutionary about DBN was that it taught design through programming. Conventional programming courses teach the function of drawing pictures but not how to draw beautiful pictures. Teaching the function of programming and the beauty of programming were two different lectures. Maeda focused on achieving beauty in programming and prepared a programming environment, books, and classes as a set.

For example, let's say you draw a straight line on a white square. For instance, you want to draw a straight line on a white square. This is a matter of course for designers, but for others, it is not. Even wh programming the same function, one must hone one's abilities to obtain beautiful results. Maeda's goal at DBN was to pursue a new world of beauty and birth a new profession.

In 2001, Casey Reas and Benjamin Fry, both students in Maeda's lab, developed a new programming environment, Processing, based on DBN. Arduino was derived from it.

More than 20 years after its birth, Processing has spread around the world. Today, the new beauty created by such programs is described as "generative art," and its creators are called "generative artists.

The idea of generative art has spread to various fields, and even the 3DCG software "Houdini" has made it possible to create CG procedurally. The result is myriad models that you can create based on the algorithm.

London-based artist Fernando Magalhães aka MGXS creates CGs that look like Japanese superheroes.[48] Instead of creating the shapes manually, he has designed an algorithm that generates superhero shapes and automatically produces countless images of superheroes based on that algorithm.

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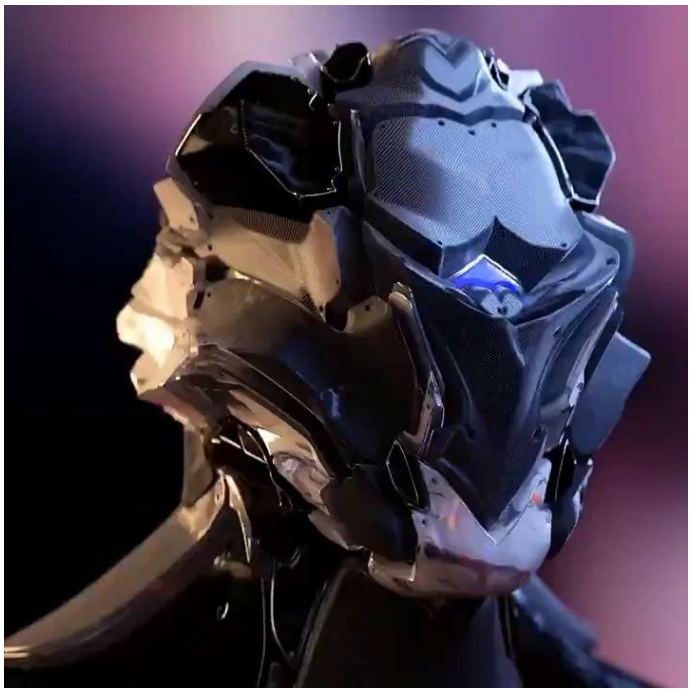
[43] Maeda, John. "Creative Code." Thames & Hudson, 2004.
[44] Fujihata, Masaki. "Algorithmic Beauty." 1990. Accessed May 10, 2023. https://dm.jagda.or.jp/80s/
[45] Stocker, Gerfried, ed. Christa Sommerer & Laurent Mignonneau. "Interactive Art Research." Springer, 2009.
[46] Reas, Casey, and John Maeda. "Creative Code: Aesthetics+ Computation." Thames & Hudson, 2004.
[47] Maeda, John. "Design by numbers." MIT press, 2001.
[48] Fernando Magalhães a.k.a. MGXS. (2019, Aug. 22). Seosh #Procedural #Generative #Houdini [Twitter post]. Retrieved from https://twitter.com/mgxs_co/status/1164546016756097031

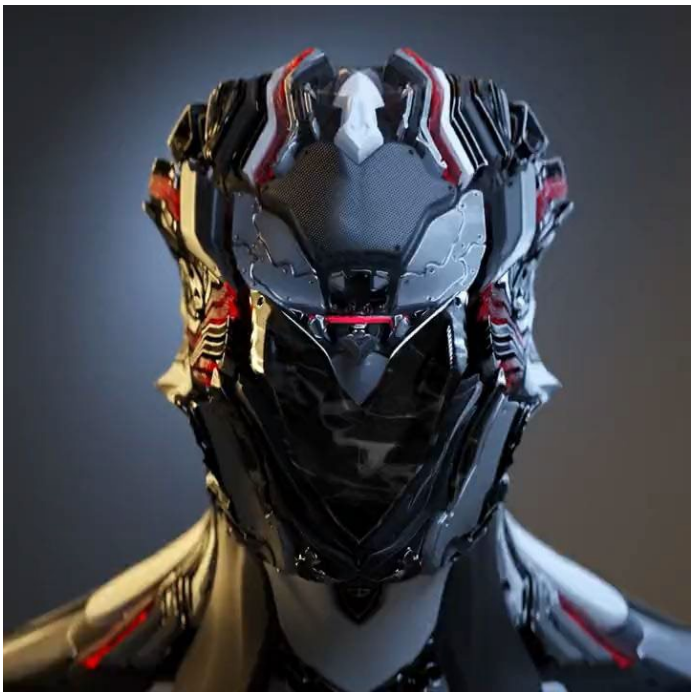
To explain the concept of Japanese superheroes, I must explain Japan's *tokusatsu* culture. *Tokusatsu* stands for "special photography."[49] The most representative TV programs that support Japan's *tokusatsu* culture are "Masked Rider" and "Goranger." These programs gained great popularity and were made into series. In these programs, actors act in large costumes called headgear. The main character in the Kamen Rider series is always a masked rider, but a new masked rider is created yearly. In other words, a new form of superhero is born every year, and although the conditions are slightly different, there are specific trends. The Japanese visual culture has grown like this. This is an integral part of the *tokusatsu* culture.



One of MGXS's works published on Twitter. This figure was taken from the author's Twitter page.

I'd like to know why Magalhães understood Japanese culture so well. After interviewing him, I understood very well. He is from Sao Paulo, Brazil, and a channel in Sao Paulo plays Japanese TV programs daily. He had been watching that channel since his childhood and had come to understand Japanese culture. Masami Kurumada's Saint Seiya particularly influenced him.

[49] Galbraith, Stuart, R. M. Hayes, and William Bond Warren. "Japanese science fiction, fantasy and horror films: A critical analysis of 103 features released in the United States, 1950-1992." Jefferson, NC: McFarland, 1994.



Another one of MGXS's works published on Twitter. This figure was taken from the author's Twitter page.

His experiment in the Japanese superhero generation is interesting because a new series of superheroes seems to be developed and condensed into a single algorithm. If a new superhero is created yearly, everyone is defined as a form of the same algorithm. In that case, reproducing it in programming can reproduce countless superheroes. It is as if the Japanese superhero is a replica that you can reproduce indefinitely.

Magalhães' experiment answers the question, "What is machine expression?" Magalhães' experiment provides one answer to the question, "What is machine expression?" Among the works of artists worldwide, it is rare to see a pioneering work that looks to the future. Through his work, I can catch a glimpse of future expression.

Generative artist Tyler Hobbs writes a blog titled "The Importance of Generative Art."[50]

> *"Sixty years ago, computers had not entered our lives. From there, computers gradually entered our lives and became the foundation of our lives, and computers are gradually transforming our lives. Computers now support the very foundations of our lives. In other words, algorithms define our lives. Similarly, we did not involve coding at all 60 years ago. From there in the art world, algorithms gradually entered the art world.*
>
> *If wood, concrete, glass, and steel were the central materials of important new buildings in the 20th century, coding has replaced them in the 21st century. Art needs to keep up with the evolution of social structures, and coding shapes not only our buildings (which it does), but also our relationships, communication, consumption, creativity, learning, memory, and perspectives."*

Changing materials change the environment. The beauty of generative art is that it presents the feel of the algorithm as something tangible. Hobbs describes the importance of generative art this way.

[50] Hobbs, Tyler. "The importance of generative art" blog post, 2021. Accessed May 10, 2023. https://tylerxhobbs.com/essays/2021/the-importance-of-generative-art

It is difficult to convey the beauty of this new algorithm, but I found an excellent example in France. It is the "Abbey of La Tourette" designed by Le Corbusier (the design started in 1953, completed in 1960). Corbusier's pupil, Yanis Xenakis, who later became famous as a composer of contemporary music, was involved in its construction.

Xenakis composed his orchestral work “Metastasis” in a mathematical process between 1953 and 1954. Xenakis adapted this work to the façade of the La Tourette monastery, which he was entrusted with following up on the construction site. The result was the impressive "wavy glass panels" in the abbey.

Xenakis was the first artist to explore the category of “new beauty created by calculation.” He may be the world's first generative artist before the computer was born.

4.5. AI Art

As noted in the background, programming art has embraced AI's cutting-edge technology, leading to AI art's creation.

In particular, technological advances in AI began with image recognition, and you can use its features in reverse to generate images. In particular, image generation using deep generative models called VAE (Variational AutoEncoder) and GAN (Generative Adversarial Network) can produce detailed images indistinguishable from the real.

A GAN model mimics the statistical distribution of training data to learn and generate new data. It consists of two parts: a generator network that creates new data and a discriminator network that attempts to distinguish between developed and real data. During training, the generators are updated to fool the discriminators. The discriminators better are updated to better distinguish between real and generated data GANs are often used for tasks such as image and video generation.

In 2016, pix2pix was developed. pix2pix is a tool built using the GAN algorithm. It can learn mappings between input and output images. Specifically, it retains a model that transforms an image from one region (e.g., a black-and-white image) into an image from another area (e.g., a color image). This is done by learning a model with corresponding input and output image pairs, where the model learns to produce an output image from the input image. the name "pix2pix" comes from the fact that this model learns to map pixels from one image to pixels in another image. You can use it for various applications, including colorizing images and generating realistic images from hand-drawn sketches.[51]

Mario Klingemann is an international artist known for his AI-based works.[52]

He has created many pix2pix-based artworks. He built a model trained on a large dataset of facial images. In doing so, unexpected details and distortions are sometimes incorporated into the portraits, and the generated images are often surreal and dreamlike. At the same time, however, every detail is realistically reproduced, creating a tension between the original image's simplicity and the final image's complexity. He calls this "neurography.

Another artist using AI technology is Scott Eaton.[53] He is a London-based artist known for his innovative sculptures and drawings using AI. He began his career as a traditional artist, studying sculpture and anatomy at the Academy of Fine Arts in Florence, Italy. He is characterized by his exceptional understanding of the human body. Just as Michelangelo's David

[51] Isola, Phillip, et al. "Image-to-image translation with conditional adversarial networks." Proceedings of the IEEE conference on computer vision and pattern recognition. 2017.
[52] Mario Klingemann, "Quasimondo." 2020. Accessed May 10, 2023. https://quasimondo.com/
[53] Scott Eaton, 2021. Accessed May 10, 2023. https://www.scott-eaton.com/

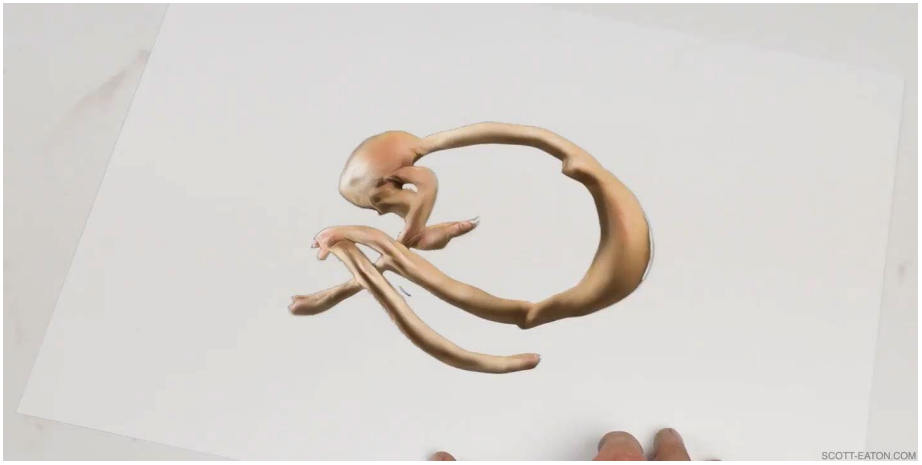
is medically accurate in its placement of muscles and blood vessels, his representations of the human body offer a glimpse into the history of Western art's attempt to reproduce the human body accurately. He later became a photographer, experimented with 3D modeling, and eventually began using AI and machine learning.

In May 2019, he also began experimenting with image generation using pix2pix. As explained earlier, pix2pix can create detailed, photorealistic images based on simple outline sketches. He has taken many photographs of the human body in motion as a photographer. He has trained pix2pix to create photorealistic images of the human body based on outlines.

One of Scott Eaton's works published on Twitter. This figure was taken from the author's Twitter page.[54]

On a sheet of paper, he would draw the body's contours. He could generate a realistic image of the human body by doing so. What is interesting about his experiment is the opposite. Once he had outlined a human body, he added lines to it in reverse, destroying it gradually. Gradually, the human body was becoming less and less realistic, but AI tried to reproduce the human body as realistically as possible. Finally, it pours ink on the paper, leaving only meaningless random black stains, the elements of the human body.

[54] Scott Eaton. (2019, Sept. 5). Drawing "Humanity (Fall of the Damned)". A quick timelapse of the drawing used as input to my Bodies network to create the final piece (currently on display at @ArsElectronica). More images of the work here: http://scott-eaton.com/2019/humanity-fall-of-the-damned [Twitter post]. Retrieved from https://twitter.com/_ScottEaton_/status/1169563505491632129



Another one of Scott Eaton's works published on Twitter. This figure was taken from the author's Twitter page.[55]

Image transformation by AI is merely a probabilistic transformation of one state into another. A human can see a human body as if it were a human body, even if only its outline is displayed; AI rendering merely reproduces the same implicit assumptions as humans. The big difference, however, is that AI is quick and tireless. Humans can take an outline and create a realistic picture. However, AI continues to reproduce the contours relentlessly, even when they gradually break down and cease to be human bodies. This suggests that AI can surpass humans, which is amusing and awe-inspiring.

AI artworks are interesting for exploring the future direction of art and provide a glimpse of the possibilities that may arise when AI is incorporated into our lives as a technology.

I interviewed him. In his interesting words, "One of the reasons my work is unique is that I experiment with stupid ideas. I look at how interesting it is and how much it fails. The more interesting the failure, the more interesting the failure. The process may have something in common with scientists and researchers," he said.

With a master's degree from the MIT Media Lab and a background in computer science, he understands the technology behind DNN and builds models himself. That makes his work special.

The challenges the neural network was trying to tackle were the same challenges an artist tries to understand."

Even as an artist, failure is sometimes a beautiful thing." I try to understand the limits of what machine learning can do; then I test it. Then I see what happens." He stated that he enjoys the results that come out of his experiments.

Perhaps artists in the age of artificial intelligence have the ability as scientists and researchers to formulate hypotheses, experiment, and learn something from their mistakes.

In Europe, artists using AI art are appearing one after another. "AI Artists"[56] is a list of artists who are creating art using artificial intelligence, and many of the artists on the list live in Europe. Is this a coincidence? I don't think so. I believe that there is a Western art tradition that considers the relationship between media and artistic expression in the background.

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[55] Scott Eaton. (2019, May 8). Creation is good... but destruction is way more interesting. #rorschach #creativeAI #ArtistPlusAi [Twitter post]. Retrieved from https://twitter.com/_ScottEaton_/status/1126099668721700864

[56] Benney, Marnie. "The Top 25 AI Artists of 2020." AIArtists.org. Accessed May 10, 2023. https://aiartists.org/

5. Discussion

5.1. Workshop Discussion

In February 2022, based on this case study, a workshop was held with the participation of relevant researchers and artists. The workshop speakers and their respective presentations are summarized in the Appendix. This chapter discusses matters from the workshop discussions relevant to this study.

In his presentation, Marlette described his experience working with artists. He worked with artist Anne-Valérie Gasc to create a giant glass powder 3D printer. He pulled cables from the four corners of the factory to allow the sand-dropping device to move freely within the large factory. They sprinkled 76 layers of glass powder on a flat surface to create the sculpture.

In his talk, he spoke from his scientific perspective about the elements necessary for a successful collaboration with an artist. Artists and scientists speak different languages. He said it took the scientists over 400 hours to modify the system with "just a few specification changes" that the artists thought was necessary. Therefore, the artists, who are scientists, need to create a common dictionary. Collaboration with the artists allowed them to become accustomed to working with people who spoke different languages, facilitating collaboration with the next doctor. This is just one example of the benefits of artist involvement in facilitating interaction between engineers, scientists, and the general public.

Magali Martin-Mazauric of INRIA gave a presentation on Terra Numerica at the workshop. Terra Numerica is an institution organized by CNRS, INRIA organized, and the University of Côte d'Azur in Sophia Antipolis in the south of France. It has a facility for an exhibition and education for digital technology.

Today, digital technology is used everywhere. Terra Numerica was created to change that. Terra Numerica is a place where the general public can learn digital technology. Still, more importantly, it is a place where teachers who teach digital technology in schools can learn how to teach digital technology. In other words, one of the main goals was to train professors and teachers. Provence, in the south of France, is a culturally rich place. The painters Picasso and Matisse loved the light of the south of France and stayed here to create their works. Picasso said, “Everything you can imagine is real.” At Terra Numerica, artists and scientists collaborate to create works of art.

We visited Terra Numerica on-site when they completed it in July 2022. I mentioned an Exploratorium in the background, and I understood that this place aims to be an Exploratorium of digital technology. At the Exploratorium, an artist-in-residence facilitated collaboration between scientists and artists. I hope that we will promote such collaboration at Terra Numerica.

Professor Gerard Assayag, affiliated with IRCAM, a national computer music research institute, will discuss his music-specific research on AI and creativity. His research aims to open new creative possibilities through AI-human interaction in music production. According to him, music production by AI has been based on algorithms specified by humans, which has limitations regarding co-creation between humans and AI. Therefore, Assayag et al. explore the possibility of new musical expression through interaction and stimulation between humans and AI.

Assayag introduced a new instrument called the HyVibe guitar, created by Adrien Mamou-Mani.[57] Here, the performer extends their sound and adds an intelligent musical layer, allowing for collaborative improvisation. It is truly a co-creation. When asked why he chose the

[57] Mamou-Mani, Adrien, et al. "Active Vibration Control Applied to Flat Panel Loudspeakers Using the HyVibe Pro." International Congress: NVH Comfort, Le Mans, France. 2021.

guitar, he replied, "By embedding an algorithm in something humans touch, we can make them aware that it is part of their own body." Interestingly, he focuses on musical instruments as an example of human augmentation.

Nao Tokui, Associate Professor at Keio University, presented AI as alternative intelligence and human creativity in music. He is an artist, researcher, university associate professor, and corporate CEO. The main focus of his presentation was "Can AI create something new and original, rather than a copy of what humans have already created?" His answer was "yes."

He presented his practice on three themes: first, "Misuse of AI," second, "Uncertainty of AI," and third, "Mastering the Weird Uses of AI." For Tokui, who DJs sessions, the uncertainty of AI's song selection and DJ play are exciting. He extended this by building a system in which three AI models - rhythm generation, baseline generation, and loop selection - interact to generate improvised dance tracks.

He used GAN for rhythm pattern generation; GAN requires the creation of two positions: the forger, who creates a forgery, and the connoisseur, who determines the authenticity of the forgery. Tokui applied to GAN the conflict that human artists face when creating artwork: the conflict between adhering to an existing style and creating a new style that is not bound by existing rhythmic patterns. One is to stay with the existing style, i.e., to follow the traditional existing rhythmic patterns. The other is to deviate from them. The other is deviating from them and creating innovative rhythmic patterns. In other words, AI will be equipped with the ability to play existing rhythmic patterns while at the same time refining its ability to deviate from them.

There are two types of artists: traditional artists who trace existing expressions and those who deviate from existing ones. The other is the traditional artist who traces existing expression and the artist who seeks new expression that deviates from existing expression. When these two positions repeatedly come into conflict within the artist, a new expression is born. I felt that his idea is a concept that can be applied to art in general.

According to the presenter, artist Biin Shen, technology is not the enemy of citizens in China. When Shen returned to China from London in 2020, she was shocked by the optimistic use of technology in China. In a public restroom in Beijing, one must stare at a camera for three seconds with facial recognition to get toilet paper. The paper only comes out in small pieces, so you must do it repeatedly.

Facial recognition technology is said to have major problems concerning privacy protection. The UN High Commissioner for Human Rights has called on the world's major institutions to stop using facial recognition.[58]

Thus, facial recognition technology, a major global issue, is being used in China as a switch to pull out toilet paper.

There is an implicit assumption in London that technology needs to be viewed critically. But that assumption was not present in China.[59]

I have been impressed by the Chinese view of technology. Once, the artist Cai Guo-Qiang held an exhibition called "Peasant Da Vinci." He held it in the city where the Shanghai World Expo was held. Instead of cutting-edge science and technology, it displayed technology developed by Chinese farmers. One of the exhibits was a robot that a farmer had made himself. The robot

[58] United Nations, Office of the High Commissioner for Human Rights, "Artificial Intelligence Risks to Privacy Demand Urgent Action – Bachelet", Press Releases (15 September 2021) Accessed May 10, 2023. https://www.ohchr.org/en/2021/09/artificial-intelligence-risks-privacy-demand-urgent-action-bachelet

[59] Supak, Gabrielle. "Political Posturing or a Move towards "Net Nationalism?": The Legality of a TikTok Ban and Why Foreign Tech Companies Should Be Paying Attention." NCJL & Tech. 22 (2020): 527.

was ugly even by the standards of the time. But the robot that the farmer had so impulsively created was impressive. The idea that everyone is an inventor and an artist is alive and well in China.

The exhibition I saw in China inspired me to organize an event called "NicoNicoGakkai Beta" in Japan in 2011. Under the name "Wild Researchers," The symposium invites the general public to present the results of their research so that anyone can become a researcher.

Professor Lionel Obadiah of Université Lyon 2 presented an anthropological reflection on imagination and creativity in robotics and AI. He is a socio-cultural anthropologist specializing in Asian religions. His research has recently focused on digital technologies, including robotics. During the Q&A session, he discussed the differences between Eastern and Western cultures regarding their attitudes toward robots, particularly why the Frankenstein Syndrome occurs.

Professor Lionel Obadia said that he has been studying "zombies" in recent years. Zombies are pop culture characters in horror movies, so why focus on them? According to him, the framework of dystopian scenarios varies from culture to culture. Each country has experienced dystopian situations throughout its history. In film scenarios, he says, they are local variations of a particular country's history.

For example, there is a movie called Godzilla. Godzilla is a character created in Japan and has become universal worldwide. However, the origin of this movie is the "Daigo Fukuryu Maru Incident": in March 1954, the U.S. military conducted a hydrogen bomb test at the Bikini Atoll. The Daigo Fukuryu Maru was operating outside the danger zone set by the U.S. but was still exposed to radiation. The crew members were exposed to radiation from radioactive fallout and died six months after the incident. The seafarer's death drew worldwide attention as "the world's first H-bomb victim" and triggered the anti-nuclear movement.

In November 1954, the movie "Godzilla" was released. This character, Godzilla, remains a world-famous movie character to this day. Godzilla is an apt response to the dystopian scenario of nuclear terror and defeat in Japan.

Professor Obadia says he is now studying zombies. Indeed, the Corona disaster that began three years ago resembles the dystopian scenario of a zombie movie.

See Ken Okamoto, "Zombie Studies," Jinbunshoin, 2017.

The scenarios in the pop culture created by novelists and filmmakers highlight contemporary human consciousness. I concur. I would like to focus on such scenarios in pop culture in the future relationship between AI and humans.

5.2. Language will develop a new civilization

One future scenario that deserves attention today is the "Snow Crash" by science fiction novelist Neal Stephenson. In this novel, he invents the term "Metaverse," and it is said that IT society will develop into a metaverse; in this sense, this is a book of prophecy.

But he says something even more interesting in this book. He says that the invention of a new language layer will give birth to a new civilization. In his words, code, or programming language, is the latest language layer.

The role of man in society is defined by changes in the major technological foundations: the first industrial revolution of the 18th century with steam machines, whose technological basis was governed by the laws of physics. Of particular importance was how to control the engine or internal combustion engine. Locomotives, automobiles, looms, and letterpresses are all powered by engines. The profession of engineering was born to control these engines. Notice that "engineering" comes from the word "engine."

In the 20th century, the “IT revolution” took place as a new industrial revolution. It operates on different principles than the physical laws of internal combustion engines, electricity, and magnetism that had been in place until then. It is that programming is defined by language. An excellent programmer is called a "hacker" and a "wizard.” When a wizard casts a spell, it comes true. When a programmer gives instructions in a language, they come true.

In the 21st century, we are witnessing yet another industrial revolution. If we call it the “AI revolution,” what is its foundation? I believe that AI is governed by imagination.

In driving AI, everything is governed by probability theory. In programming languages, you tell it to be 0 or 1, but with probability theory, it's somewhere between 0 and 1. You can no longer strictly distinguish between 0 and 1; you can only tell it to be 0 or 1. This, in my view, is more like a painting than a language. From this point of view, what can be imagined can be realized.

Picasso's words, “Everything you can imagine is real.”

Scott Eaton says, “Artists control AI with their imagination and ideas.”

What is the most important ability in the coming AI age? I believe it is imagination. The imagination of artists will create the society of the future.

6. Conclusion

Finally, I summarize my discussion.

In Chapter 1, I hypothesized that as artificial intelligence technology advances and society undergoes major transformations, there may be a way to predict and understand these changes by focusing on art.

I referred to Mary Shelley's "Frankenstein" and Augusta Ada Byron (Madame Lovelace) as figures who linked science and art. These women were pioneering examples of foreseeing the future of technology with an artistic sensibility. Also, Alan Turing examined in 1950 whether machines could have intelligence and concluded that they could. His predictions of the future were right on target.

Dr. Frank Oppenheimer introduced the Exploratorium as an example of how art and science came together in the 1950s. He used the power of art to make science accessible by actively collaborating with artists and creating the groundbreaking Exploratorium science museum. Billy Kluver also formed E.A.T., a close collaboration of artists, engineers, and scientists.

These trends have been accelerated by the invention and spread of the Internet, and the author's creations and research are part of this trend.

I also discusses the differences between Eastern and Western attitudes toward artificial intelligence. It confirms that in Japan there is no resistance to the everyday use of robots, whereas in Europe there is a phenomenon known as "Frankenstein Syndrome". I also referred to Yuk Hui's concept of "cosmotechnics".

In Chapter 2, I formulated a research question.

1. What are the most important competencies in the coming AI age?
2. What can art do for society in the future?

In Chapter 3, I employed a field research approach to answer these questions. Specifically, I decided to conduct case studies of art and technology institutions, interviews with artists, and workshops with artists and researchers.

In Chapter 4, I describes the case studies Ars Electronica, "Les Machines de l'Ile," Maker Faire, generative art, and AI art. I introduces artworks by Fernando Magalhães, Mario Klingemann, and Scott Eaton.

In Chapter 5, I describes each of the researchers who participated in the workshop and their artwork. I presents the main part of the presentation by each researcher and artist who participated in the workshop. It then quoted science fiction author Neal Stephenson and concluded that just as programming languages were important in the IT revolution, the imagination of artists will be the most important skill in the AI age.

I would like to reiterate here the answers to the research questions.

1. What is the most important skill in the coming AI age?

The answer is "imagination." In the IT revolution, programming languages were important and programmers were needed to make full use of them. But in the AI revolution of the 21st century, the ability of artists to imagine things that are not here and now will be necessary.

2. What can art do for the society of the future?

I believe that the answer to this question has become clear through the field and workshops. Based on the discussions in this paper, the role of art in the future society may be summarized as follows.

1. Drawing a picture of the future society.
2. Questioning the meaning of drawing a picture of the future society.
3. Creating the future society itself.

In other words, it is possible for artists to use their imagination to predict and express the great changes that will occur in the future, and this is the role of art. At the same time, as the example of the Exploratorium shows, art can also play a role in explaining the content of cutting-edge technology and making it available to all citizens.

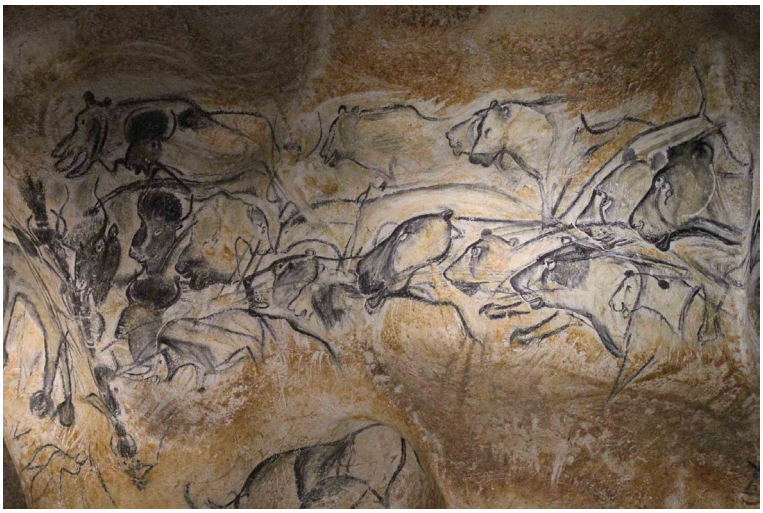
With the above, I would like to conclude this report.

The following is a postscript.

I would like to review my European activities. I considered modern Western civilization as my research subject in my research plans. I specialize in the relatively new science and art of computers and media art. Therefore, I planned to research cutting-edge examples in Europe.

However, when I went to Europe, I found that there were buildings here and there that were thousands of years old. There are many old things, including buildings from the Roman era.

The most impressive works of art I saw in Europe were the cave murals of the Chauvet Caves. The famous Lascaux Cave in France's murals is about 20,000, but the relatively recently discovered "Cave of Chauvet" is about 36,000. In other words, it is probably the oldest cave mural in the world. Soon after its discovery, the original cave was closed, and a detailed replica, "Grotte Chauvet 2," was built and opened to the public. Although it is a replica, the quality is so high that it looks like the real thing is right before you. I was also impressed by the high quality of the wall paintings. The murals of lions painted by prehistoric people were amazingly realistic and elaborate. They are records and memories of prehistoric times that make the word "history" seem hazy.



Mural of lions in Grotte Chauvet 2. Taken from Wikipedia.[60]

Traveling through various European countries, I realized that the Mediterranean civilization should be considered whole, not divided into individual countries. The Mediterranean coast is the place where civilization began. It is in this Mediterranean civilization that people were born and developed. This European land is the birthplace of art and science, and technology. Art has continued to exist in this land from ancient times to today.

In other words, to think about art, science, and technology, it was necessary to consider the present day in light of these thousands of years of history.

I would like to summarize the year 2022 and beyond briefly a workshop in February 2022. From there, 2022 was a year of rapid progress in AI technology. The two big progress were AI image generation tools and chatted AI tools.

MidJourney, an AI image generation tool, was born. This tool generates images according to instructions (called "prompts") given to the AI by words. In particular, the tool "Stable Diffusion" is open source and publicly available, including the model. The release of this tool led to the creation of many derivative tools.

The appearance of ChatGPT was also shocking: a large-scale language model called GPT3 already existed, but it was private and not available to the public. However, an organization called OpenAI developed a chatting environment and released it under the name ChatGPT, and it exploded in popularity.

7. Appendix

7.1. Workshop Overview

The six speakers for this workshop were as follows:

- Nao Tokui (Keio University), AI as Alternative Intelligence and Human Creativity in Music. Case Studies in 2015 – 2021
- Gérard Assayag (IRCAM), Raising co-creativity in cyber-human musicianship
- Jean-Pierre Merlet (INRIA), Mixing robotics, arts and health monitoring
- Lionel Obadia (University of Lyon 2), Augmented, virtual, double and digital humans: anthropological reflexions on imagination and creativity in robotics and AI

[60] Grotte Chauvet 2 - Ardèche. Accessed May 10, 2023. https://fr.wikipedia.org/wiki/Grotte_Chauvet_2_-_Ard%C3%A8che

- Biin Shen (Artist), Catalyze the future
- Magali Martin-Mazauric (INRIA), Terra Numerica: Digital Sciences at your fingertips. Discover, Explore, Experiment!

A summary of each speaker's presentation follows.

Nao Tokui (Keio University), AI as Alternative Intelligence and Human Creativity in Music. Case Studies in 2015 – 2021

Tokui is an artist, researcher, founder, and CEO of the Tokyo-based art collective Qosmo and organizes a laboratory called CC Lab (Computational Creativity Laboratory) at Keio University.

The theme of Tokui's talk was "Can AI help us create something new and original instead of copying what humans have already created?" The answer was "yes. The answer was "yes." Tokui himself could hardly read musical instruments or sheet music. Still, he entered the University of Tokyo in 1995 and the Artificial Intelligence Laboratory in 1998 and began DJing, which awakened his fascination with music. He is interested in programming and AI from this experience.

In this session, he will talk about three major themes.

The first is "misuse," or the importance of using music tools correctly. From the history of music and other creative fields, there is a history of misuse and misappropriation of new technologies, for example, turntables and samplers being used in ways they should not be.

Tokui pointed to the polarity between "programmer's tools," which require the installation of Python and other programming tools, and "build (too) tools," which are one-click tools but difficult to use creatively, and the need for something in between them.

Tokui demonstrated an "exploitable" AI tool for musicians that can train models on data that no one has ever used, which he said he did in 2020. The tool can be a plug-in for a well-known digital audio workstation software called AbletonLive. It can load its music data (MIDI files). In the case of rhythm generation, it is a MIDI file. Still, you can also load melodies), and by simply dragging and dropping it, the software can train its own AI model to generate new rhythmic music automatically.

The second topic is "accepting the uncertainty and errors that AI brings. First, a visualization of the rhythm generation model introduced in the first topic was presented, but isn't this still an area where AI can mimic human music? In 2017, He introduced NeuralBeatbox, which combines a rhythm generation model with a sound classification model trained on pre-recorded sound sources to rhythmic output patterns.

The demo showed how participants could record using their faces and bodies, and the AI would generate their beats, allowing them to enjoy a beatbox session with a friend. I created this work during the Corona lockdown. This classification of sounds is not perfect, but that is what we wanted to do: deviate from what humans have created."

When one tries to create something new, one deviates from convention and common sense and hopes it will express creativity. However, according to conventional thinking, that deviation could simply be a mistake or error. So we need to know how to accept errors and how to distinguish between errors and creativity. And error and creativity are one of my main themes." Tokui said.

He then introduced the AIDJ Project, which uses the uncertainty of AI.

For Tokui, who DJs sessions, the uncertainty, and unexpectedness of AI's song selection and DJ play is very interesting, and has been showcased at numerous venues, including Google I/O and the Scopiton Festival in Nantes.

It has also been extended to generate improvised dance tracks through the interaction of three AI models: rhythm generation, bassline generation, and loop selection. In addition, Tokui participates in the operation of the turntables and mixer. This is no longer a disc jockey, but more like a machine or AI jockey," says Tokui.

The third theme is "Mastering the Weird Uses of AI.

GAN (Generative Adversarial Network) is a framework famous for creating fake mug shots that can be mistaken for the real thing, and Tokui used it for rhythmic patterns.

The generator learns to trick the two discriminator networks into creating new rhythms that do not belong to any musical genre but could.

Tokui was aiming for a "tug-of-war between convention and deviance " here. An AI that tries to judge deviations as good or bad, this pattern of thinking, Tokui believes, is the same as what human artists do.

After playing a demo of the rhythm track, Tokui quoted Scott Adams, the cartoonist of Dilbert." Creativity is about making mistakes, but art is about knowing which are good." He said, "AI is a tool for making 'interesting mistakes,' which leads to creating something new and original."

Gérard Assayag (IRCAM), Raising co-creativity in cyber-human musicianship

Assayag, belongs to IRCAM, a research institute that studies the synchronization of sound and music. It is part of the Centre Georges Pompidou and is responsible for its music and acoustics research. Within IRCAM, Asayag created the "Music Expression Team. This team includes researchers related to AI and creativity, with a special focus on music, and is the largest of its kind at IRCAM. The team focuses on five pillars, of which Assayag belongs to the REACH (Raising co-creativity in Cyber-Human Musicianship) pillar related to artificial intelligence.

Open Music, developed by Assayag and his colleagues, is a visual programming language allowing composers to design new musical applications visually. However, this was not an artificial intelligence approach but a classical approach in which the composer specifies an algorithm for creating music. So, at Asayag, we switched our goal to creating music produced by the interaction of virtual agents, which is similar to true artificial intelligence.

“oMax” is a software environment that learns the typical style traits of musicians in real-time and performs interactively with them. It simultaneously scans and navigates recordings, applying machine learning models to create models, copy music, generate new music, and suggest it to the performer. "oMax" has many forks and successor projects, including related work simultaneously at Sony Music and Spotify. François Pachet's work is well known. The most famous is the related work done by Sony Music and Spotify, and François Pachet.

About the Interaction Paradigm,

The system has an initial listening phase (artificial listening) to learn. It segments and distributes the music stream over a mathematical or geometric structure. Next, a string structure (symbolic stream) is found among them, and a machine learning algorithm is used to train the model. Finally, new sequences are regenerated and rendered. These three processes (listening, learning, and generation) take place simultaneously in real time, and the figure below shows a visualization of a musical sequence learned by OMax in real time This is like a map of the real music, with colored arcs connecting similar locations in the music. The AI makes connections, and the system can simply move over this map to create new sequences that statistically match the original material.

The figure shows the relationship between planning and reactivity in OMax, OMax's successor system (DYCI2), and two other systems. The axis of reactivity shows how quickly the

system responds to the composer; the successor system to OMax is a compromise between being fully responsive to the movements of a live performer and being able to plan and develop interesting music. The successor system to OMax is a compromise between being fully responsive to the movements of a live performer and being able to plan and develop interesting music. The successor to OMax is a hybrid system that is a compromise between being fully responsive to the movements of the live performer and being able to plan and develop interesting music.

Assayag used a two-minute video to show several examples: first, a performance by a pianist and three singers synthesized by AI; to design new musical applications visually time to accompany the pianist, who improvised from an audio archive; second, a human-AI The second was a jam. The system captured the performance in real-time, learned from it, and played sounds in response to the musicians. The system responded to the musician and engaged in dialogue-like[3] communication.

Assayag et al. recently started a mixed Musical Reality Creative Instruments (MERCI) laboratory project. They entered into an industrial partnership with HyVibe, which is developing a new musical instrument called the HyVibe Guitar. HyVibe is developing a new musical instrument called the HyVibe Guitar. Assayag and his team's goal is "to be able to integrate artificial intelligence into musical instruments. It can also add an intelligent musical layer to the musician's way of being and improvising with the musician. The RICH project is based on the idea that co-creation requires an interactive situation in which the musician and the computer system can co-create and play together.

Cyber-human co-creativity is manifested when coherent or contrasting joint actions are created. As the system learns from the musicians in real-time and the musicians learn from the system in real-time, complex feedback loops and reinforcement mechanisms are created, and new structures emerge.

In summary, REACH has two central tasks: the first is to complement the performance of digital agents with more sophisticated AI. The second is to shorten the distance between humans and digital agents (augmenting the real with digital technology). The second is to create an immersive environment of mixed reality devices to increase the affinity between AI and humans (augmenting the real through digital technology).

He concluded his lecture by showing a video of a pianist and an AI singer performing and presented examples of augmentation by humans.

Jean-Pierre Merlet (INRIA), Mixing robotics, arts and health monitoring.

Jean-Pierre Meret is a roboticist, and a member of a team called ifa source that provides people with free systems.

What are the advantages of scientists collaborating with artists, and what are the advantages of artists collaborating with scientists? Currently, it is difficult for scientists and artists to collaborate. Scientists have a limited understanding of the arts, and collaborating with artists requires much understanding and effort. On the other hand, artists are unaware of the technical possibilities and sometimes seem to have an attitude that limits their creativity.

Despite these difficulties, according to Meret, there are exciting possibilities for collaboration between scientists and artists. As an example, he presented a cable-driven parallel robot. The purpose of this robot is to move B, shown in the figure, in all directions in XYZ, by adjusting the length of the four cables connected to B by a winch. This robot assists the disabled person in moving (from sitting to standing, walking assistance, etc.). Because it is automated, it can be performed by a single person, leading to respect for the self-esteem of the disabled person. It also allows for real-time monitoring of the subject's health status.

A meeting with artist Anne-Valerie Gasque in 2018 led to an exhibition in 2019 in which he will use the robot to create 3D structures with glass microbeads. They thought this would be the perfect environment to test the control and durability of the robot. Throughout the exhibition, the primary goal was to improve safety and performance for assistance.

During the month-long exhibit, the robot traveled more than 4 km and operated an average of 4 hours and 15 minutes daily. Seventy-six layers (1.5 tons) of glass powder were deposited. One cable failed during installation, and the encoder and the motor shaft broke, but nothing was fatal. The robot was scheduled to be exhibited at IORA 2020, a large robotics conference in June 2020. But it was postponed due to Corona. It has not been on display for some time but will be at a nearby museum this summer (2022).

Lessons learned by science from art. The exhibit allowed for the developing new algorithms, software, hardware, and methodologies to be developed. On the other hand, some colleagues say this is not real science. There are similarities in the discussions between doctors and artists, including differences in language and levels of scientific knowledge. Collaborating with artists has facilitated communication with physicians. Collaboration with artists was also meaningful for a better understanding human receptivity and patient needs.

Lionel Obadia (University of Lyon 2), Augmented, virtual, double and digital humans: anthropological reflexions on imagination and creativity in robotics and AI.

Lionel Obaida gave a presentation titled "Augmented, Virtual, Dual, and Digital Humans: Anthropological Reflections on Imagination and Creativity in Robotics and AI."

As a socio-cultural anthropologist, Obaida specializes in Asian religions and has recently worked on digital technologies, including robotics. He studies the expression of new attitudes, cultural frameworks, and imaginaries in various comparative cultural settings, including research institutions, exhibitions, corporations, and universities.

As an anthropologist, he is interested in the relationship between humans and their material environment through continuous and discontinuous technologies. He stated that humans have always been interested in mediating their relationship to reality through technology, from primitive technologies to the tide of hypermodern, high-speed devices colonizing our lives.

From an anthropological perspective, he said, robots are "significant others" living in a new ecosystem; SSH (Social Sciences and Humanities) sheds new light on AI and robotics issues. How humans interact with machines, and how contemporary and futuristic scenarios permeate society and influence technological fields, user ideas, and behaviors. He then points to the obsession with anthropomorphism, focusing on images and imagination through screens and visual culture. Even the representation of AI software on a flat-screen begins and ends with the representation of the human body, just as even the representation of AI software on a flat screen is anthropomorphic.

Human-centered AI and robotics seem to respond to the tendency of humans to see technology as a replication of life, and "human" has three epistemological domains.

1. human-like (similarity)
2. almost human (what a human should be)
3. super-human (already beyond human)

He coined the slogan "bios to bois." He meant from bios for computer system setup to bios in the sense of life in a robot.

He also proposed that the human-robot relationship could be theorized in terms of the three T's, referring to the "uncanny valley" problem of neither human nor non-human.

1. Tools: use the device.
2. Toys: play with the device.
3. Temptations: engage with the device, develop attachments and sometimes even sexual desires.

Biin Shen (Artist), Catalyze the future.

I am interested in how humans perceive and understand technology in different cultures; I studied under Professor Fiona Levy at the RCA (Royal College of Art, London). As such, my work has elements of speculative future scenarios.

Humans will use technological tools from the Stone Age. In today's global society, similar technology is used worldwide, but in China, the view of technology is slightly different than in other countries.

In one park in central Beijing, facial recognition technology is used in public restrooms. To get toilet paper, one must remove their glass and stare at the machine for three seconds. Since the paper comes out only a little at a time, this process may have to be repeated several times. Incidentally, this facial recognition works even when Pikachu is projected on the screen. A performance robot that boils noodles, a piano that bakes lamb kebabs, and a smartphone in Shenzhen have all influenced my creative process. The Chinese have a uniquely optimistic attitude toward technology that will change their way of life.

In ancient Chinese cosmology, a series of thoughts and rules lurk behind what appears to be a magical talisman. It is a virtual myth mixed with reality and the most sensible reflection of how people of each period understood their natural environment. It is believed that writing spells in Chinese characters can ward off evil spirits and bring happiness, but Chinese characters are more than just letters. Kanji characters have also influenced modern people's sense of reality. They can be thought of as encapsulating data and algorithms, as in blockchain technology.

The Chinese character "SHU" means method or technology. It also implies magic and represents fiction. I based my contemplation on the mythology of the Qing Dynasty. The idea is to remove the dilemma of modern technology and restore the power of imagination. For example, projected on the screen is an image of a bitcoin holder who can transform any electronic device into a bitcoin mining machine and collect more bitcoins.

Here is Berlin artist Simon Veckert's 2020 work, in which a wheelbarrow carries many smartphones, creating a virtual traffic jam on Google Maps. Fictional activity affects reality.

It is also interesting to note that in 2012, Google Maps listed a "Sunday Island" that did not originally exist. It was mistakenly listed on a map from 1876. Moreover, the map was not even a map of its time.

Technology as a game is one of the mechanisms I often use in my creative work. This is an AI-based message game in which ten words, far apart, lose meaning as they are repeatedly translated.

Art is crucial in today's world, where a sense of reality is suppressed.

By reviving the power of fiction, art can change the natural world in the current technological situation. It is essential to arouse the public's interest in technology to make them rethink the status quo, which will catalyze a better future.

Magali Martin-Mazauric (INRIA), Terra Numerica: Digital Sciences at your fingertips. Discover, Explore, Experiment!

Why Terra Numerica? The digital, like gravity, exists everywhere on earth. However, a serious digital divide remains. People know how to use their computers and smartphones but need

help understanding how they work. Despite the proliferation of science expos and public lectures, the digital has not penetrated our culture to the same degree as the arts. Therefore, Terranumerica wants as many people as possible to be exposed to this knowledge.

Provence is culturally rich, with many schools, institutes, private companies, and film studios. We are creating a place where people in the digital science field can come together. We are not trying to create something "new." We are bringing people together to leverage their experience and expertise in scientific mediation. It is a place of innovation, creation, and co-creation. We are also about training professors and teachers. We also share devices for digital science.

To tell the structure of Terra Numerica CNRS, Inria and Université Côte d'Azur are the founding members. There are about 20 full members, comprising research institutes, schools, unions, private companies, and influential local figures in various fields. Approximately 150 people work at Tetra Numerica. About 150 people work for Terra Numerica, including researchers, lecturers, citizens, students, scientific mediators, artists, and administrative staff.

The history of the Terra Numerica

Project started in December 2018; the name was chosen, and we created the logo in 2019; we received the first funding, and the first results were presented in 2020; three partners in 2021; 500 m2 space shared by researchers and citizens on the grounds of Sophia Antipolis in 2022.

In 2022, we launched the project. It is a center to support, inspire, create, and share creative thinking. And in 2025, the company plans to open a "Terranumerica Digital City" on the Côte d'Azur in south France to promote digital science.

Art and Science

Picasso once said, “Everything you can imagine is real.”

I will present the following projects with Espace Art Concrète de Mouin Sartoux. On the left is a painting by Robert Delaunay, and on the right is a triangulation algorithm created by an artist at IRNIA. The perspectives of the artist and scientist intersect. On the left is a neural network produced by an artist at IRNIA.

It is the work of Carl Andre, who used 55 copper plates to learn mathematics and algorithms.

Art is everywhere. This is another project on the theme of spirals. This is a cross-disciplinary approach, where students know something mathematical is hidden in nature, history, science, and engineering and develop observation and insight. For example, origami also links science and art. In origami, the process of making brings deep learning.

Previous FFJ Discussion Papers

DP 23-03 (July 2023)

"ROBOTS IN THE WILD: An Ethnography of Robot-Human Interactions outside the Laboratory", Fabio GYGI (EHESS, SOAS), 2022 FFJ/Air Liquide Fellow

DP 23-02 (June 2023)

"Political Economy shaped by Financialization: Impacts on Monetary Policy and Foreign Economic Policy of Japan", Saori KATADA (University of Southern California), 2022 FFJ/Banque de France Fellow

DP 23-01 (March 2023)

"Public spaces of mobility in Paris, Tokyo, and Buenos Aires", Andrés Borthagaray (Furban / City on the Move), 2022 FFJ/Michelin Foundation Fellow

DP 22-07 (October 2022)

"A Study on "Jurisdiction" and Consistency in Urban Policy: Crossed perspectives Japan-France", Mari Uchiumi (Komazawa University), 2022 FFJ Visiting Researcher

DP 22-06 (September 2022)

"Monetary, fiscal and demographic interactions in Japan: impact and a comparative assessment", Pierre L. Siklos (Wilfrid Laurier University and Balsillie School of International Affairs), 2021 FFJ/Banque de France Fellow

DP 22-04 (July 2022)

"Diffusion of Connectivity Technology and development of new business models: How Connectivity Technologies redefine the role of human within organization? Empirical learnings from Japanese mobility service providers", Haruki Sawamura (École Polytechnique), 2019 FFJ/Valeo Fellow

DP 22-03 (July 2022)

"Bibliometrics analysis of mHealth and AI to discover the concept of AI in the field of mHealth", Kota Kodama (Ritsumeikan University), 2020 FFJ/Air Liquide Fellow

DP 22-02 (May 2022)

"Cycling for all? A feminist analysis of the Tokyo Bicycle Utilisation Promotion strategy", Marion Lagadic (University of Oxford), 2021 FFJ/Michelin Foundation Fellow

DP 22-01 (Mars 2022)

"Potentials and Challenges of The Connected Autonomous Shared Electric Vehicle (CASE) from Urban Geography Perspective in Southeast Asia Mega-Urban Regions", Kulacha Sirikhan (The University of Tokyo), 2021 FFJ/Valeo Fellow

DP 21-05 (December 2021)

"East Asian and European Firms: Comrades or Competitors", Willem Thorbecke (Research Institute of Economy, Trade and Industry), 2020 FFJ/Banque de France Fellow

DP 21-04 (December 2021)

"The Mobility of Paris Residents and Retailers: Their Viewpoints on the Effects of the City's Pedestrianization", Meriç Kirmizi (Ondokuz Mayıs University), 2020 FFJ/Michelin Foundation Fellow

DP 21-03 (August 2021)

"City logistics for sustainable and liveable cities", Eiichi Taniguchi (Kyoto University), 2020 FFJ/Michelin Foundation Fellow

DP 21-02 (May 2021)

"The impact of Paris 2024 on the construction of the Grand Paris Express: a hidden extra cost of the Olympic", Alexandre Faure (Fondation France-Japon de l'EHESS, EHESS)

DP 21-01 (March 2021)

"Local Government and Innovation for Sustainable mobility", Soichiro Minami (Policy Research Institute for Land, Infrastructure, Transport and Tourism), 2018 FFJ/Valeo Fellow

DP 20-05 (Septembre 2020)

"International Spillover Effects of Unconventional Monetary Policies of Major Central Banks", Tomoo Inoue (Seikei University), Tatsuyoshi Okimoto (Australian National University), 2019 FFJ/Banque de France Fellow

DP 20-04 (July 2020)

"Characteristics of Bike taxis in African rural society: A case study of Dschang, West Cameroon", Makiko Sakai (Tokyo University of Foreign Studies), FFJ Visiting Researcher

DP 20-03 (June 2020)

"Decomposing Preference for Redistribution Beyond the Trans-Atlantic Perspective", Ryo Kambayashi (Hitotsubashi University), Sébastien Lechevalier (EHESS, CCJ-FFJ), Thanasak Jenmana (PSE)

DP 20-02 (April 2020)

"A Comparative Analysis of Autonomous Vehicle Policies among Korea, Japan, and France", Jeehoon Ki (KISTEP), 2018 FFJ/Renault Fellow

DP 20-01 (March 2020)

"Comparing the Development and Commercialization of Care Robots in the European Union and Japan", James Wright (Sheffield University), 2019 FFJ/Michelin Fellow

DP 19-05 (November 2019)

"Credit Guarantees and Zombie Firms: A Case Study of Small and Medium-Sized Enterprises in Japan", Scott Wilbur (Yale University), 2018 FFJ/Banque de France Fellow

DP 19-04 (October 2019)

"Impact of R&D Activities on Pricing Behaviors with Product Turnover", Yasushi Hara (Hitotsubashi University), 2018 FFJ/Michelin Fellow, Akiyuki Tonogi (Toyo University) & Konomi Tonogi (Rissho University)

DP 19-03 (September 2019)

"From Agribusiness to Food Democracy. Comparative Study on Agricultural Policy and Organic Farming in France and in Japan", Shoichiro Takezawa (National Museum of Ethnology, Japan); 2018 FFJ/Air Liquide Fellow

DP 19-02 (June 2019)

"Legitimation of Income Inequality in Japan: A Comparison with South Korea and the United States", Shin Arita (The University of Tokyo), Kikuko Nagayoshi (Tohoku University), Hirofumi Taki (Hosei University), Hiroshi Kanbayashi (Tohoku Gakuin University), Hirohisa Takenoshita (Keio University) and Takashi Yoshida (Shizuoka University); Prizewinners of the 2019 FFJ/SASE Best Paper Award.

DP 19-01 (May 2019)

"A Study on New Mobility Services and Sustainable Urban Development", Ai Nishimura, 2017 FFJ/Renault Fellow

DP 18-06 (December 2018)

"A Study of New Technologies of Personal Mobility and Robot Suit for the Elderly and Persons with Disabilities", Toshiaki Tanaka (University of Tokyo, Hokkaido University of Science), 2017 FFJ/Valeo Fellow

DP 18-05 (November 2018)

"Developments in Well-Being at Work in Japan: A Survey and a Comparison with France", Louise Baudrand (EHESS), César Castellvi (EHESS), Nao Kinoshita (EHESS), Adrienne Sala (Sciences Po Lyon) & Sébastien Lechevalier (EHESS, Fondation France-Japon de l'EHESS)

DP 18-04 (November 2018)

"Understanding AI Driven Innovation by Linked Database of Scientific Articles and Patents", Kazuyuki Motohashi (University of Tokyo, NISTEP and RIETI, 2017 CEAFJP/Michelin Fellow)

DP 18-03 (November 2018)

"The Yen Exchange Rate and the Hollowing-out of the Japanese Industry", Ansgar Belke (University of Duisburg-Essen) & Ulrich Volz (SOAS University of London, 2017 CEAFJP/Banque de France Fellow)

DP 18-02 (October 2018)

"Cross-cultural (France and Japan) and Multidisciplinary Discussion on Artificial Intelligence and Robotics: Tendencies and Research Prospects", Naoko Abe (CEAFJP Research Fellow)

DP 18-01 (July 2018)

"Impact of Shareholder-Value Pursuit on Labor Policies at Japanese Joint-Stock Companies: Case of Nikkei Index 400", Kostiantyn Ovsiannikov (University of Tsukuba, Prizewinner of the 2018 FFJ/SASE Best Paper Award)

DP 17-05 (November 2017)

"Female Board of Directors and Organisational Diversity in Japan", Yukie Saito (CEAFJP Associate Researcher, University of Geneva, Institut de Recherches Sociologiques)

DP 17-04 (August 2017)

"*Keiretsu* Divergence in the Japanese Automotive Industry: Why Have Some, but Not All, Gone?", Akira Takeishi (Graduate School of Economics, Kyoto University; CEAFJP Visiting Researcher) et Yoshihisa Noro (Mitsubishi Research Institute, Inc.)

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DP 17-02 (April 2017)

"Does 'Driving Range' Really Matter? The Hidden Cost of Internal Combustion Engine Vehicles and the Potentially New Value Proposition of Electric Vehicles: Two Cases from Countryside and Urban Side of Japan", Hidetada Higashi (2016 CEAFJP/ Valeo Fellow)

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DP 16-01 (April 2016)

"How Do Credit Hours Assure the Quality of Higher Education? Time-Based vs. Competency-Based Debate", Ayaka Noda (National Institution for Academic Degrees and Quality Enhancement of Higher Education (NIAD-QE)

DP 15-04 (December 2015)

"Government Policy and the Evolution of Japan's Photovoltaic Industry, 1961-2014", Maki Umemura (Cardiff University, 2015 CEAFJP/Michelin Fellow)

DP 15-03 (December 2015)

"Japan's Financial Crisis and Lost Decades", Naohisa Hirakata (Bank of Japan), Nao Sudo (Bank of Japan), Ikuo Takei (Bank of Japan), Kozo Ueda (Waseda University, 2015 CEAFJP/Banque de France Fellow)

DP 15-02 (May 2015)

"Can Increased Public Expenditure Efficiency Contribute to the Consolidation of Public Finances in Japan?", Brieuc Monfort (CEAFJP Associate Researcher)

DP 15-01 (May 2015)

"Policy Regime Change Against Chronic Deflation? Policy Option under a Long-Term Liquidity Trap", Ippei Fujiwara (RIETI, Keio University, Australian National University), Yoshiyuki Nakazono (Yokohama City University), Kozo Ueda (Waseda University, 2014 CEAFJP/Banque de France Fellow)