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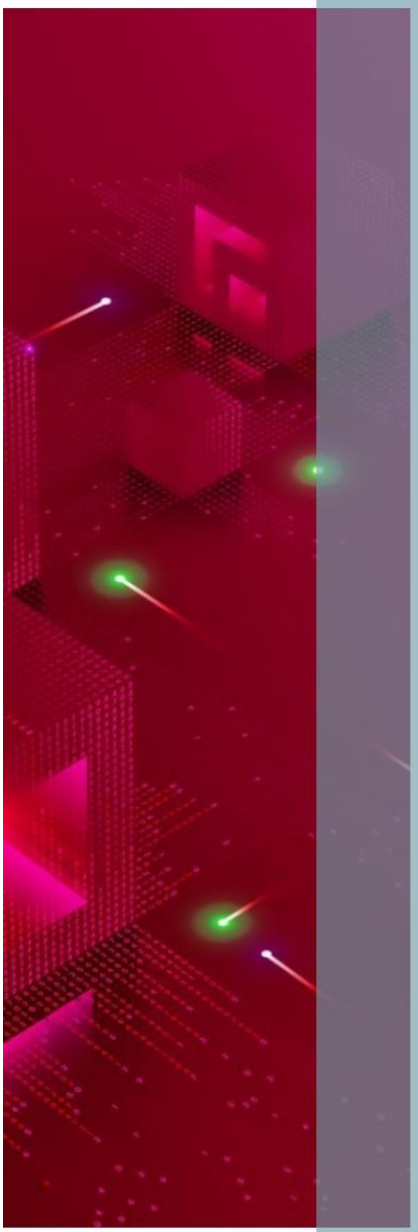

AI, CULTURAL HERITAGE, AND ART

BETWEEN RESEARCH AND CREATIVITY

WORKSHOP PROCEEDINGS

SEPTEMBER 22, 2023

AI, Cultural Heritage, and Art
Between Research and Creativity
Workshop proceedings – September 22, 2023

Edited by Antonella Guidazzoli and Maria Chiara Liguori

Cineca

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SUMMARY

FOREWORD

Alessandra Poggiani – Director General, Cineca

2024 is the year of artificial intelligence. In the coming months, its full potential will emerge in all fields: from technology to medicine, from sustainability to meteorology and, indeed, cultural heritage.

While the contribution of AI and supercomputing to increase productivity and efficiency is very clear, it is still necessary to look at the ethical aspects and how to exploit its strength to achieve benefits for all.

AI applications on cultural heritage and arts are many, and many more yet to be discovered. Imagine the possibility of digitising and processing large amounts of material: information would not only be accessible to anyone anywhere, but also safely stored and protected from the wear and tear of time.

AI with high performance computing capabilities can process these virtual archives and select specific research inputs, create semantic connections, analyse contextual influences, and generate information and knowledge for restoration, reconstruction or wider dissemination. All tasks that can now be implemented in few weeks and that would take human work many years of time-consuming data entry, research and analytics.

Fair access, transparency and reliability are the key words of the current technological transformation, which can allow everyone to access culture, art and knowledge, consulting books, works, materials, reconstruct moments of the past, anticipate future actions.

We are witnessing the birth of a new era where science, technology and art come together to transcend the boundaries of time and space. Cineca is at the heart of this ecosystem and intends to play an important role, not only by providing high performance computing capacity, but also by actively participating in the state-of the art debate with several initiatives, of which these workshops are an outstanding example.

INTRODUCTION – THE NEXT STEP FORWARD

Pierdomenico Memeo - Science writer, outreach expert

After the conclusion of the first workshop, we were left with a deep sense of satisfaction with the work we had done and the things we had learnt from our esteemed speakers and guests, but at the same time we were uncertain about what to do next.

We felt that the issues we were addressing certainly needed a deeper exploration of their ramifications and consequences, but we also knew that we would not want a simple expansion (let alone a rehash) of the initial premise: a social and technical examination of the increasingly close relationship between Artificial Intelligence and Cultural Heritage.

So, we gathered our thoughts and took some time to reflect on the why, the how and even the need for a second workshop on the same topic, in the same venue and with the same group. To be truly useful, things have to be needed, not just wanted.

But as we looked around for insights and inspiration, we realised that we were approaching the issue from the wrong angle: there was no way we could bring up the same topic a second time, because technology, and the culture surrounding it, was advancing so rapidly that by the time we sat down for our meeting, there would be a whole new conversation to be had.

This is the challenge of our time: keeping up with the rapid development of technology, but maintaining the knowledge, skills and experience we have gained over time. The only insurance against the changing wind is a solid base and a community dedicated to maintaining the structure: a community of research institutions, cultural organisations and business partnerships. With academics, developers, entrepreneurs, critics, artists, all at the same table, to create knowledge, share practices and exchange visions at the crossroad of technology, cultural preservation and artistic expression.

As I mentioned in the previous introduction, CINECA has long been at the forefront of these discussions, emphasising the importance of creating common ground between professions and serving public awareness of technology and its impact on society, for instance at the *European Researchers' Night 2021*, with the online workshop *I Sing the Body Electric: AI and Gender Bias*, and

exploring the connection between science and art, as in the case of the *Into The UnKnown* workshop at the *European Researchers' Night* 2020.

But looking back at our past initiatives, we also charted the course for the future: what was born out of a need of the moment, a conversation to expand and deepen our understanding of the relationship of AI, Cultural Heritage and Art, was really just one point in a series of such moments, and as such showed us the way forward. The next step forward.

These Proceedings are therefore an account of this next step, taken with the hope and intention of making it a stage in a long line of initiatives that will follow the quest for the integration of IA into the conservation and promotion of cultural heritage and the promotion of new forms of artistic expression, creating an ever-widening meeting ground between researchers, scholars, practitioners and the public.

My thanks go to our contributors, who added their expertise to our meeting and poured their reflections into these pages, leaving me with even more curiosity than before. My gratitude also goes to Antonella Guidazzoli, head of CINECA's VisIT Lab, and Maria Chiara Liguori, digital historian, for working so hard to make this happen. And to everyone at CINECA, who decided that having me hosting this workshop and writing these lines was a good idea.

Now, with me, take the next step.

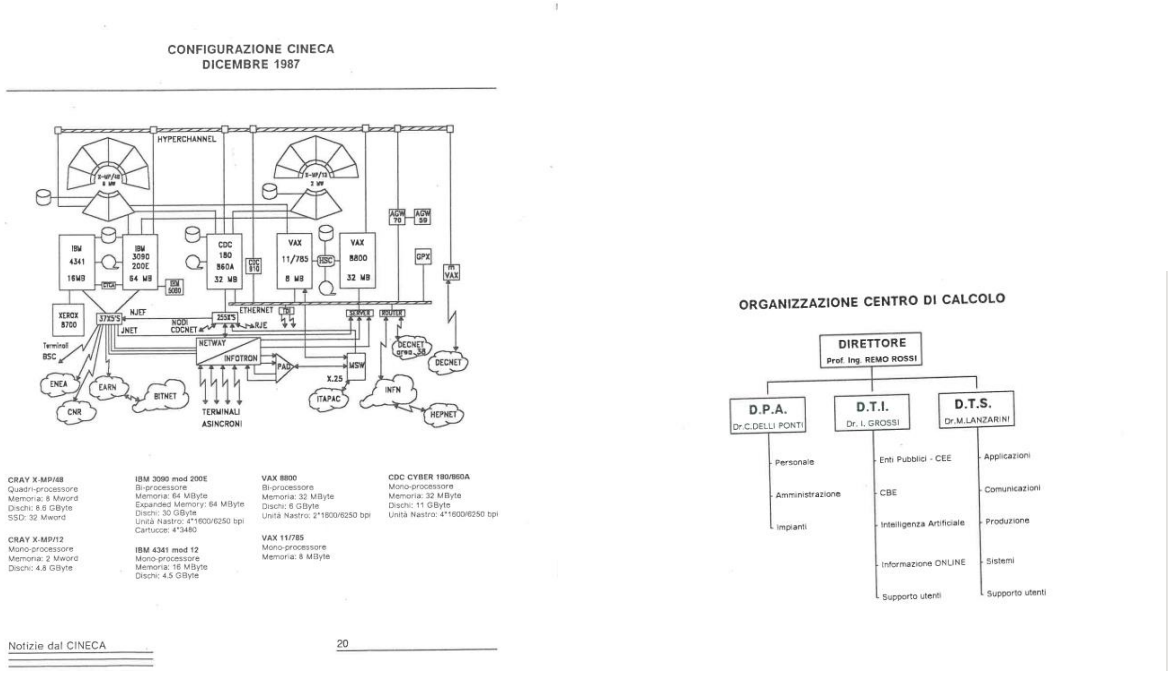
AI BETWEEN COLLECTIVE INTELLIGENCE AND IMAGINATION. SOME THOUGHTS

Antonella Guidazzoli – Head of VisiLab Cineca

The second workshop dedicated to AI, Cultural Heritage, and Arts organized by VisitLab Cineca continues its task of exploring AI possibilities from the point of view of Cultural Heritage in the fields of Digital Humanities disciplines and Arts.

Taking inspiration from Cacciari's latest book, *Metafisica Concreta* [1], let's face this reflection: philosophy must be less abstract and science less technical. Cacciari grapples with the role of metaphysics in a time dominated by effective technical-scientific knowledge. The conclusion drawn is that every entity reveals itself differently based on the perspective from which it is - scientifically, aesthetically, or theoretically - observed.

This reflection suggests a need for creating new cognitive paths and considering a similar mindset even when dealing with Artificial Intelligence.



Figg. 1-2 – Cineca HPC system configuration in December 1987 and Cineca organisation chart, showing the presence of a team dedicated to Artificial Intelligence. In Notizie dal Cineca*, n. 1, 1988*

The extreme of the possible is the impossible; here lies a role for artificial intelligence between science, art, or in other words between our collective intelligence and imagination.

AI is already omnipresent. The technology is not a novelty: at Cineca, a team was already working on it more than 30 years ago, but the time was not ripe. The difference is that now computing power and big data are available. Powerful supercomputers, such as Leonardo, enable technologies essential to train artificial intelligence networks. In this competition whoever has the most GPUs wins.

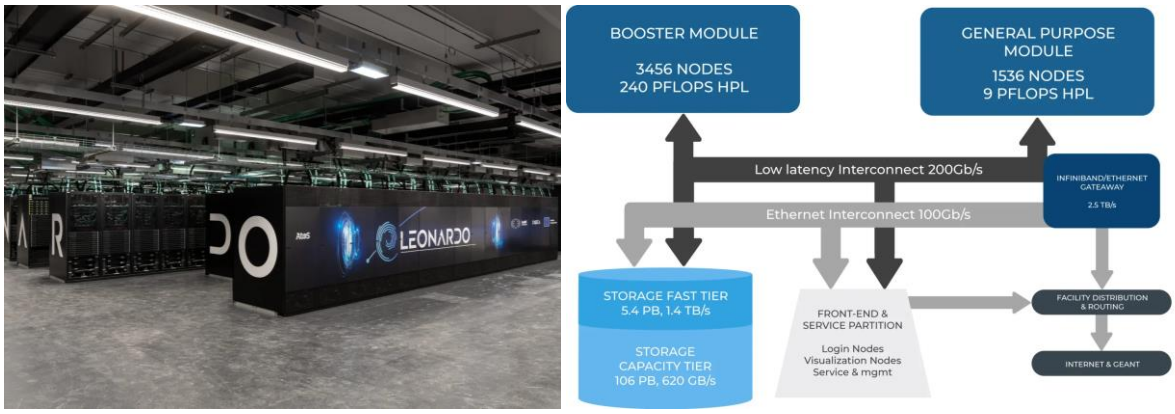


Fig. 3-4 – Leonardo HPC system configuration, November 2022.

More and more digital resources are and will be available. The National Recovery and Resilience Plan, part of the Next Generation EU program, conceived as a reaction to the pandemic crisis, revolves around three strategic axes shared at a European level: digitization and innovation; ecological transition; social inclusion. To the plan dedicated to "Digitisation, Innovation, Competitiveness, Culture" a total of € 49.2 billion was allocated.

These digital contents can nourish new digital cultures and feed new artistic productions that can change our imagination.

AI tools can be conceived as powerful agents according to Floridi's point of view [2]. AI lacks intelligence but in the field of Digital Humanities can, for example, enable researchers to analyze documents and audio/video sources at a larger scale, allowing them to ask new questions and look for new connections among data, an occurrence that researchers are already exploiting in scientific fields.

Moreover, Floridi's article suggests that LLMs separate agency from intelligence. Although incredibly powerful and potentially beneficial, they shouldn't be the sole source of complex reasoning or critical information. Instead, they could offer a deeper understanding of a text's content and context, complementing human input rather than replacing it.

The ideal author is not just an LLM or a human, but a person who uses an LLM skillfully.

In the cultural heritage field, thanks to well-designed AI tools we could extensively analyse millions of digitized contents in various fields, from periodicals to manuscripts and audio / visual content.

In particular, digital Cultural assets are challenging: they can be also bases for artistic interpretations, and they can be valuable content for cultural creative industries.

Moreover, regarding the relationship between artificial intelligence and art, artists generally have two approaches. Either they use AI as a new tool, or they have a defiant attitude and boycott AI, revealing its inconsistency.

Artists anticipate the future. Art can remap and broaden the domain of artistic imagination, as in the *Terramars* project, by Weili Shi [3], or Fassone's *And We Thought* [4].

AI and art can foster creativity and imagination; challenge hypotheses, assumptions, and biases; encourage reflection and introspection; and promote empathy and understanding.

New cooperation spaces between artists and scientists are emerging. Collaboration between artists and technologists in corporate research centres can also help us rethink economic and social models and enable a more sustainable and inclusive future as the Grin Project experience shows us.

We need to create ecosystems that generate new textures between artistic doing, philosophical doing, scientific techniques, and ethical doing.

As Yuval Harari claims, for every dollar invested in AI, we must invest another dollar in education and the development of our cognitive skills.

> "If for every dollar we invest in developing artificial intelligence (AI),
> we invest another dollar and another minute in developing our minds,
> we'll be fine," [5]

Artificial intelligence is not so frightening, says Vito Mancuso, human stupidity is more frightening [6]. We must not find ourselves in Hegel's dialectic between slave and master, where the master remains, in a sense, subservient to the slave who performs tasks.

In this scenario, we should also consider that, very shortly, new computing environments can trigger exponential accelerations such as accelerated computing and quantum computing.

On one hand, IBM is making available QC machines on the cloud to allow everybody to get used to this new computing paradigm, while NVIDIA's vision for AI-accelerated computing is to democratize AI access, with AI addressing global challenges, such as climate change, healthcare, and transportation.

To realize this vision, NVIDIA is developing a comprehensive ecosystem of AI-accelerated products and solutions including powerful GPUs for AI processing, software tools, and platforms like Omniverse, with the open Universal Scene Description (USD) format, developed by Pixar Animation Studios, made available to host digital twin solutions in an open-source 3D scene. It is a high-performance, scalable, and extensible format to describe the geometry, materials, animations, and other aspects of 3D scenes. A wide range of 3D software applications, including Maya, Houdini, and Blender supports USD.

Quantum computing traces its origins back to the 1980s. The famous physicist Richard Feynman asserted that, since the essence of nature is quantum, one must use quantum simulations to fully grasp its complexity. QC employs the principles of quantum mechanics to store and process data. Our task now at Cineca is to share with researchers the possibilities offered by quantum computing.

In the academic and industrial fields, we are on the brink of a second quantum revolution, one that holds the promise of harnessing quantum properties like entanglement and superposition of states. It is not correct to conceive quantum computing as an extension of Moore's law or as just a faster version of classical computers, but rather quantum computing represents a new branch in computing.

It is the first time that computing, computing as a category, say with a capital C, has a branching in history. There will be classical computers and there will be quantum computers. And they are going to work in concert.

One is not going to substitute the other, but it is important to make this important distinction of this branch that is taking place.

And the reason that they matter is that certain problems are impossible for classical computers to solve.

Quantum computing holds promise for revolutionizing fields such as cryptography, optimization, drug discovery, material science, and machine learning, hence in AI in general, by solving complex problems much faster than classical computers.

Quantum computing is based on a hardware model that has little in common with the hardware of classical computers and it requires a new way to think about programming.

In 2024, CINECA will host in Bologna Technopole EuroQCS-Italy a new quantum computing machine that will be integrated into the EuroHPC pre-exascale supercomputer Leonardo.

Cultural heritage and Arts could represent a challenging area of research and inspiration in these new computing scenarios. Cultural heritage research and applications can also contribute to the growth of ethical awareness and the creation of sustainable human-centred applications.

In these scenarios, we must create frameworks steeped in ethics to promote inclusion, diversity, equity, accessibility, and transparency [7]. The ecosystems integrating art, philosophy, science, and ethics will be the only way to prevent hidden AI dark sides from emerging, but this will be one of the focuses of our next workshop.

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ARTIFICIAL INTELLIGENCE AS A KEY TO THE VALORISATION AND CONSERVATION OF CULTURAL HERITAGE: AN INTERDISCIPLINARY APPROACH

Stefano Allegrezza - Università di Bologna

Abstract: Artificial Intelligence is evolving very rapidly and is transforming multiple sectors of society, as well as our daily life. It promises to revolutionise also the cultural heritage sector, with results that are largely yet to be discovered and that we may not even be able to imagine yet. It is therefore important to explore and understand how it can affect the field of cultural heritage and how we can make the most of this technology to preserve, promote and enrich it. Furthermore, it is essential to use this technology responsibly, addressing ethical challenges and working to ensure that cultural heritage becomes truly accessible to all. Only through an interdisciplinary approach and collaboration between cultural and academic institutions, scientists, developers and the public can we enhance and preserve our cultural heritage to make it available for future generations.

Introduction

In recent years, Artificial Intelligence (AI) has become increasingly relevant due to its impact into every field of modern society. Intelligent algorithms and techniques are now widely used in business, healthcare, industry, finance, agriculture, and education. Artificial Intelligence is also already part of our personal lives and is used in many of the activities we perform daily. For instance, most computer tools and mobile phones have Artificial Intelligence features, used in voice recognition and by virtual assistants (such as Apple's Siri, Microsoft's Cortana, or Google's Alexa, which we have used without knowing that they were based on Artificial Intelligence). Everyone is also familiar with facial recognition systems (Apple's Face ID or Microsoft's DeepFace), machine translation systems (Microsoft Translator, Google Translate, DeepL, QuillBot, etc.), grammar checker and language correction tools especially in the academic context (Trinka, Paperpal), search engines (Consensus, Bing), copywriting (Adcreative, Bertha AI, Simplified), content creation (Writesonic, ChatGPT, Stable Diffusion, Dall-E, Midjourney);

marketing (Copy AI, Jasper AI, Simplified, Mutiny, ContentEdge); autonomous vehicles (such as self-driving cars and drones)[1].

Intelligent algorithms can answer customer questions via chat, recognise a person's face to enable access, sort documents according to content, filter resumes to select the ideal candidate. In everyday life, 'recommendation systems' (offered by Netflix, YouTube, or Amazon) suggest products to buy, films or music according to our tastes, and so on.

Artificial Intelligence also plays a key role in the world of sport: it is used to capture and analyse images of matches (the famous 'challenge' in soccer), provide coaches with reports on how to better organise the game, including optimising field positions and strategy. Artificial Intelligence systems are also widely used in games, e.g. in game programming, from chess to backgammon (two games that have contributed significantly to the development of learning algorithms).

Other areas in which Artificial Intelligence is being used on an ongoing basis are the financial market, robotics, and medicine. In the latter sector, Artificial Intelligence is used to support the reading of X-ray images and the diagnosis of certain forms of cancer, heartbeat analyses, nevi screening and the creation of virtual personal assistants (e.g. companion robots). Even in the cinema[2] and audiovisual world, Artificial Intelligence is widely used and is employed in so many activities, including 'rejuvenation': those who have seen the film 'Indiana Jones and the Dial of Destiny' (which is the real title of the film that everyone knows as 'Indiana Jones 5', 2023), have certainly noticed that for the first 25 minutes of the film Harrison Ford, who is about to turn 81,

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1 - The use of machine learning and Artificial Intelligence in the automotive sector is well known. Vehicles capable of moving in traffic even without a driver are now something beyond experimentation, even if their use is currently still limited to certain sectors and situations.

2 - Examples of the use of Artificial Intelligence techniques are numerous in the film industry and in many cases anticipated technologies that were later actually developed. The example that perhaps more than any other has stuck in the collective memory is the on-board supercomputer HAL 9000 on the space ship 'Discovery 1', in Stanley Kubrick's 1968 film '2001: A Space Odyssey'. Endowed with extraordinary reasoning capabilities, as well as 'almost' human feelings, HAL 9000 is able to speak with a totally human voice, have human sensory perceptions and emotional experiences, and steer the spaceship to its destination without the aid of human intervention. The origin of the name 'HAL' is often attributed to a play on the acronym IBM, he name of the most famous computer manufacturer of those years. By applying Caesar's cipher, with a forward shift of just one letter of the alphabet, instead of three, as in the real cipher, to the three letters 'H-A-L', the letters 'I-B-M' are obtained. Artificial Intelligence is present in our unconscious in many ways, both positive and negative, essentially in the numerous depictions in films and series, some with positive views, others with negative views on the impact of Artificial Intelligence in society. The list of works that have addressed the topic of Artificial Intelligence, with the possible ethical implications in their interactions with human beings, is endless. Many examples can be cited, from the just mentioned '2001: A Space Odyssey' (1968) and 'Blade Runner' (1982), to more recent examples such as 'The Matrix' (1999); 'A.I. - Artificial Intelligence' (2001), written and directed by Steven Spielberg and based on a project by Stanley Kubrick; "I, Robot" (2004), derived from the book of Isaac Asimov (Asimov, 1950), 'Her' (2013), 'Transcendence' (2014), 'Ex Machina' (2014) and the British series 'Black Mirror' (2011). The topic of Artificial Intelligence has constantly appeared also in major newspapers and news reports, highlighting the innovations it has promoted in many fields of knowledge.

appears as a young man of about 35; this was possible not thanks to an actor who played him when he was young - this was the case in 'Indiana Jones and the Last Crusade' with the actor River Phoenix - but thanks to Artificial Intelligence techniques.

This is only the most recent example, and maybe the most sensational and important one, of a phenomenon that has been going on in the world of cinema for at least 3-4 years: the rejuvenation, or ageing, of the faces of actors with the use of AI[3]. The difference with what was happening until a few years ago is that rejuvenation is not done through special effects (as we have understood them so far, using make-up or computer graphics), but by leaving all the work to an Artificial Intelligence. Artificial Intelligence is also capable of making a speaker change languages, thus enabling him to speak in unknown languages and even changing his lips. In this regard, there was a stir in September 2023 when the deputy prime minister and infrastructure minister Matteo Salvini posted a video on social media in which he spoke fluent French for about a minute about the Pontida meeting. The speech ended with a 'je vous attends', obviously addressed not only to the participants but also to the leader of the Rassemblement National, Marine Le Pen, who was expected on the Pontida stage the next day. Someone must have wondered how this was possible, since the minister makes no secret of the fact that he does not know French. The explanation lies in the use of Artificial Intelligence, which was able not only to translate the original speech from Italian into French, but also to maintain exactly the timbre and tone of the minister's voice and to modify the face (and especially the mouth) to perfectly adapt his lips to the words spoken: in other words, it was able to generate a perfect 'fake', absolutely impossible to 'spot' if one did not know that the minister did not speak French.

The most interesting developments in the field of Artificial Intelligence are currently those of 'Generative Artificial Intelligence' (such as GPT chat, Bard, Perplexity, etc.), which is widely

[3] - In the case of Indiana Jones, the Artificial Intelligence that did the work is called 'Fran' (the acronym stands for 'Face re-aging network'); it was developed in-house by Disney, which announced it at the end of 2022. This reveals how indispensable these technologies are becoming even for larger studios, which are obviously also trying to bring them in for economic reasons. Fran has not been trained on the faces of real people, captured (as everyone does and it is quite legitimate to do) by scraping the Internet and social networks: it uses the so-called 'synthetic data', a more privacy-friendly practice and the only possible solution. In fact, as the developers themselves explained, it would have been 'practically impossible' to train Fran in any other way to get the desired results, because it would have required 'images in pairs showing the same subject with the same facial expression, the same pose, the same lighting and the same background at two known and different times in his life'. At two different ages, in short. Hence the idea of using synthetic data: Fran's developers created a database consisting of several thousand randomly generated faces**,** faces of non-existent people probably created with tools such as Dall-E, Midjourney and Stable Diffusion. They then aged or rejuvenated those faces using some machine learning tools and at that point fed all the data into Fran, so that it could do the same thing and predict which parts of a face would be affected by ageing (or rejuvenation), where wrinkles would appear, where the skin would be smoother and so on. (https://www.repubblica.it/tecnologia/ 2023/05/08/news/fran_ai_harrison_ ford_indiana_jones_5_deaging-398913016/). Somehow an AI that has learned to do things from another AI (and perhaps that is a little worrying).

talked about and has applications in all sectors[4]. Generative Artificial Intelligence is demonstrating the ability to generate not only texts or images but also original works of art, both visual (photographs, videos) and musical. For example, it is possible to analyse a vast amount of existing artistic works through machine learning algorithms and to create new ones reflecting the style, theme or characteristics of the author who is no longer alive. It can generate programming code as well. To create a new app or service, there is no need to know how to write code or do graphic design. You will just tell your AI agent what you want. It will be able to write the code, design the look and feel of the app, create a logo, and publish the app to an online store [1].

AI has all the characteristics to produce a new revolution in the way of working[5] and creating, and it has been made available to the public in a very short time.

To summarize, although the public is convinced that the use of Artificial Intelligence is relegated to particular areas, it permeates our lives and is abundantly used in even the simplest of our daily activities. Artificial Intelligence is also increasingly being used in the cultural heritage field and this paper aims at providing an overview of some of the most interesting applications.

What is Artificial Intelligence

But what exactly is Artificial Intelligence? And what are the distinct categories of Artificial Intelligence? Actually, there is no unambiguous definition of AI and the various formulations of it vary depending on the particular aspect one wants to consider: on the one hand, one can focus on the internal reasoning processes, on the other on the external behaviour of systems, in principle always taking similarity or proximity to human behaviour as a kind of 'measure of effectiveness'.

The European Commission's Plan on Artificial Intelligence defines AI-based systems as 'systems that exhibit intelligent behaviour by analysing their environment and acting - with a degree of autonomy - to achieve specific goals' [2].

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4 - There are several very interesting examples of generative Artificial Intelligence: ChatGPT, a software that simulates and processes human conversations, capable of generating texts that coherently answer questions posed by the user; Midjourney, Stable Diffusion and Dall-E, which create images from text input; Make-a-video, which converts textual input into short videos; Synthesia, which allows the creation of very realistic 'AI avatar' videos that can 'speak' 120 languages; MusicLM, still under study and experimentation, allows music to be generated from a textual description.

5 - According to a report published on 14 June 2023 by McKinsey, generative AI (such as Chatgpt and similar systems) can bring 4.4 billion value to the global economy and can save 60-70 per cent of workers' time. A value that companies are preparing to seize. According to the latest data from the Polytechnic of Milan, 61 per cent of large Italian companies have initiated AI projects, 34 per cent are already adopting them.

The independent High Level Expert Group on Artificial Intelligence set up by the European Commission in June 2018 adopted the following definition of Artificial Intelligence[6]:

> "Artificial Intelligence (AI) refers to systems that exhibit intelligent behaviour by analysing their environment and performing actions, with a certain degree of autonomy, to achieve specific goals. AI-based systems can consist only of software that acts in the virtual world (e.g. voice assistants, image analysis software, search engines, voice, and facial recognition systems), or incorporate AI into hardware devices (e.g. in advanced robots, self-driving cars, drones, or Internet of Things applications)" [3].

Simply put, Artificial Intelligence can be defined as the ability of a technological system to solve problems or perform tasks and activities typical of the human mind and abilities[7]. Artificial Intelligence is a broad branch of computer science that seeks to build intelligent machines with aspects of human intelligence. It is one of the most complex and impressive human inventions to date, but the field remains largely unexplored and with enormous potential for growth.

The scientific community has agreed to define two different types of Artificial Intelligence:

- *Weak Artificial Intelligence (weak AI)*: includes systems capable of simulating some human cognitive functions without, however, achieving the typical human intellectual capabilities; these are essentially problem-solving algorithms capable of replicating some human logical reasoning to solve problems, make decisions, etc. (as in the game of chess); in fact, these systems act as if they had a brain, but they are not 'really' intelligent, they only simulate being intelligent. To provide the answer to a problem they investigate previous similar cases, compare them, work out a series of solutions and then choose the most rational one based on the analysed data and known rules.

- *Strong Artificial Intelligence (strong AI)*: systems capable of replicating human cognitive capacities to the point of becoming sapient (or even self-aware) fall into this category. There are theories

6 - The Polytechnic of Milan defines Artificial Intelligence as: 'the branch of computer science that studies the development of hardware and software systems endowed with capabilities typical of human beings and capable of autonomously pursuing a defined purpose by taking decisions that, until then, were usually entrusted to human beings. Typical human capabilities relate specifically to the understanding and processing of natural language (NLP - Natural Language Processing) and images (Image Processing), learning, reasoning and the ability to plan and interact with people, machines and the environment. The real novelty of Artificial Intelligence-based systems compared to traditional software-based systems is that an AI system is not based on programming (i.e. on the work of developers who write the system's operating code) but on learning techniques: that is, algorithms are defined that process a huge amount of data from which it is the system itself that has to derive its understanding and reasoning capabilities.

7 - Looking at the IT sector, we could identify Artificial Intelligence as the discipline that deals with making machines (hardware and software) capable of 'acting' autonomously (solving problems, performing actions, etc.).

that lead some scientists and experts to believe that one day machines will have an intelligence of their own - thus not emulating that of humans - autonomous and probably superior to that of human beings[8]. In essence, these systems have cognitive capacities that cannot be distinguished from those of humans.

The systems currently in use almost always fall within the realm of *weak Artificial Intelligence*, but progress is steady, and it cannot be ruled out that real systems based on *strong Artificial Intelligence* will be implemented in the near future[9].

Techniques based on Artificial Intelligence

Most of the AI examples we hear about, from computers that play chess to self-driving cars, are based on one of several Artificial Intelligence techniques: *Machine Learning, Deep Learning, Natural Language Processing, Computer Vision*, etc. The same techniques are also applied in the field of cultural heritage.

Machine Learning is one of the main branches of Artificial Intelligence. It assumes that systems can learn from data, identify patterns, and make decisions, possibly with minimal human intervention. Basically, these systems allow machines to learn from their experiences, fix mistakes and adapt to new inputs to learn to perform a task/activity autonomously with 'almost' human logic. *Machine learning* is evolving along a line of research based on the use of neural networks organised in multiple layers of depth and therefore called *Deep Learning*[10]. This is a special type of

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8 - At that moment, called 'AI Singularity', the AIs in our lives will become self-aware or achieve a capacity for continuous improvement so powerful that they evolve beyond our control.

9 - According to other scholars, AI falls into three categories: 1) *Artificial Narrow Intelligence* (ANI). Defined as weak AI with a narrow range of abilities, it is the only type of AI we have available to us so far. Narrow AI is used in facial recognition, voice recognition/voice assistants and autonomous driving of cars; 2) *Artificial General Intelligence* (AGI). This is referred to as strong AI, with the ability to mimic human intelligence or behaviour to solve any problem. For the time being, strong or deep Artificial Intelligence is not yet available, but researchers are working to improve the ability of machines to see, understand and learn like humans. 3) *Artificial Super Intelligence* (ASI). It is the hypothetical AI that surpasses human intelligence and capabilities. It has always been a source of inspiration for science fiction in which robots take over the world. Having powerful, self-aware super-intelligent machines may be an exciting idea, but their impact on humanity remains uncertain. For now, it is still many years before artificial super-intelligence becomes a reality. See EBAN ESCOTT, *What are the 3 types of AI? A guide to narrow, general, and super Artificial Intelligence*, https://codebots.com/artificial-intelligence/the-3-types-of-ai-is-the-third-even-possible, 24 October 2017

10 - *Machine learning* approaches are usually distinguished into three types: 1) *supervised learning*, in which the algorithm is given examples of the inputs and the respective outputs desired for them ('annotated' or 'labelled' data), so that the model, during the training process, learns a rule of association between input and corresponding output, so that it is subsequently able to generalise to new datasets; this approach can be used to solve classification problems, i.e. the association to input data of a label within a finite set of labels, and regression problems, i.e. the prediction of numerical data in a continuous domain, and not a discrete one such as classification labels, based on the parameters

Machine Learning inspired by the structure and functioning of our brain, which trains the computer to perform tasks in a human-like manner, such as recognising speech, identifying images, or making predictions. Deep Learning requires a very powerful computational capacity capable of 'holding' different layers of computation and analysis (which is what happens with the neural connections of the human brain). This may sound like a futuristic level of technology, but actually these systems are already in use in pattern recognition, voice or image recognition and *Natural Language Processing* (NLP) systems. The aim of the latter is to create systems that foster human/machine interaction and understanding. They mainly deal with texts (of any nature, including web pages, social media posts and tweets, business information, etc.)[11]. Among Artificial Intelligence systems, those based on Natural Language Processing have achieved the greatest success in recent years: the spell-checkers found in Office Automation suites or automatic translation systems (also available online, such as Google Translate or DeepL) are just some of the NLP applications that we use daily in our lives.

The enormous success of Deep Learning is due by the remarkable achievements of particular types of neural networks, *Convolutional Neural Networks* (CNN) in many fields, including *Computer Vision* and *Image Processing*. The latter aims to reproduce the tasks and functions of the human visual apparatus, enabling computers to derive meaningful information from digital images, videos, and other visual input, and to take actions or make recommendations based on this information. Finally, Computer Vision is a field of Artificial Intelligence that trains computers to interpret and understand the visual world. Using digital images from cameras and video and through deep learning models, machines can accurately identify and classify objects and then react to what they 'see'. From facial recognition to self-driving cars, to analysing a live football match, computer vision rivals and surpasses human visual capabilities in many areas. Advances in

learnt; 2) *Unsupervised learning*, in which the inputs provided have neither a defined structure nor associated outputs and the purpose of the algorithm is therefore to identify patterns in the inputs in order to reproduce or predict them; some examples of the use of this paradigm are the problems of clustering, i.e. the grouping of data according to the regularities identified in them, and of reducing the size of data features, i.e. the elimination of non-significant information (noise) and redundant information in order to compact data in which identifiable patterns emerge; 3) *Reinforcement learning*, in which the algorithm learns through interaction with the environment with a system of rewards and punishments; this approach is commonly used in situations where an AI agent, such as a self-driving car, operates in an environment and the choices made generate feedback (reinforcements) from the environment.

[11] - With regard to the processing of texts, NLP can perform many tasks such as: 1) Text Classification: interpretation of a text in order to classify it into a predefined category (e.g. spam); 2) Information Extraction: locating and extracting specific information within documents; 3) Text Analysis: analysing a text and possibly identifying key elements (e.g. topics, people, dates); 4) Sentiment Analysis: detecting the mood within a text (e.g. positive/negative review); 5) Automatic Summarisation: producing a summarised version of one or more text documents.

recent years have been such that solutions based on statistical descriptions of images have gradually given way to neural networks trained on millions of images[12].

Computer vision is one of the areas where, especially in recent years and thanks to the use of neural networks, greater efforts and investments are being made by companies and public organisations, how the big progresses that has been made in facial recognition and self-driving cars demonstrate[13].

Worthy of mention are the *recommendation systems*, considered the main pillar of the business model of every *social* platform and of *eCommerce*. Underlying many digital services are algorithms that keep track of users' actions, comparing them with those of other users in order to learn their preferences. It is in this way that as the user uses the platform, the recommendations will become increasingly precise. It should be noted that these AI applications are thus able to direct users' choices based on information that they themselves have provided directly or indirectly. Among the most popular solutions there are systems that suggest a purchase based on previous ones by influencing the user's decision-making process and more specifically the customer journey [4], which is the path taken by the customer throughout the entire relationship with a company. This journey includes both *online* and *offline* stages and is thus the story of the bond between the customer and the company [5].

Increasingly popular are *Chatbots* or *Virtual Assistants*, that are tools based on Artificial Intelligence able to replace the human being in the interaction with the customer/user [6]. In other words, a *chatbot* is a system that can converse with humans and provide answers to a series of specific questions. In more advanced cases, a *chatbot* can even understand the tone and context of the dialogue and then exploit this information within the conversation. It is used both within business processes and in customer relationship systems. It is available seven days a week, around the clock, offering real-time help. This *software agent* can perform actions based on commands received from a user expressing themselves through natural language, either written or spoken, by means of Text-to-text, Text-to-speech, Speech-to-text, and Speech-to-speech.

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12 - One of the best-known applications is the use of *captcha* (an acronym for 'Completely Automated Public Turing Test to Tell Computers and Humans Apart'), which is widely used in the filling in of online forms to distinguish humans from machines. What perhaps not everyone knows is that in addition to the objective of ensuring that the user is indeed a human being - and thus limiting the spread of bots - captcha are also intended to train neural networks to recognise images.

13 - The tasks studied and processed by Computer Vision include: 1) *Image Classification*: analysis of image content and attribution of a label (e.g. dog, cat); 2) *Object Detection*: identification of one or more entities within an image; 3) *Semantic Segmentation*: subdivision of the image into sections at the pixel level (e.g. to highlight the pixels of a medical report showing a tumour); 4) *Face Recognition*: recognition of people's faces.

Artificial Intelligence applied to cultural heritage

Artificial Intelligence has application in each of the many types of assets that make up cultural heritage: artistic and historical heritage, architectural heritage, archaeological heritage, library and book heritage, archival heritage, museum heritage[14], and so on.

It is certainly not possible to deal exhaustively with all the various applications of Artificial Intelligence in each of these areas, but it is possible to summarise the most important applications and to provide some examples from both the national and international scene.

1) Artificial Intelligence and the Enhancement of Cultural Heritage

- *Digitisation*: AI can automate the process of digitising artefacts, ancient books, and historical documents, making them easily available online.

- *Immersive experiences*: AI-based virtual reality (VR) and augmented reality (AR) projects enable visitors to museums and historical sites to experience cultural heritage in a much more immersive way - think virtual tours, digital reconstructions, and interactive simulations - allowing them to create immersive virtual experiences through which people can 'time-travel' and visit historical sites or explore ancient cities.

[14] - What is cultural heritage? Pursuant to Article 10 of the Italian "Code of Cultural Heritage"(Legislative Decree 42/2004), cultural heritage consists of 'immovable and movable property belonging to the State, the regions, other public territorial authorities, as well as any other public body and institute and private non-profit legal persons, including civilly recognised ecclesiastical bodies, which are of artistic, historical, archaeological or ethno-anthropological interest'. These include a) things of interest to palaeontology, prehistory and primitive civilisations; b) things of numismatic interest that, in relation to the period, the techniques and materials of production, as well as the context of reference, are of a rare or valuable nature c) manuscripts, autographs, correspondence, incunabula, as well as books, prints and engravings, with their matrixes, having a character of rarity and value; d) maps and musical scores having a character of rarity and value e) photographs, with their negatives and matrixes, cinematographic films and audiovisual media in general, having a rare and valuable character; f) villas, parks and gardens of artistic or historical interest; g) public squares, streets, roads and other urban open spaces of artistic or historical interest h) mining sites of historical or ethno-anthropological interest; i) ships and floating structures of artistic, historical or ethno-anthropological interest; l) rural architecture of historical or ethno-anthropological interest as evidence of the traditional rural economy. Also according to the above-mentioned Article 10, cultural heritage consists of (a) the collections of museums, picture galleries, galleries and other places of exhibition of the State, regions, other public territorial authorities, as well as of any other public body and institution; (b) archives and individual documents of the State, regions, other public territorial authorities, as well as of any other public body and institution c) the book collections of the libraries of the State, the regions, the other territorial public bodies, as well as of any other public body and institution, with the exception of the collections that perform the functions of the libraries indicated in Article 47, paragraph 2, of Presidential Decree No. 616 of 24 July 1977.

- *Virtual and Augmented Reality*: AI can power virtual and augmented reality experiences that allow visitors to museums or historical sites to explore the past in an interactive way, thus enhancing education and the visitor experience.

- *Customizing the visitor experience and developing customised cultural content*: AI can analyse visitor preferences to identify visitor interest trends and behavioural patterns and then suggest visitor paths (e.g. to museums or cultural sites) based on this information, thereby improving visitor engagement, and enabling cultural institutions to tailor their offerings more effectively.

- *Translation and Interpretation*: AI can be used to automatically translate ancient texts or texts in lesser-known languages, to help visitors better understand the historical and artistic context and to provide access to global cultural heritage.

2) AI Technologies for Cultural Heritage Preservation

In this sector, too, AI has brought great revolutions.

- *Diagnostics*: AI can be used to analyse works of art, historical artefacts, and monuments in detail, for example to precisely identify the materials used. Computer vision algorithms can detect damage or changes over time, providing crucial information for conservation. In addition, AI can contribute to the chemical and physical analysis of historical materials.

- *Digital Reproduction*: In many projects, AI is used to create high-fidelity three-dimensional models of objects, buildings, archaeological sites and works of art. These models enable scholars to examine cultural assets in detail and preserve them virtually for future generations.

- *Reconstruction*: Artificial Intelligence algorithms can analyse high-resolution images to identify damage and create 3D models for the digital restoration of ancient works of art and artefacts. Some projects use AI to digitally restore artworks and documents damaged or degraded over time, reconstructing missing details or restoring original colours. This can also be useful to simulate how works of art looked in the past.

- *Virtual Restoration*: AI can be used to digitally reconstruct damaged or destroyed objects and works of art, enabling experts to visualise them in optimal condition.

- *Preventive Conservation*: IA can be used to monitor the state of conservation of cultural property in museums and conservation facilities and prevent damage caused by humidity, temperature, and exposure to light. In this way, it allows potential damage or deterioration to be predicted in advance, enabling preventive conservation interventions.

3) Artificial Intelligence and Cultural Heritage Research and Analysis

AI is also revolutionising historical research and the analysis of cultural heritage:

- *Text and image analysis*: Natural language processing algorithms enable scholars to analyse massive quantities of historical texts and images to identify cultural and social trends, extract meaningful information and relationships between events, and discover new information or previously unrecognised relationships.

- *Translation and transcription*: AI-based machine translation can enable a better understanding of ancient texts or languages that are no longer spoken. In addition, automatic transcription of manuscripts can make ancient documents accessible to a wider audience.

- *Cataloguing, Archival Description and Metadata*: AI can be used to automate the process of cataloguing, classifying and metadata of works of art, manuscripts, photographs, documents, and other cultural objects, enabling their more efficient management and simplifying research and organisation.

- *Data mining of collections*: AI can help discover hidden connections between objects and artworks in collections, revealing new perspectives on history and culture.

- *Analysis of big data*: AI can be used to analyse vast amounts of data (e.g. archaeological data) to discover new information about ancient civilisations and archaeological sites[15].

- *Detecting forgeries*: AI can be a powerful tool in detecting forgeries, analysing details such as the artist's signature, style and materials used. In some cases, AI has been used to identify and return stolen or purloined cultural objects, thus contributing to reconciliation between countries and cultures.

Some examples

It is important to give some examples to better understand how Artificial Intelligence can be used in the cultural heritage sector.

[15] - In this regard, the Cultural Landscapes Scanner (CLS) pilot project conducted and co-funded by ESA together with IIT, which uses Artificial Intelligence techniques to discover archaeological heritage sites hidden underground and identify them, is worth mentioning. This is possible thanks to a system capable of using remote sensing data from a variety of sensors in the form of anomalies or traces detectable on bare ground, crops and vegetation.

The Ancient Olympia Common Place project (2021)

One of the most talked-about projects has been the 'Ancient Olympia: Common Grounds' project, which has involved the Greek Ministry of Culture and Sport in collaboration with Microsoft and its AI for Cultural Heritage initiative[16], and concerns the safeguarding, preservation, and digital archiving of the place where the first Olympics took place using Artificial Intelligence. It is possible to visit these places, so rich in history, by taking a virtual journey back in time, more than 2000 years, to walk along the 'digital' streets of the ancient city of Olympia, the original venue of the Olympic Games (Figure 1).

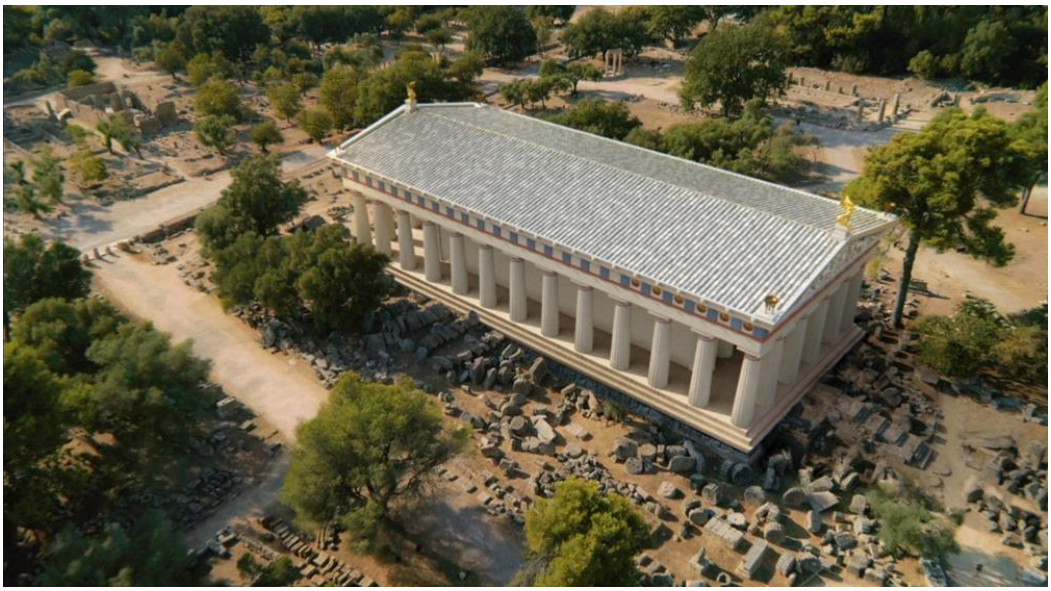

Fig. 1 – Reconstruction of the temple of Zeus.

It is possible to virtually visit the original site, either remotely through augmented reality technology, or in person, on the archaeological site, thanks to Microsoft's HoloLens technology (a standalone mixed reality visor launched in early 2019).

This ambitious project involved the preservation of 27 monuments, including the original Olympic Stadium. Each preserved building also boasts a history feature, showing how that monument has changed over time. Both ground-based cameras and drones were used to take hundreds of thousands of images of the site, which Microsoft's AI then processed to create

16 - Microsoft, for example, initiated 'AI for Cultural Heritage', which harnesses the opportunities of Artificial Intelligence to provide more effective tools for people and organisations dedicated to preserving and enriching cultural heritage. This intent is the fourth pillar of Microsoft's AI for Good programme, which takes the form of a five-year, $125 million commitment to use Artificial Intelligence to address some of society's biggest challenges.

highly accurate photorealistic models. The collaboration between the Greek Ministry of Culture and Sport and Microsoft brought together people with diverse backgrounds - theorists and technicians, as well as archaeologists and developers - and from various parts of the world to work, find new ways to overcome difficulties, and ultimately find common ground to bring this project to life.

The InterPARES Trust 'AI in the Middle age'

The second example is a project that was conducted as part of the InterPAREStrustAI project, the international research project that is investigating applications of Artificial Intelligence in the field of records management and archives.

The project in question, entitled 'AI in the Middle age. Arrangement of the documents via appearance-based recognition', involves researchers from several universities, both Italian and foreign (e.g. the Universities of Macerata and Pavia and Washington University) and institutions (e.g. the State Archives of Milan, Novara, and Ascoli Piceno in Italy).

The project uses Artificial Intelligence to extract new information from the parchment fonds stored at the State Archive of Milan (ASMi). The latter preserves more than 130,000 documents on parchment, covering almost a thousand years of history. In particular, the 'Diplomatic Museum' fund (6th century - 1100) holds the oldest original Italian private deed, which dates back to the year 721, and many documents prior to the year 1000. It contains imperial and royal diplomas, papal bulls, bishop's deeds and 'pagensi' deeds. The 'Parchments for fonds' fund (916 - 20th century) contains imperial and royal papers, papal bulls, chancery documents and private deeds from numerous secular and ecclesiastical institutions in northern Italy (12th - 18th century). Although it has been studied since the 18th century, because of its vastness this material has not been analysed systematically to identify common features recurring in homogeneous groups of documents. Only using Artificial Intelligence it is possible to automatically process such a vast number of scanned documents and thus arrive at new forms of knowledge. One of these is the definition of the number and activity of notaries in the city of Milan and its countryside. Through deep learning techniques, the project was able to automatically investigate a large number of documents and make a substantial contribution to the knowledge of Milanese notaries in the Middle Ages. The key feature chosen for the research is the 'signum tabellionis', the personal sign that notaries affixed before their signature as a guarantee of authenticity. It appears in almost all private deeds and has specific and easily recognisable characteristics (shape, position, etc.). This is a first application in this field, but once

perfected and developed, AI could be used in a wide range of applications such as, for instance, recognising the particular writing system of each individual notary; analysing signatures on the verso of documents and tracing the previous archival arrangements or uses of groups of documents; recognising images or other recurring features in large sets of documents; identifying common patterns in maps or manuscript drawings.

Transkribus (2019)

Transkribus is a comprehensive platform for digitisation, image analysis, handwritten text recognition (HTR) with the help of Artificial Intelligence, automatic transcription, and research of historical documents. The platform was created in the context of the two EU projects tranScriptorium (2013-2015) and READ (Recognition and Enrichment of Archival Documents - 2016-2019) and was developed by the University of Innsbruck. Currently the platform is managed and further developed by the European Cooperative Society READ-COOP. The platform integrates tools developed by research groups across Europe, including the Pattern Recognition and Human Language Technologie (PRHLT) group at the University of Valencia and the Computational Intelligence Technology Lab (CITLab) group at the University of Rostock in Germany. Transkribus makes large collections of archive material accessible through handwriting recognition techniques. With Transkribus, especially older prints are translated in a much better quality than with OCR (Optical Character Recognition). Transkribus is now used all over the world: numerous institutions are using it[17].

The REPAIR project (2021)

In 2021, the RePAIR (Reconstruction the past: Artificial Intelligence and Robotics meet Cultural Heritage) project was launched; its goal is the use of AI assisted special robots that can reconstruct archaeological artefacts by scanning micro-fragments. The physical reconstruction of shattered works of art is, in fact, one of the most laborious phases of archaeological research. Extracted from excavation sites, countless ancient artefacts, such as vases, amphorae, and frescoes, are damaged.

[17] - For instance, as part of a project promoted by the Aarhus City Archive and the Danish Archives Organisation, municipal and local archives in Denmark are conducting a trial on the adoption of new Artificial Intelligence solutions using Transkribus, which will perform machine reading and automatic transcription operations and facilitate parallel crowdsourcing and communication initiatives - for the digitisation of ancient manuscript registers kept by municipal and parish administrations between 1840 and 1940. The project also includes the testing of text recognition models to be applied to older documents.

Fig. 2 - Physical reconstruction of shattered artworks - source: https://www.repairproject.eu/project

The RePAIR project aims at developing an intelligent robotic system capable of autonomously processing, matching, and physically assembling fragmented artefacts in a fraction of the time required by humans, to breathe new life into ancient works of art. This new system will be tested in emblematic case studies from the archaeological site of Pompeii (UNESCO World Heritage Site), which, first due to the eruption in 79 A.D. and then the bombing during the Second World War, suffered considerable damage and the frescoes it contained were literally smashed to smithereens. It will start with the restoration of world-famous frescoes, currently divided into thousands of fragments, and stored in deposits[18], such as the ceiling of the House of Painters at work in the 'Insula dei Casti Amanti'. Basically, the RePAIR robots, equipped with special mechanical arms, can recompose the frescoes by recognising the various fragments and their arrangement through 3D scanning (Figure 2). The project is coordinated by Ca' Foscari

[18] - As the director of the Archaeological Park of Pompeii, Gabriel Zuchtriegel, pointed out, '*Amphorae, frescoes, mosaics, are often brought to light fragmented, only partially intact or with many parts missing. When the number of fragments is very large, with thousands of pieces, manual reconstruction and recognition of the connections between the fragments is almost always impossible or very laborious and slow. This results in many finds lying in archaeological deposits for a long time, without being able to be reconstructed and restored, let alone returned to public view. The RePAIR project, the result of research and technological expertise, with the help of robotics, digitisation and Artificial Intelligence, aims to solve an atavistic problem*. Marcello Pelillo, project co-ordinator and professor of Artificial Intelligence at Ca' Foscari University in Venice, added that '*From a scientific and technological point of view, the project poses major challenges that we will use the most advanced techniques in the field of Artificial Intelligence, Artificial Vision and Robotics to tackle*.

University of Venice and relies on the interdisciplinary contribution of scientific and research institutes working in the fields of computer vision, robotics, and Artificial Intelligence, with the fundamental contribution of Archaeology and Conservation of Cultural Heritage. Partners in the 'RePair' project, together with the Archaeological Park of Pompeii, are the Ca' Foscari University of Venice (coordinating institution), the Ben-Gurion University of the Negev in Israel, the IIT-Italian Institute of Technology, the Associacao do Instituto Superior Tecnico Para a Investigacao e Desenvolvimento of Portugal, the Rheinische Friedrich Wilhelms Universitat of Bonn in Germany, and the Ministry of Culture. The project received funding from the European Union's Horizon 2020 research and innovation programme, under Grant Agreement no. 964854.

The ReAD project (2022)

In October 2022, the ReAD (Representation of Architectural Data) project was launched. It is 20-month project promoted by the Institute of Cognitive Science and Technology of the National Research Council (CNR-ISTC), the Central Institute for Catalogue and Documentation of the Ministry of Culture (MiC-ICCD) and the Department of Architecture of the University of Roma Tre (RM3-Darc), selected within the framework of Lazio Innova and financed through the ERDF, the European Regional Development Fund[19].
ReAD was created with the aim of promoting the knowledge, protection, and valorisation of the architectural heritage, thanks to the application of technologies linked to Artificial Intelligence[20]. More specifically, the project intends to work on unstructured textual and iconographic sources using computational technologies capable of automatically extracting significant information and making it available to professionals and scholars of architecture to carry out their work, with the possibility of performing interpretative analyses on existing architectural heritage. The system will be able to support, for example, architectural historians in carrying out stylistic and typological comparisons useful for their own research; or again, to support restorers architects in knowing automatically, starting from architectural drawings, the consistency of the elements on which to intervene in the restoration phase, speeding up the calculation of work expenses. The application will then allow the quick identification of chronologically homogeneous buildings or buildings with certain construction and stylistic characteristics. The many possible queries will

19 - The project is coordinated by Aldo Gangemi, Director of the CNR-ISTC, together with Valentina Presutti (CNR-ISTC, University of Bologna).

20 - The innovation introduced combines the most advanced Artificial Intelligence techniques for the recognition of heterogeneous sources in the domain of architectural heritage, allowing texts and images to be interrogated and combined to extract large amounts of information on the national architectural heritage.

also easily support the activities of archivists and cataloguers of architectural heritage, making it easier to identify the necessary data and enter them into inventories and cataloguing systems. The experimental activity uses the extensive descriptive information contained in the database of the General Catalogue of Cultural Heritage of the Ministry of Culture already available in open format (linked open data), and the ICCD's vast photographic archive on cultural heritage, allowing the project to start from a significant knowledge base on architectural heritage. The data will be made available within the semantic web, guaranteeing the usability and accessibility of all to the results of the ReAD project[21].

Conclusions and final considerations

These are not the only examples of applications of Artificial Intelligence to the cultural heritage sector. We should mention many other initiatives, such as ESA's 'Cultural Landscapes Scanner', which uses Artificial Intelligence to identify hidden archaeological sites; the 'AI-Muse (Artificial Intelligence for Museums)' project, a collaboration between the University and the Polytechnic of Turin, with support from the Compagnia, which is developing a platform for the virtual use of cultural heritage; and the 'Artificial Intelligence for Cultural Heritage' project of the Italian Ministry of Culture, which is promoting research and development of AI technologies for cultural heritage. These examples and the ones presented before show the various fields of application of Artificial Intelligence to the cultural heritage field, some already developed, others under study and still to be developed. These examples show also that the use of Artificial Intelligence in the cultural heritage field requires an interdisciplinary approach that stems from the collaboration between experts in different disciplines - including computer science, engineering, art history, archaeology, architecture, archives, librarianship... and many others - to develop AI solutions that are specific to the needs of cultural heritage.
Issues related to ethical challenges also need to be taken into account, such as those related to the collection and analysis of personal data related to cultural heritage that may raise privacy and security concerns; or those related to respect for the cultures and communities involved in the preservation and enhancement of cultural heritage; or those related to bias and interpretation: AI may reflect the biases of its creators - or of the data it has been trained with - influencing historical and cultural interpretations. In essence, using AI without having first fully explored all

[21] - The project will also make use of terminological tools: controlled vocabularies defined by communities of experts in the architectural domain, which will be able to contribute to a homogeneous and articulated reading of the graphic and photographic documentation. As the computational systems are developed, the extrapolated data will be made public for immediate re-use by companies operating in the area.

possible implications from the point of view of privacy and data protection means exposing oneself to liability for damages from AI and (among other things) also sanctions from the point of view of privacy.

That is why it is important to arrive at a regulation of Artificial Intelligence as soon as possible, which shows how to adopt AI correctly from the point of view of compliance. In this respect, the European Parliament is working on the final draft of the so called 'Artificial Intelligence Act' that should enter into force in 2024. The regulation follows a risk-based approach and establishes obligations for suppliers and those who employ AI systems depending on the level of risk that AI can generate. Thus, AI systems that present an unacceptable level of risk to people's safety, such as those used for social scoring (ranking people according to their social behaviour or personal characteristics) will be banned. The most relevant novelty is the total prohibition of 'real-time' remote biometric identification systems in publicly accessible spaces. Retrospective' remote biometric identification systems are accepted, but only for the prosecution of serious crimes and only after judicial authorisation. As for generative AI (like ChatGPT or Bard), this will have to comply with transparency requirements [7], clearly reveal that the content was generated by an Artificial Intelligence, design the model in such a way as to prevent the generation of illegal content, and publish summaries of copyrighted data used for training.

In conclusion, Artificial Intelligence promises to revolutionise the cultural heritage sector in many ways, with results that are largely yet to be discovered and that we may not even be able to imagine yet. However, it is essential to use this technology responsibly, addressing ethical challenges and working to ensure that cultural heritage becomes truly accessible to all. Only through collaboration between cultural institutions, scientists, developers, and the public we can enhance and preserve our cultural heritage and make it available to future generations.

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THE ERA OF AI COPILOT: HOW ARTIFICIAL INTELLIGENCE IS REDEFINING THE WAY WE CREATE AND INTERACT

Gerardo Gabriele Volpone - Microsoft

Introduction

This document provides a summary of the pitch delivered during the "Secondo Workshop Intelligenza Artificiale, Beni Culturali e Arte", organized by Cineca on September 22, 2023. The pitch focused on how AI is transforming the way we work, create, and interact, and how Microsoft is leading this innovation with its cloud and AI solutions. The pitch was structured in three main parts after an introduction about the importance and impact of AI for organizations and individuals: the Microsoft copilot strategy, the Azure AI offering and the Responsible AI principles.

The importance and impact of AI for organizations and individuals

According to a report by MIT Sloan Management Review [1], 87% of organizations believe AI will give them a competitive edge. AI is not only a strategic advantage for businesses, but also a powerful enabler for Culture, Art and social good, as it can help address some of the most pressing challenges of our time.

Microsoft cloud is based on the vision of empowering every person and organization on the planet to achieve more with AI. Microsoft Cloud is a comprehensive cloud platform, composed of six solution areas: Infrastructure, Digital app and innovation, Data and AI, Modern work, Business applications and Security. Microsoft Cloud offers a unique value proposition for customers and partners, as it provides a consistent and integrated experience across different environments, such as hybrid, multi-cloud, or edge; it enables innovation and differentiation with cutting-edge technologies, such as AI, IoT, or blockchain; it ensures trust and responsibility with the highest standards of security, privacy, and compliance; and it supports the digital transformation and growth of every industry and sector, with tailored solutions and services.

Fig. 1 – Azure AI

One of the key solution areas in Microsoft cloud is Azure AI, a collection of artificial intelligence services offered by Microsoft as part of its Azure cloud platform. The Azure AI services are designed to make it easy for developers and organizations to add AI capabilities to their applications, without the need for extensive expertise in AI. Azure AI main componentes are:

- Azure Cognitive Services: A collection of pre-built APIs that allow developers to add capabilities such as natural language understanding, computer vision, and speech recognition to their applications.
- Azure Machine Learning: A cloud-based platform that allows developers to build, deploy, and manage machine learning models, as well as to create custom machine learning algorithms.
- Azure Applied AI Services: A suite of scenarios-based services that enable organizations to accelerate adoption such as Azure Cognitive Search which provides search capabilities over structured and unstructured data by using machine learning models.

Some benefits of using Azure AIare:

- Integration with Azure platform, which provides scalability, security, and compliance, as well as many other tools and services that can be used to build and deploy AI-enabled applications.
- Openness and interoperability, which allow developers to use their preferred frameworks, languages, and tools, and to leverage existing investments and skills in AI.

- Innovation and differentiation, which enable developers to access the latest advances in AI research and technology, and to create unique and impactful solutions for their customers and stakeholders.

The Microsoft copilot strategy

"Amplify human ingenuity with a copilot for everyone".

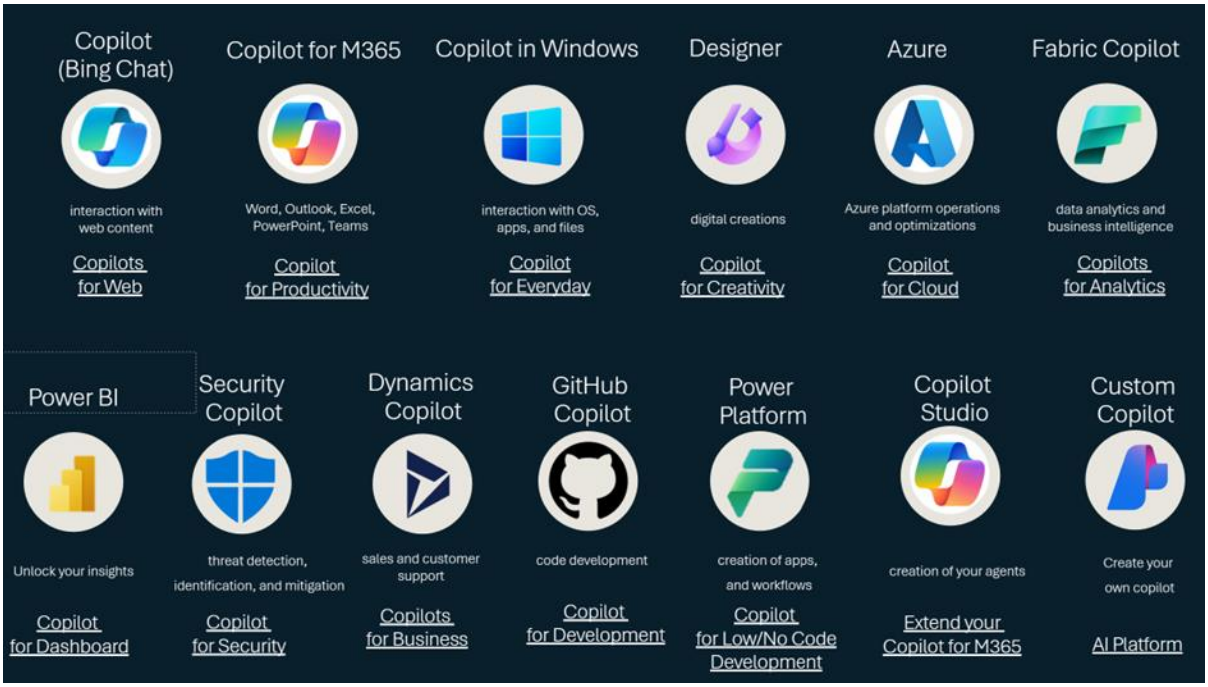

Fig. 2 – Microsoft Copilots

Microsoft copilot strategy is based on the idea to infuse AI in every Microsoft product, such as Microsoft 365, Dynamics 365, Microsoft Security, Microsoft Fabric, GitHub, etc… to provide a copilot for everyone, that is, a smart assistant that can augment human capabilities and enhance productivity and creativity.

A copilot is a smart assistant that can understand the context and intent of the user, and provide relevant and timely suggestions, insights, or actions, to help the user achieve their goals and tasks. oAI, as infused in different Microsoft products can be tailored on different work and creation scenarios and personas, like the functional analyst, the Marketing & Merchandising expert, the Supply chain & Store operations employee and Developers & Data professionals:

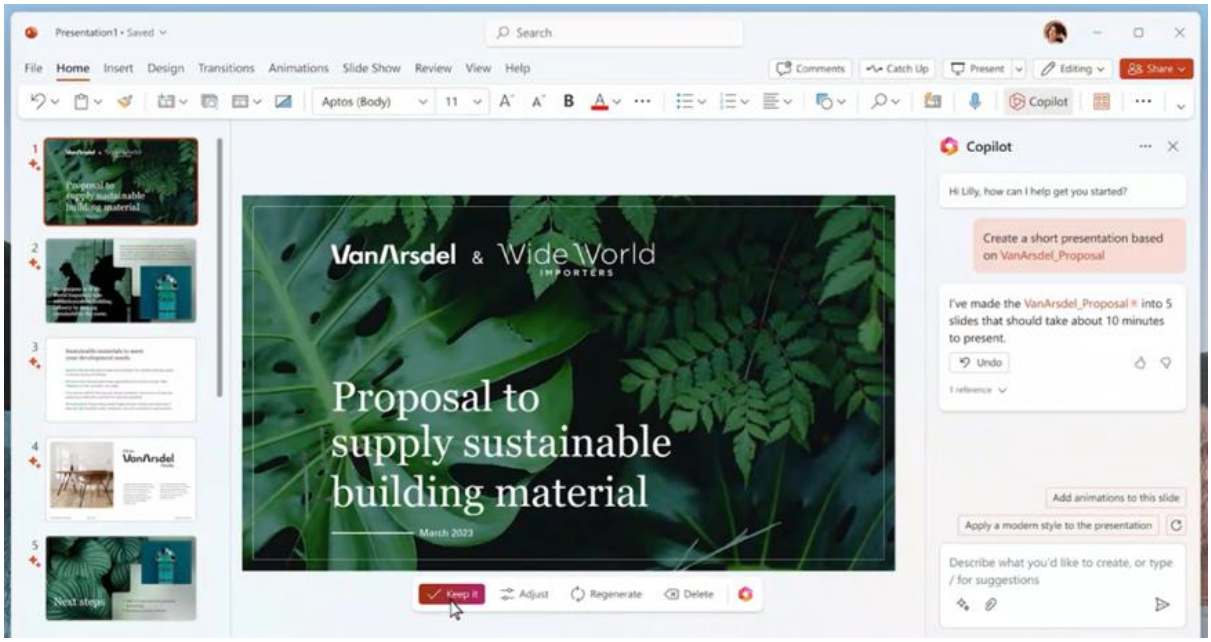

Fig 3 - Microsoft 365 copilot

Microsoft 365 copilot can help users create, communicate, and collaborate more effectively, using services such as Microsoft Word, Microsoft PowerPoint, Microsoft Outlook, or Microsoft Teams. For example, Microsoft Word can use AI to generate summaries, captions, or citations for documents; Microsoft PowerPoint can use AI to design and enhance presentations, or to generate subtitles and translations for live presentations; Microsoft Outlook can use AI to schedule meetings, prioritize emails, or suggest replies; Microsoft Teams can use AI to transcribe and translate meetings, or to create polls and surveys.

Dynamics 365 copilot can help users manage and optimize their business processes and operations, using services such as Dynamics 365 Sales, Dynamics 365 Customer Service, Dynamics 365 Marketing, or Dynamics 365 Finance. For example, Dynamics 365 Sales can use AI to generate sales forecasts, recommend products, or identify leads; Dynamics 365 Customer Service can use AI to route cases, provide solutions, or escalate issues; Dynamics 365 Marketing can use AI to segment customers, personalize content, or optimize campaigns; Dynamics 365 Finance can use AI to detect fraud, monitor cash flow, or automate invoices.

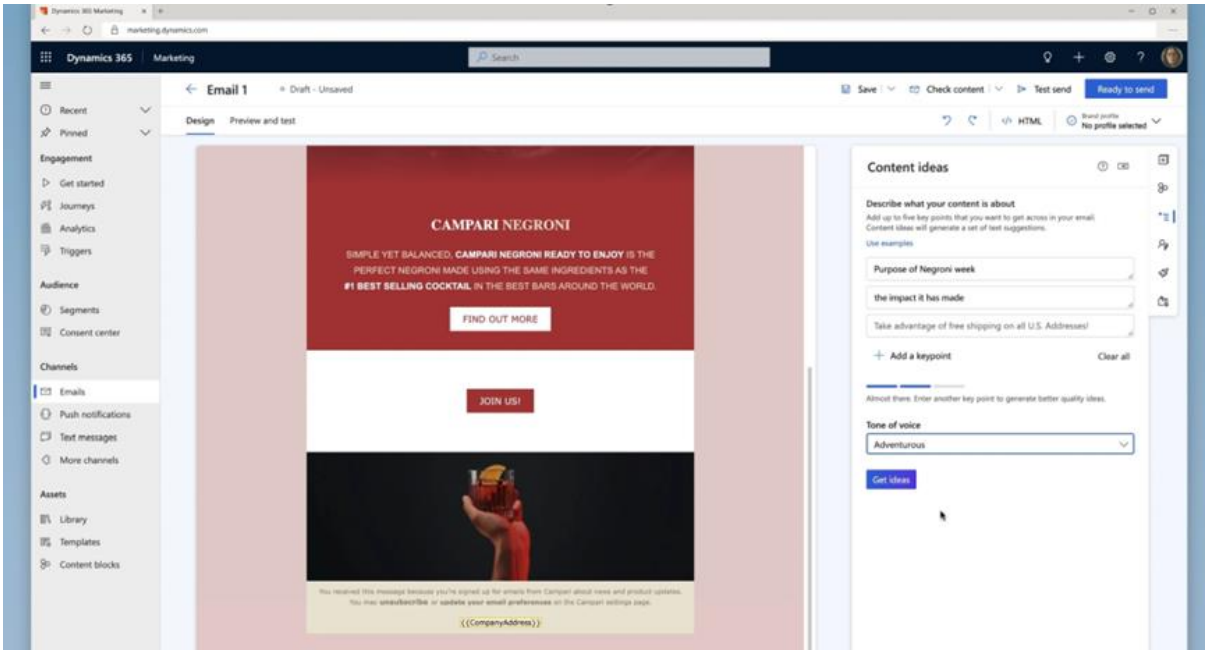

Fig. 4 – Microsoft Dynamics 365 copilot

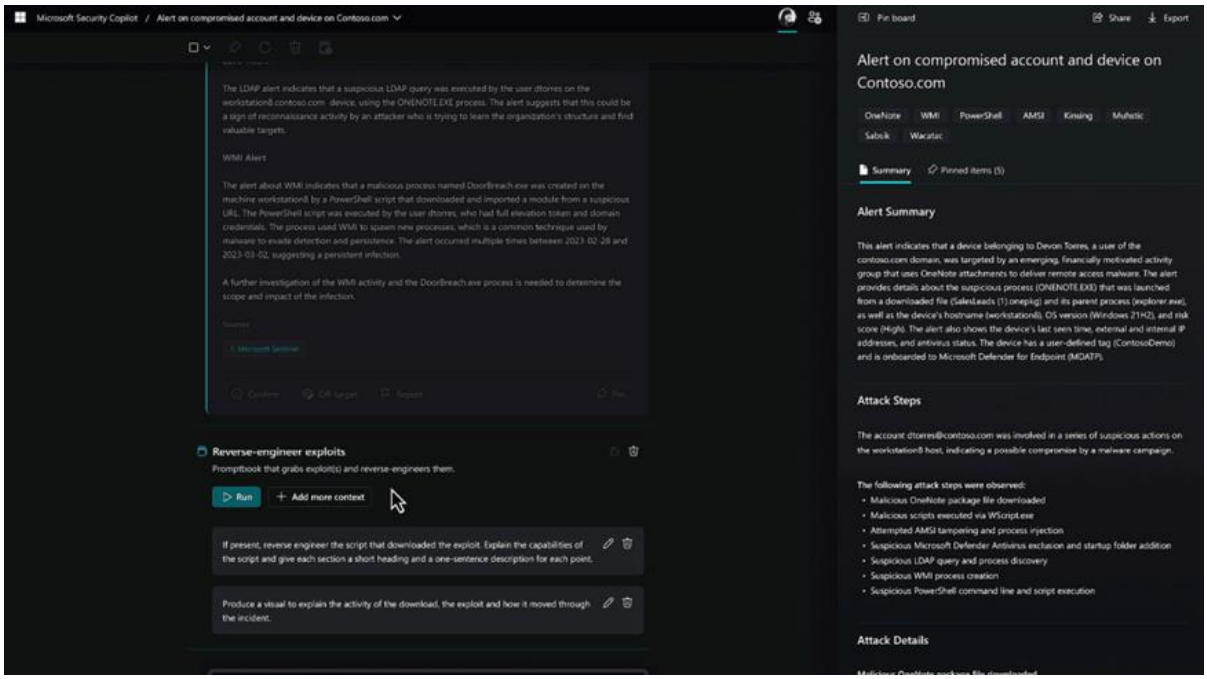

Fig 5 – Microsoft Security copilot

Microsoft Security copilot can help users protect and defend their data and systems, using services such as Microsoft Defender, Microsoft Sentinel, or Microsoft Identity. For example, Microsoft Defender can use AI to detect and prevent threats, such as malware, phishing, or ransomware; Microsoft Sentinel can use AI to collect and analyse security data, such as logs, alerts, or incidents; Microsoft Identity can use AI to verify and authenticate users, such as using biometrics, passwords, or tokens.

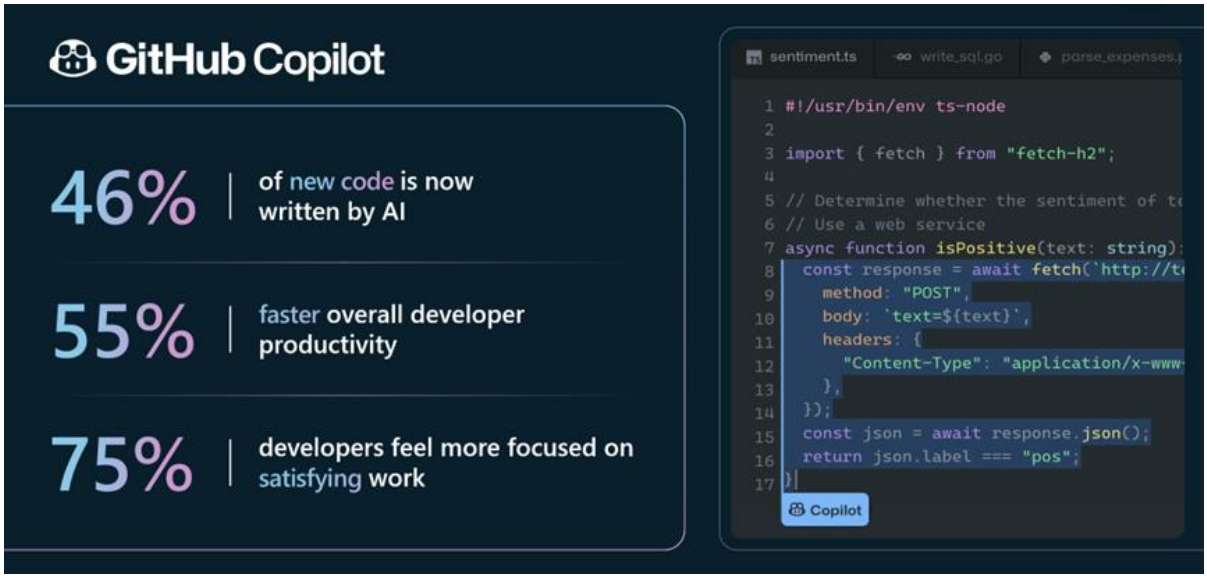

Fig. 6 – Microsoft GitHub copilot

GitHub copilot can help users write better code faster, using a service that leverages OpenAI Codex, a powerful AI system that can generate and complete code based on natural language inputs. GitHub copilot can suggest code snippets, functions, or entire programs, for various languages and frameworks, such as Python, JavaScript, or React. GitHub copilot can also learn from the user's own code and preferences and adapt to their style and needs.

Power BI copilot can help users analyze and visualize their data and insights, using a service that integrates with various data sources and platforms, such as Excel, SQL Server, or Dynamics 365. Power BI copilot can use AI to create and optimize reports, dashboards, or charts, based on natural language queries, such as "show me the sales by region and product category" or "compare the revenue and profit of this quarter and last quarter". Power BI copilot can also provide explanations, suggestions, or forecasts, based on the data and the user's goals, such as "why did the sales drop in January?" or "what are the best products to promote next month?".

And so on…

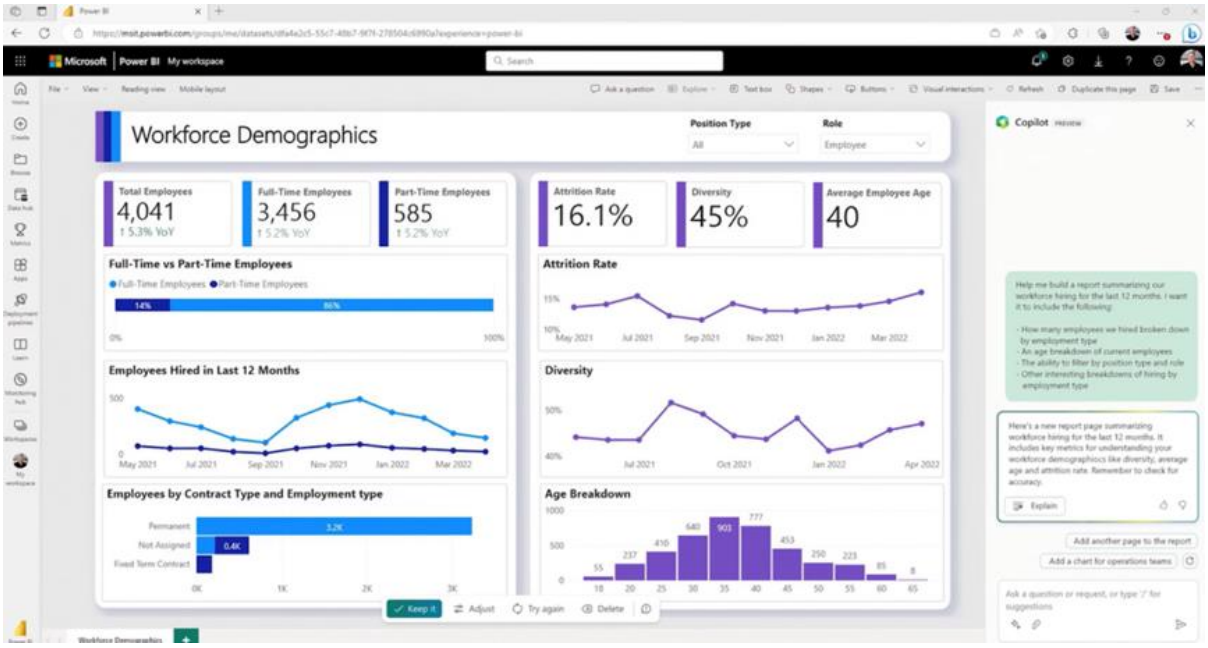

Fig. 7 – Microsoft Power BI copilot

For example, on November 15, 2023, Microsoft released the report *What Can Copilot's Earliest Users Teach Us About Generative AI at Work?* [2] with data that shows that the productivity gains are real: the research has been conducted using a combination of surveys and experiments to deeply understand how Copilot is transforming work—learning with and alongside Microsoft customers.

First Look
Across our research, here's what stood out:

- 70% of Copilot users said they were more productive, and 68% said it improved the quality of their work.
- Overall, users were 29% faster in a series of tasks (searching, writing, and summarizing).
- Users were able to get caught up on a missed meeting nearly 4x faster.
- 64% of users said Copilot helps them spend less time processing email.
- 85% of users said Copilot helps them get to a good first draft faster.
- 75% of users said Copilot "saves me time by finding whatever I need in my files."
- 77% of users said once they used Copilot, they didn't want to give it up.

The Azure AI offering

"Deliver transformational experiences by building your own intelligent apps".

Generative AI is what makes apps truly intelligent. This is a paradigm shift from the present. AI is moving from its auto-pilot phase, which was all about narrow, purpose-built tools that use machine learning models to make predictions, recommendations, and automate tasks to its copilot phase, where there's tremendous opportunity to revolutionize how just about everything

gets done. With intelligent apps, you can enable natural language interaction, constantly improving user experiences, and quickly delivering new features to market.

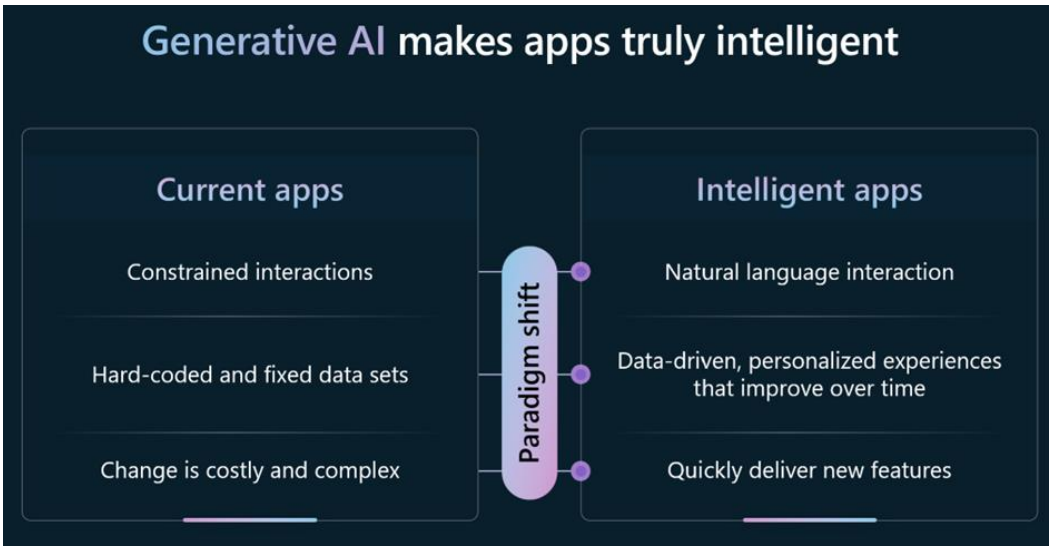

Fig. 8 – Shifting paradigms with Generative AI

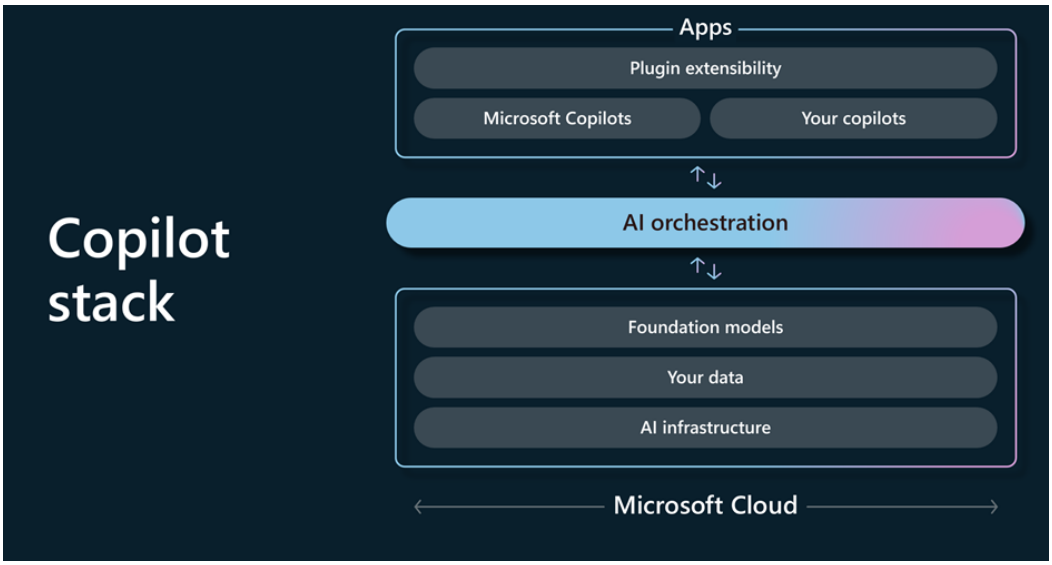

Fig. 9 – Microsoft Copilot stack

Microsoft allows customers to build their own copilot and AI solutions at scale and with full security and privacy, such as the AI model-as-a-Service, the Azure OpenAI services, the copilot stack, the AI orchestration, the user experience solutions.

Azure AI enables customers to leverage the power of pre-built AI, such as cognitive services and conversational AI, or to customize and extend AI with Azure Machine Learning.

The copilot stack is an application development pattern that can help customers conceptualize how to bring together next-generation foundation models, their own data, and powerful AI infrastructure, to create custom and scalable AI solutions. Foundation models are large and general AI models that can perform a variety of tasks across different domains, such as natural language processing, computer vision, or speech recognition. Foundation models can be pre-trained on large and diverse datasets, such as the web, and then fine-tuned or adapted to specific tasks or domains, using smaller and more relevant datasets. Foundation models can also be composed or integrated with other models or services, to create more complex and sophisticated AI solutions. Some examples of foundation models are: GPT, which is a natural language model that can generate coherent and fluent texts based on natural language inputs; or DALL-E, which is a vision and language model that can generate images based on natural language inputs.

The AI orchestration is a set of techniques and tools that can help customers tailor the inputs and outputs from the foundation layer, to create more personalized and contextualized AI solutions.

The user experiences are the ways in which customers can interact with the AI solutions, using various modalities and devices, such as voice, text, gesture, touch, or vision. User experiences can involve aspects such as user interface design, user interaction design, user feedback, user satisfaction, user engagement, user retention, user loyalty, and user trust. User experiences can also involve technologies such as chatbots, voice assistants, smart speakers, smart displays, smart phones, smart watches, smart glasses, or smart TVs.

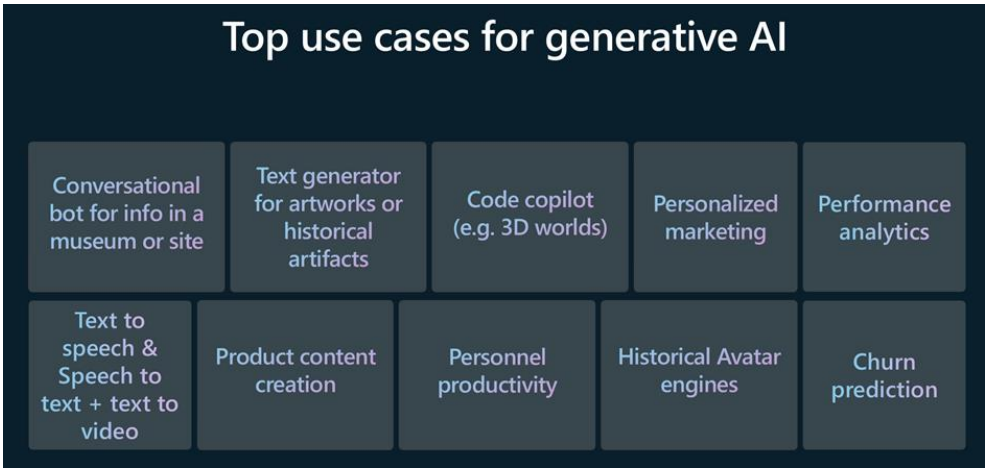

Fig. 10 – Top use cases for Generative AI

Cognitive services are a set of APIs and SDKs that allow customers to add AI capabilities to their applications without requiring deep expertise in AI. Cognitive services cover different domains, such as vision, speech, language, decision, and search, and can perform tasks such as face detection, speech recognition, sentiment analysis, anomaly detection, and web search. Computer Vision API, which can extract information from images or videos, such as objects, scenes, text, or colors, is an example of how cognitive services can be used to enhance the cultural and artistic experience.

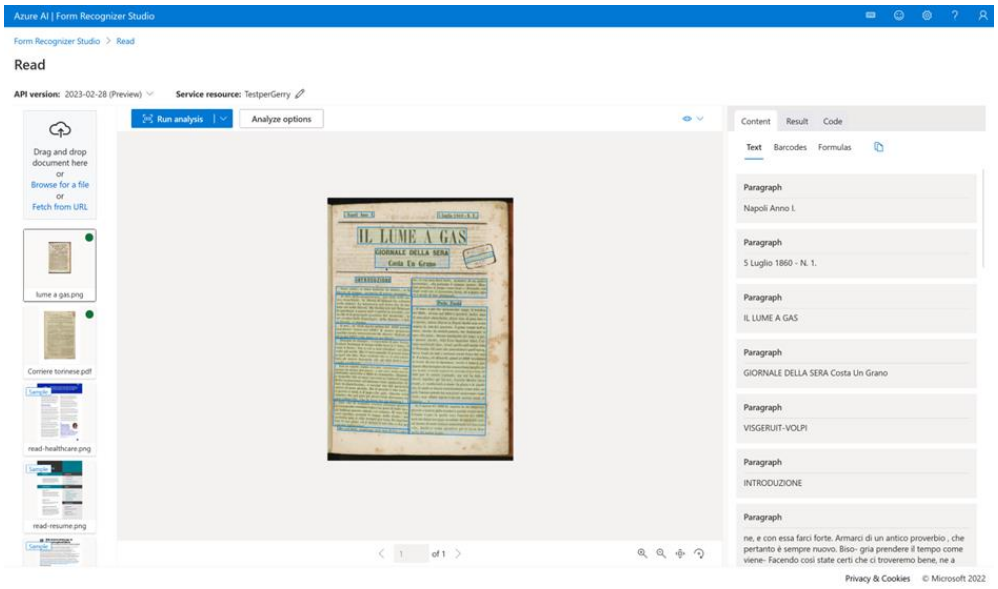

Fig. 11 – Using Computer Vision API for extracting information from documents

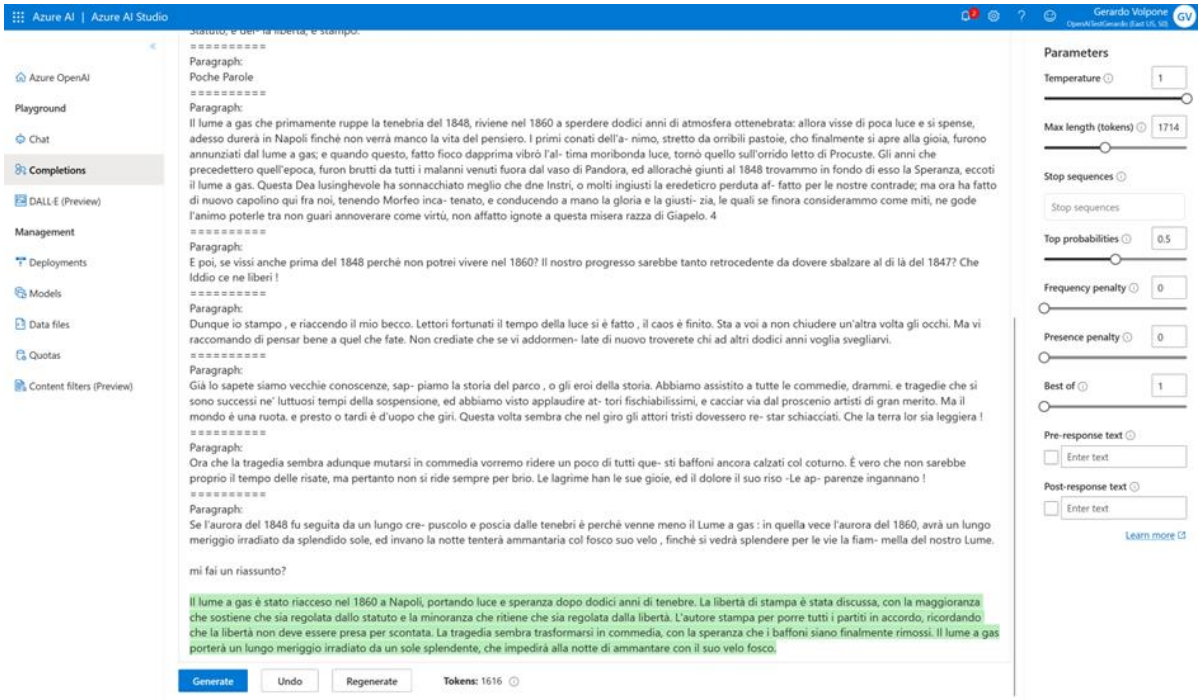

Fig. 12 – Automatically extracted data can be used to generate abstracts or other useful documents

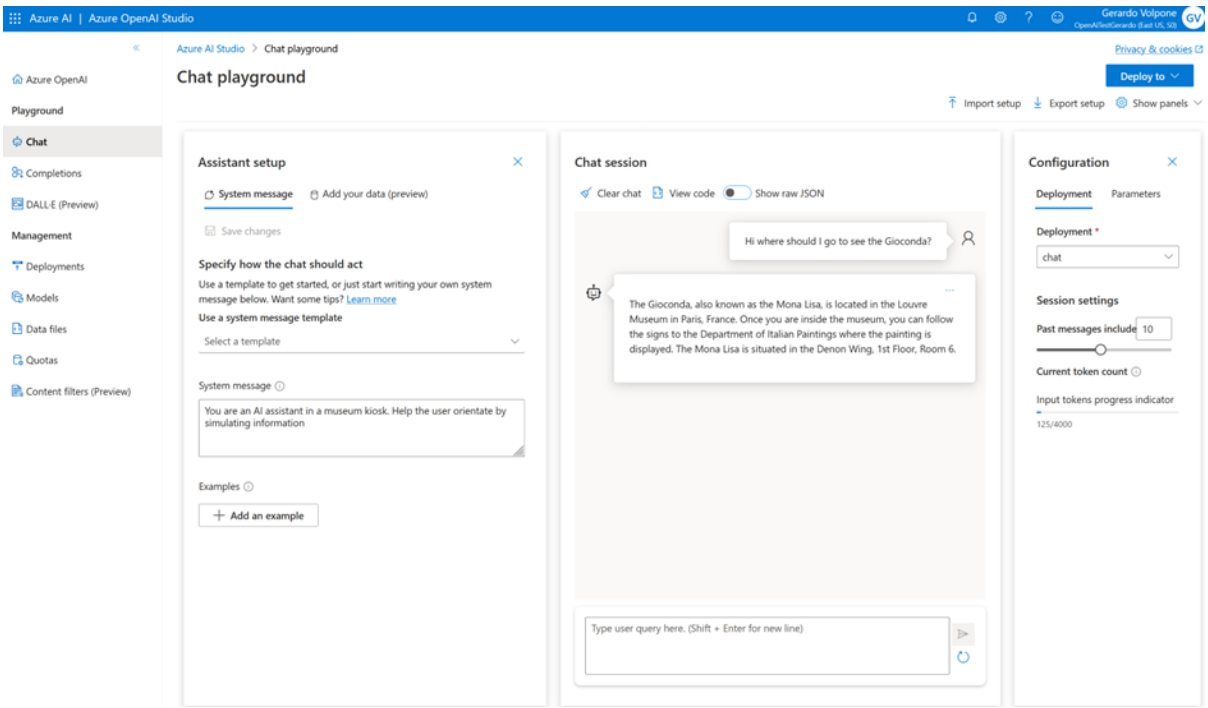

Fig. 13 – A use case for Conversational AI

Conversational AI is the ability to create natural and engaging interactions between humans and machines, using voice or text. Conversational AI includes services such as Azure Bot Service, which allows customers to build and deploy intelligent chatbots that can interact with users across multiple channels, such as websites, mobile apps, or social media platforms; or Azure Speech Service, which allows customers to convert speech to text and text to speech, and to

translate speech across different languages. Conversational AI can be used to create immersive and personalized experiences for the cultural and artistic sector as well, such as a virtual assistant that can provide information and guidance to visitors of a museum or a site, or a voice-enabled app that can generate captions and descriptions for artworks or historical artifacts. Azure Machine Learning is a cloud-based platform that allows customers to build, train, and deploy machine learning models using various tools and frameworks, such as Python, R, PyTorch, TensorFlow, or Scikit-learn. Azure Machine Learning supports the entire machine learning lifecycle, from data preparation and experimentation, to model training and deployment, to model management and monitoring. Azure Machine Learning also offers features such as automated machine learning, which can automatically select the best algorithm and hyperparameters for a given dataset and task; or Azure Machine Learning designer, which can create machine learning pipelines using a drag-and-drop interface. A recommender system that can suggest relevant content or products to users based on their preferences and behaviour, or a classifier that can categorize images or texts according to their style, genre, or theme are examples of how Azure Machine Learning can be used to create custom and scalable AI solutions for the cultural and artistic domain.

Microsoft responsible AI principles

"Safeguard your business and data with the most trusted AI platform".

The Microsoft responsible AI principles are a set of guidelines and best practices that aim to ensure the ethical, reliable, and inclusive development and use of artificial intelligence.

Microsoft believes that the development and deployment of AI must be guided by the creation of an ethical framework, as set out in *The Future Computed,* presenting six core principles that should guide the work around AI. Four core principles of fairness, reliability & safety, privacy & security, and inclusiveness are underpinned by two foundational principles of transparency and accountability [3].

Fig. 14 – Microsoft responsible AI principles

Microsoft began its AI governance work by adopting a set of principles in January 2018.

- The first principle is fairness. This means that AI systems should treat everyone fairly and not cause different effects for groups of people who are in similar situations. For example, when AI systems give advice on medical treatment, loan applications, or employment, they should give the same suggestions to everyone with similar symptoms, financial circumstances, or professional qualifications.
- The second principle is reliability and safety. To earn trust, it's also important that AI systems work reliably, safely, and consistently in normal situations and in unexpected conditions. How they act and how many conditions they can handle reliably and safely depends largely on the range of situations and circumstances that developers think of during design and testing.
- It's also essential to create AI systems that can protect private information and resist attacks. As AI becomes more common, protecting privacy and securing important personal and business information is becoming more critical and complicated. Privacy and data security issues need special attention for AI because access to data is necessary for AI systems to make accurate and informed predictions and decisions about people.
- For the 1 billion people with disabilities around the world, AI technologies can be a game-changer. AI can improve access to education, government services, employment, information, and a wide range of other opportunities. Inclusive design practices can help system developers understand and address potential barriers set in a production

environment that could unintentionally exclude people. AI has the potential to make computer systems more accessible to those who cannot access computers today. AI must be developed and deployed in a way that can benefit all and is accessible by all.

- A key part of transparency is what we call intelligibility or the helpful explanation of the behavior of AI systems and their parts. Transparency is an important principle as people cannot tell whether the top four principles are being met unless there is enough transparency around how systems have been built and work. It is also essential to the way these systems are managed, operated, and documented.
- The final principle is accountability. We believe the people who design and use AI systems must be accountable for how their systems operate. This is perhaps the most important of all the principles.

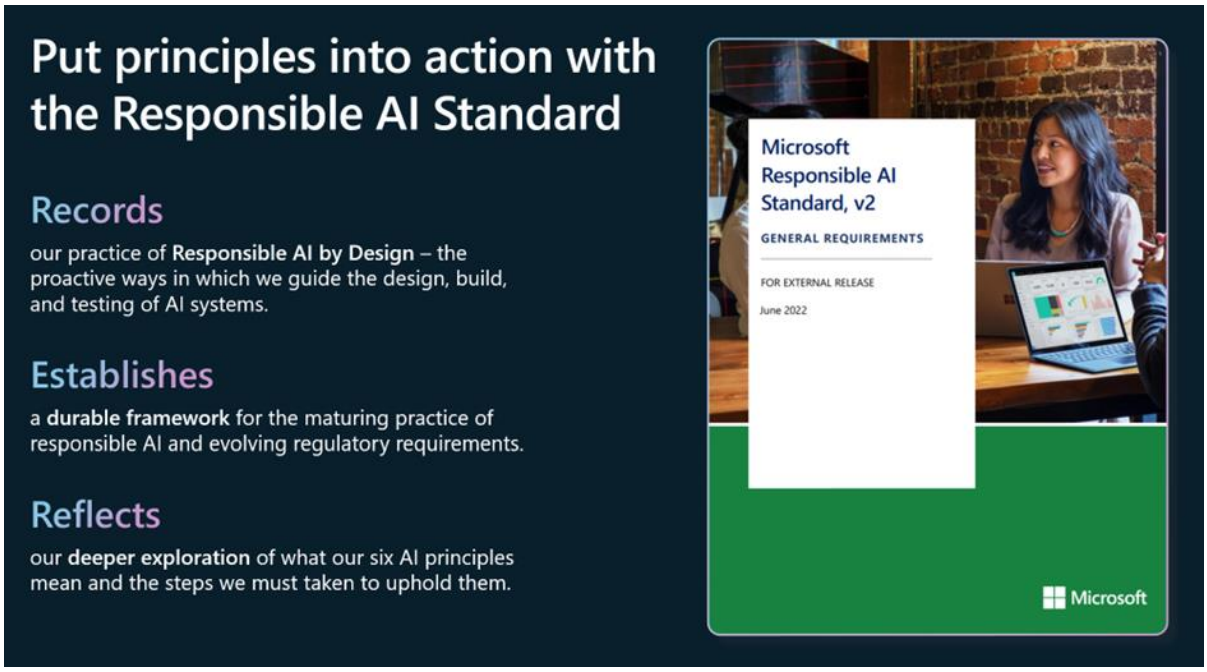

Fig. 15 – Microsoft Responsible AI Standard

Microsoft is committed to putting these principles into practice, and helping its customers do the same. In 2022, the company published the Responsible AI Standard, an internal guide for responsible AI [4]. Devising the Standard has been a multi-year, cross-company effort, and Microsoft made it ahead of comprehensive new regulations on the topic and as norms in this space are still developing.

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PRESERVE, DELIGHT, CREATE: HOW DEMOCRATISING AI CHANGES THE PROFESSIONS OF CULTURE

Anna Elisabetta Ziri – PwC

Introduction

The rapid evolution of artificial intelligence (AI) is transforming many sectors, including the fields of cultural heritage conservation and presentation. AI offers groundbreaking solutions to challenges in historical preservation, enhancing accessibility and interpretation. The integration of AI in cultural heritage is not a new concept, but recent advances, especially in generative AI, have led to significant innovations in how we preserve, display, and experience culture.

There are some concrete examples where AI has made a substantial impact on cultural related activities. A crucial role in preserving our heritage is played by the 3D scanning of monuments, often leveraged by certain AI algorithms. A prominent application was the 3D scans in documenting Notre Dame Cathedral after the fire on April 15, 2019, ensuring that a detailed and accurate record was available for restoration efforts and contributing to the preservation of this iconic historical landmark.

This dramatic incident also underscored the importance of converting scans into Building Information Modeling (BIM) systems for restoration work. European initiatives, such as the Inception project, have been at the forefront of facilitating the transition from scans to BIM, employing a variety of technologies. These efforts are particularly crucial in managing the extensive cultural heritage assets in countries like Italy, where there is a richness of historical sites and monuments.

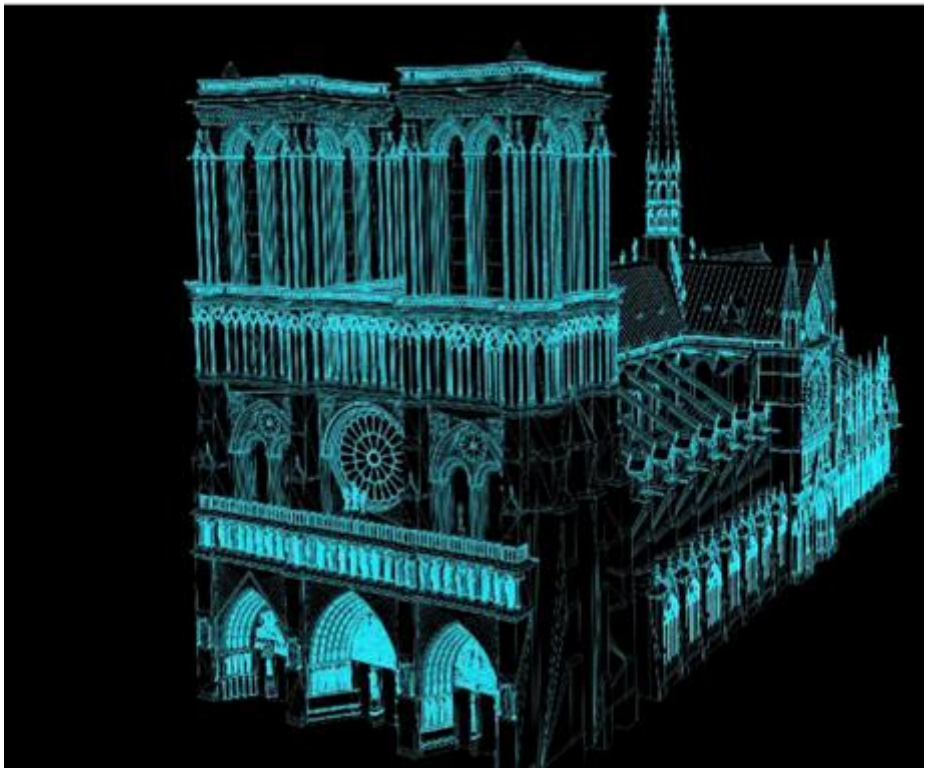

Fig. 1 – Artificial Intelligence has already been used to efficiently analyse and catalogue cultural heritage assets through image recognition and data processing, thus facilitating their digitisation and preservation.

3D scans of Notre Dame Cathedral. Image by Andrew Tallon/Vassar College via National Geographic

Moreover, AI plays a crucial role in enhancing the cultural engagement experience. Many historical sites are delicate and cannot endure the wear and tear of extensive tourism. AI helps alleviate the impact of excessive tourism by providing visitors with comprehensive information and virtual access to sites that are physically off-limits.

By intelligently processing digitized cultural data, AI enriches cultural heritage enjoyment. It can analyse use preferences to recommend personalized points of interest along less fashionable tourist paths and employs computer vision algorithms to augment the reality of the sites visited, providing a richer, more immersive experience.

Artificial Intelligence, also by mastering the distinct styles of historical artists, contributes significantly to the creation and restoration of cultural heritage. For example, advanced digital restoration algorithms can repair damages on artworks, aligning the repairs with the original style and era, thereby helping to preserve and allow for the appreciation of previously incomplete works. A powerful demonstration of AI's creative prowess is its use in trying to finish

Beethoven's Tenth Symphony, employing pattern recognition and stylistic mimicry to bring a new dimension to cultural artifacts [1]

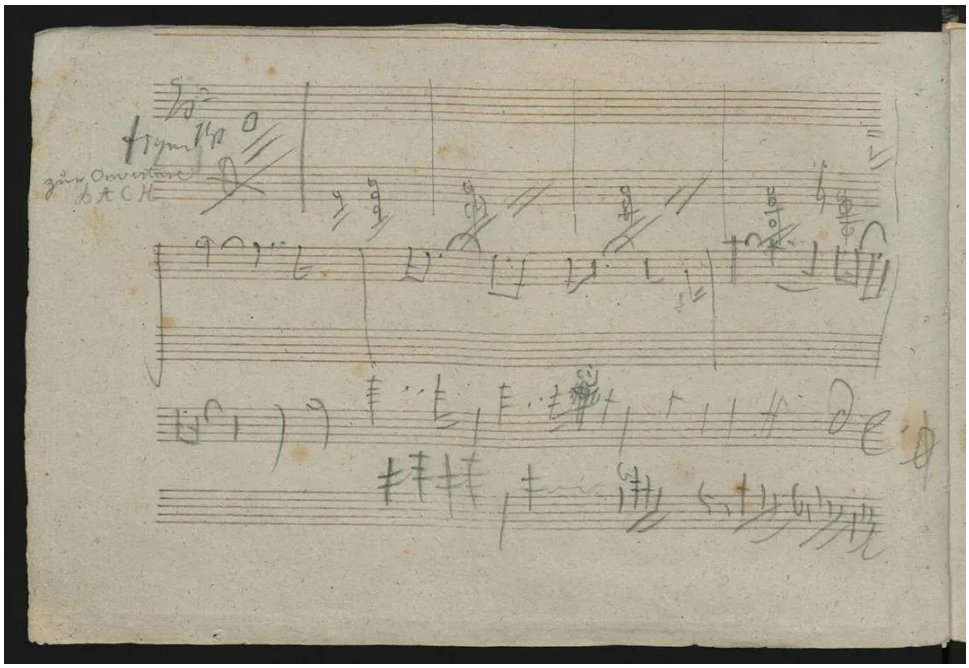

Fig. 2 – Beethoven's notes for his Tenth Symphony, Beethoven House Museum, CC BY-SA

Generative AI

The development of AI technologies for cultural heritage applications has been complex and resource-intensive. The Inception platform's four-year development cycle exemplifies the significant investment of time and capital required for such initiatives. Projects tended to be vertical, focusing on specific monuments and financed for particular purposes and use cases, rather than being broad and inclusive as the field demands.

Now a lot is changing due to the advent of Generative AI. The transformative impact of language model technologies, such as GPT-4, had been proved in diverse professional fields, including but not limited to cultural heritage, scientific publishing, and customer support. The access to advanced artificial intelligence levels the odds among individuals with varying skill levels and significantly enhances efficiency, quality, and the handling of information overload. Additionally, the nuanced application of these technologies for tasks like summarization, deep retrieval, transformation, augmentation, and advanced translation, facilitate work particularly in professional contexts with specific terminological demands.

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Fig. 3 - Prompt /imagine: studio photography, cinematic close-up shot, Steve Jobs presenting the new iPhone, Kodachrome, retro futuristic --ar 1:1 --seed 100

Generative AI technologies have the potential to initiate a revolution comparable to the evolution of the internet or the mobile access revolution that followed the introduction of the iPhone. The ability to prompt a diffusion model to generate images, such as depicting Steve Jobs presenting the iPhone, exemplifies the simplicity and power of generative AI applications. This technological progression is not a novelty; significant investments and research have been advancing the capabilities of generative AI for some time. However, recent developments have seen a peak in interest and funding, notably Microsoft's investment in OpenAI, indicating a growth trend that is expected to continue as companies invest more heavily in the technology.

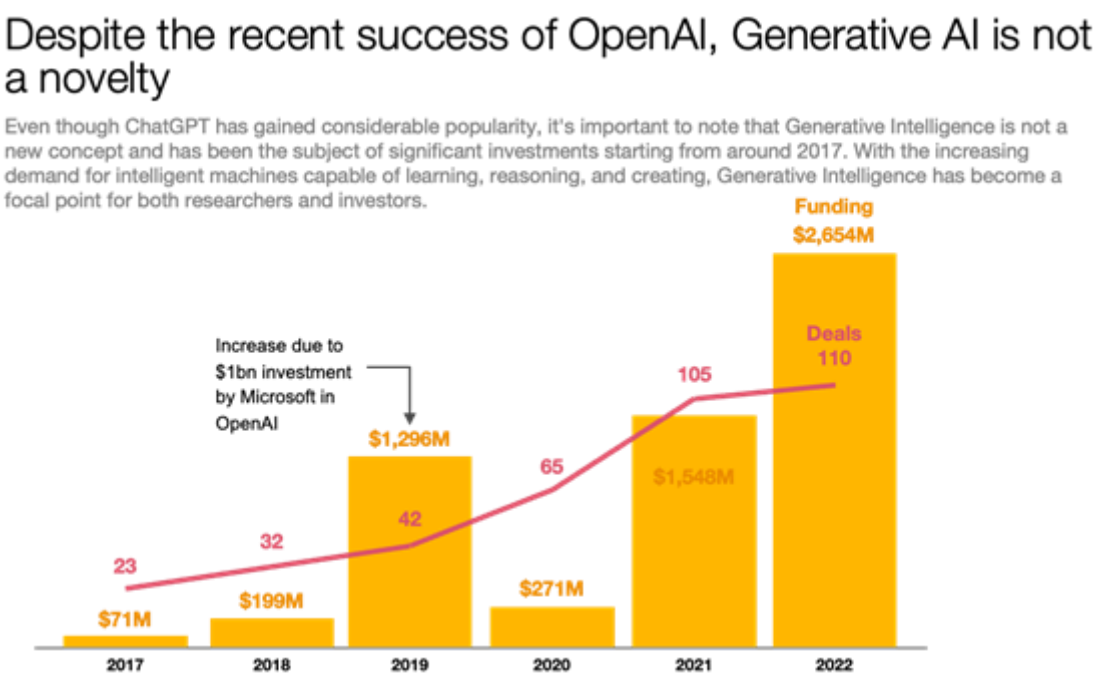

Fig. 5 – Investments in Generative AI during the last few years.

The democratization of AI is set to transform the everyday tasks of "Cultural Heritage Knowledge Workers," by offsetting resource scarcity, so the spreading of the technology will be welcomed for preserving, engaging the audience or creating in the field of the cultural heritage. Generative AI, as a general-purpose technology, has the potential to influence every industry, not limited to specific verticals like cultural heritage or gaming. The concept of democratization in this context refers to lowering the barrier to entry, allowing pervasive access across all domains.

Large Language Models and the impact on knowledge workers

In the work by Eloundou et al. GPTs are GPTs, Generative Pretrained Transformers are presented as General Purpose Technologies, meaning they have wide-ranging social, political and economic implications on, for example, various occupations and industries within the US economy[2] .LLMs are general-purpose AI models that have gained significant attention due to their ability to tackle a wide array of complex language-based tasks and OpenAI GPTs are a subset of them. The same acronym (GPT) is used for General-Purpose Technology, a technology that has the potential to impact multiple sectors of the economy and improve over time. To be classified as a GPT, a technology must meet three core criteria: improvement over time, pervasiveness throughout the economy, and the ability to spawn complementary innovations. Evidence from the AI and machine learning literature demonstrates that large

language models (LLMs) meet the first criteria and have the potential to meet the latter two criteria. LLMs are considered a type of GPT due to their versatility and potential to impact a wide range of tasks and industries. The study finds that most occupations exhibit some degree of exposure to LLMs, with higher-wage occupations generally presenting more tasks with high exposure. Approximately 19% of jobs have at least 50% of their tasks exposed to LLMs when considering both current model capabilities and anticipated LLM-powered software. It is easy to deduct that knowledge workers in Cultural Heritage fields will be heavily impacted as well.

Will this lead to a general job loss or a change in the labour markets? The impact is still unclear, but this could be the case where the **Jevons Paradox** applies. The Jevons Paradox is a phenomenon where the increase in efficiency of a resource leads to more of that resource's consumption, not less. In the case of AI, as it becomes more cost-effective and efficient, its use is multiplied and democratized. This increased use, in turn, leads to greater productivity in the given sector and the spread of new industries and jobs. Historical examples include coal, where increased efficiency led to broader usage. Similarly, generative AI is anticipated to transform all work sectors by enabling scalability and reducing costs, even in culturally rich but financially constrained areas.

As we venture further into the realm of Generative AI, we will encounter several known risks that warrant careful consideration. Among these is the issue of unintentional biases; models may inadvertently reflect and amplify the biases latent in their training data, perpetuating existing societal prejudices. Another concern is the realm of intellectual property and plagiarism. The capabilities of Generative AI to produce texts and images raise the spectre of creating content that closely mirrors works protected by copyright, potentially leading to intellectual property disputes.

Moreover, there is a growing concern regarding the dependence on solutions generated by AI. An over-reliance on AI-generated outputs may erode the adaptability and resilience of professionals, who might become excessively dependent on these tools. This over-reliance could stifle the development of critical thinking and problem-solving skills that are essential in a rapidly changing world.

Security vulnerabilities also present a formidable challenge. Generative Intelligence tools, if not safeguarded, have the potential to be manipulated to generate and disseminate malware or other security threats, thereby endangering the integrity of software applications.

In light of these considerations, it is strategic to deploy automation wisely. The objective should be to automate tasks, not the decision-making process itself. Outputs derived from AI should be subjected to rigorous human review procedures to ensure accuracy and reliability. Strategic use of automation involves using these tools to streamline repetitive tasks and concurrently investing in the training of personnel for more complex and nuanced responsibilities. Moreover, it is vital to evaluate the broader economic implications as this technology gains widespread implementation, to prepare for and mitigate potential disruptions.

Lastly, it is crucial to remain vigilant and not take the accuracy of AI results for granted, to avoid "falling asleep at the wheel." Continuous oversight and critical evaluation of AI-generated content are indispensable to harnessing the full potential of AI while mitigating its risks.

Dall'Acqua et Alii, help us understand the impact of AI on professional work, particularly in complex and knowledge-intensive tasks [3]. The study involved 758 consultants from Boston Consulting Group and explored how AI, specifically GPT-4, affects productivity and quality in different tasks.

Fig. 6 - The Jagged Technological Frontier

The concept of the *Jagged Technological Frontier* describes the uneven capabilities of AI, where it excels in certain tasks while struggling in others that seem similarly complex. Within the AI capability frontier, tasks related to creative product innovation and development were found to significantly boost productivity and quality, resulting in completing 12.2% more tasks on average and 25.1% quicker, with more than 40% higher quality compared to a control group. However,

outside the AI frontier, tasks such as analyzing data and interviews to provide strategic recommendations were found to be challenging for AI without extensive guidance. The study highlights AI's dual role as both a performance enhancer and a potential disruptor, depending on the task's alignment with its capabilities. The need for professionals to navigate the uneven landscape of AI capabilities skillfully is emphasized, as it can lead to significant gains in productivity and quality within its capability range. In our contemporary era, marked by an unprecedented deluge of information, the capacity to swiftly condense and sift through pertinent data has become indispensable. This rings particularly true for those entrenched in scientific publishing and cultural heritage management, where the sheer volume of materials can be staggering. Language models have emerged as critical tools in this context, equipping users with the means to refine extensive research findings and lengthy project records into digestible, actionable insights.

The term 'deep retrieval' captures the essence of extracting responses and content from a specified knowledge base or dataset. This function is integral to unearthing content that aligns with ongoing research. Language models demonstrate their prowess here, delivering accurate and contextually appropriate information rapidly.

When it comes to the transformation and augmentation of data, we refer to the process of elaborating upon existing datasets to create more intricate versions. Language models have revolutionized this process, condensing what once required months of dedicated model training into a significantly reduced timeline.

Further illustrating AI's breadth of application is the integration of generative chat systems within platforms, such as customer support centres. AI's ability to provide precise answers to user queries, coupled with training non-expert staff to wield these advanced tools, underscores its tangible benefits in boosting operational efficiency.

In the realm of translation and semantic comprehension, we witness AI's sophistication through tools like PwC's 'doc translator,' which adeptly navigates the intricacies of professional terminologies. This advanced application of AI does not merely translate; it preserves the semantic integrity across languages, proving itself an invaluable tool in international partnerships and the propagation of historical documents, such as the treatises of Dante.

Lastly, AI's role in media monitoring and summarization cannot be overstated. Platforms like PwC Press Media Mind illustrate AI's capacity to track news cycles and generate summaries that cater to niche interests, including cultural heritage. This capability is vital for professionals who

must remain abreast of the latest discussions in their domain, whether for organizing exhibits or conserving cultural sites.

Conclusions

Artificial intelligence, particularly generative AI, stands at the forefront of a paradigm shift in cultural heritage conservation and presentation. As the technology matures, with the possibility of reaching the sophistication of large language models like GPT, its potential applications are boundless. The widespread and rapid adoption of these AI tools by millions of users underscores the readiness of the market and the public's interest in AI-driven cultural experiences. The future of cultural heritage and their workers appears poised for profound changes as AI becomes more deeply integrated into the fabric of these practices.

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PRESERVING THE PAST, IMAGINING THE FUTURE: CULTURAL HERITAGE AND NEW ARTISTIC PRACTICES IN THE AGE OF ARTIFICIAL INTELLIGENCE

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In this contribution, I would like to bring some strictly human-generated reflections on the concepts of Digital Art and Digital Art History and try to deconstruct some very popular questions in these fields to help the reader orient herself in these fields and invest in the quality of research questions. Moreover, I will try to outline some useful theoretical concepts, such as Distant and Close Viewing, with the aim of demonstrating how the "proximity" to the datasets and the AI tools used by artists and historians alike can be a useful parameter to take into consideration. It is by now famous the anecdote attributed to the Dutch computer scientist Edsger Dijkstra: 'asking whether a computer can think is no more intelligent than asking whether a submarine can swim'. Could this question trigger the same short-circuit if we instead asked whether a computer could create art, or help us to understand and study it? The anecdote is compelling and provocative, as it entails us to invest in the quality of words and increase the sharpness of our reasoning.

On the one hand, a distinction must be made between these often-unrelated fields of Digital Art and Digital Art History. A definition, such as the one proposed by Betkowska-Kafel (2015), already emphasises the inter- and multi-disciplinary nature of a research environment based on digital methods that brings together and connects different areas of enquiry that are potentially very distant from each other: "Digital art history is not a discrete discipline - but an umbrella name for methods that involve digital tools, techniques and processes of analysis and interpretation, ranging from basic statistics to complex applications of AI" [1].

In the Italian language there is an ambiguity in the use of the expression 'Digital Art History', which can be understood as 'Storia dell'arte *digitale*' (author's italics), i.e. as the nascent discipline of computerised interrogation of art works by art historians; but also as "History of *Digital Art*" (author's italics), i.e. the historical research of the origins, the developments and the future perspectives of digital art. In this contribution, where not specified, reference will always be made to the first meaning of the term proposed in the paragraph, i.e. the discipline of Digital Art History as a branch of the Digital Humanities. This contribution wants to highlight concepts

such as transparency and explicability in the relationship between Digital Art History and Digital Art, concepts that are extremely relevant for both disciplines: a relationship, this one, scarcely noticed by critics. At the same time, the differences in the use of AI for art-historical research, on the one hand, and for creative production, on the other, are to be emphasised, with the aim of understanding their respective characteristics and potential.

Fig. 1: Technological milestones in AI art production diagram (from Cetinic, She 2022).

At the time of writing, we are at a time of peak attention with respect to AI art, both media- and marketwise. However, the generative experiments of Harold Cohen, creator of the first computer programmes capable of creating art back in the early 1970s, remind us that the relationship between computer science and artistic production has been in existence for more than half a century. More recently, it is with the spread of mainstream generative AI (such as in popular applications, such as Dall-E, Midjourney and Stable Diffusion) and AI generated images that AI produced a real paradigm shift for all artists and a breakpoint in visual culture. Looking back at the last 10 years of development of image production, systems exploiting AI (diagram from Cetinic, She 2010) reminds us of the rapidity of a technological development that accelerates over time and does not seem to slow down [2].

Fig. 2: Obvious, Portrait of Edmond de Belamy*, 2018.*

Many will remember the *Portrait of Edmond de Belamy*, created in 2018 by the art collective Obvious, an image created by an AI (in this case by a GAN, Generative Adversarial Network, composed of two competing algorithms: a generator and a discriminator) and sold by Christie's auction house for $432,000. The work was sold as a physical object (a 70x70 cm canvas print) and not as digital media. The issue of the medium is a crucial aspect when analysing a 'digital' artwork, as it pertains to the problem of the interface: direct code-brain interfaces do not yet exist, a factor that limits the fruition of digital art, which is inherently immaterial, to a physical medium that can be intercepted by the senses, such as a print, a projector or a digital screen. The list of digital artworks that have already entered the collective imagination has grown exponentially over time. In 2022, photographer and digital artist Jason Allen created *Théatre d'Opèra Spatial*, placing first in the Colorado State Fair Fine Arts Competition in the category 'digitally manipulated art/photography' and winning a prize of 300 $. The artist's confession, made after winning the prize, that he had used Midjourney, a popular image generation programme, to generate the image caused a stir. Allen did not limit himself, however. He not

only presented the AI output, but also worked assiduously on the image itself using image processing and retouching programmes, combining the product of AI with human work, while still using state-of-the-art software that in turn makes extensive use of AI algorithms. The media prominence of such works constitutes a point of no return in the target communities.

Fig. 3: Jason Allen, Théatre d'Opèra Spatial*, 2022.*

Central to this development is the issue of authorship. Not only from the point of view of criticism and aesthetic appreciation, but also from the point of view of copyright, which have direct implications for the valuation of works of art (when they are on the market) and ethical implications regarding the message these works convey. These are therefore issues of primary interest to a very wide range of stakeholders: artists, developers, gallery owners, collectors, critics, art historians... Questions that permeate both common discourse and specialist journals grip us: is the work of art a product of artificial intelligence or of the human? Or perhaps of the participation of the two? Is the predominant element in artistic creation human or technological? What role does artificial intelligence play in relation to the artistic product? If the artwork is a product of AI, does that make the AI an author? There are no pre-packaged answers to these questions, that can be valid in all circumstances. This paper will provide theoretical instruments to set up conceptual tools to help us address these questions.

To square the problem correctly, it is necessary to look at it from the perspective of the human-technology relationship: that is, to examine the way humans interact with the machines. Mark Coeckelberg, in a recent contribution, summarised the main ways in which the relationship between AI and art is usually categorised [3; pp. 1-13]:

- **AI as a tool**: the artist uses AI as a tool, as if it were his 'paintbrush' (a colloquial but very popular expression). Whether the result of this process is art or not is a matter of aesthetic debate, just as with analogue art. However, this instrumental interpretation is reductive, insofar as AI can do things that the human does not want it to do, that is, it leads to unexpected results, unlike a passive tool, such as a paintbrush or a chisel.
- **AI as expansion or augmentation**: the 'artistic agency' of the artist is enhanced, augmented, or extended by AI. That is to say: art is realised by the human and the machine; with AI extending the textual input prompt (or other types of prompting, such as graphic or multimodal) and enabling more of what the artist has in mind. However, this interpretation is still very anthropological: in fact, image generation softwares based on LLMs add elements to the image (whether stylistic or in terms of content) that go beyond the artist's initial expectations and ideas. To speak of AI 'extending' the human's artistic capabilities is therefore reductive.
- **AI as another entity**: AI appears as a human or as an 'almost human'. According to this interpretation, we perceive AI not so much as a 'something' but a 'someone': AI is perceived as a non-human entity that co-creates the work of art alongside the artist in a process of co-creation. The weakness of this point of view lies in its romanticisation (and consequent personalisation) of the machine, according to the romantic artistic ideal. Instead, there is a widespread awareness on the part of artists that AI is a technology, and not an entity.

By tracing fallacious and weak elements in each of the three main interpretations given to the relationship between art and AI, Coeckelberg aims at elaborating a though process that mediates instrumentalism and the perception of AI as an'other' entity, but at the same time does not limit itself to the concept of extending the artist's work. That is, we need a more relational and dynamic approach that sees AI art as a performative practice: when an artist makes use of AI for his creative process, he activates a technoperformance in several 'acts'. As demonstrated by the aforementioned cases of the *Portrait of Edmond de Belamy* and *Théatre d'Opéra Spatial*, media generation is in fact a multi-stage process, the sequence of which is not determined: it can start from a textual prompt as well as from a sketch by the artist, or from other forms of input, even multimodal (audio files, other structured or unstructured data, etc.) and then go through several stages of generation, post-production and refinement, both digital and manual. The process can then be repeated. The image may 'pass through the hands' of the artist or the AI systems even numerous times, as if they were several coats of oil paint superimposed on each other, until the final result is achieved: '[...] to say that the image or work of art is created by humans or created

by AI is therefore both a reduction and a misleading description of the whole process of these performances. Humans and AI are connected in the human-machine relationship, and this relationship is not static but dynamic, constantly changing, in which there is a genesis and emergence of subjects and objects, artists and works through co-performance processes"[4, p. 9] The artist participates in the creative process and is no longer at the centre of the artistic experience.

Moving to the opposite spectrum of the possibilities of applying digital technologies to art, and in particular to cultural heritage, we find the disciplines of the digital humanities, which embrace various fields, among which Digital Art History is rapidly evolving as an autonomous branch. An exhaustive treatment of this field, which today can boast several in-depth dissertations, is beyond the scope of this contribution. At the very least, an attempt will be made to introduce a combination of concepts useful both for the classification of research products and for the design of research projects.

Fig. 4: Distant/Close Viewing Continuum diagram (Pescarmona, 2023)

A "continuum", i.e a non-discretised continuous line, can thus be constructed between the two concepts of Distant and Close Viewing, expressions borrowed from Franco Moretti's theorisation of "Distant Reading" applied to the field of computational linguistics. Distant reading is, once again, an "umbrella" definition that allows us to embrace the set of practices aimed at the investigation of a large quantity of texts "from a distance", i.e. according to quantitative and computerised approaches. Similarly, Distant Viewing can be understood as the set of practices aimed at the investigation and quantitative exploration, conducted with computerised methods, of large sets of images and their metadata. It is possible to state, making a generalisation, that the advent of Distant Viewing corresponds to the so-called "computational turn" of philological disciplines working on images: for the purposes of this study, it is of particular interest to the history and the criticism of modern and ancient art. Conversely, Close Viewing, a rarer term in criticism, can be interpreted as the set of computer and computational

practices aimed at the investigation of *small* datasets of images. The diagram of the distant-close viewing continuum can help to visualise these concepts and the methodologies they encompass.

Fig. 5: Screenshot of Matthias Bernhardt's "Gugelman Galaxy" project.

At the Distant Viewing end of the spectrum are the more quantitative disciplines: AI, ML (Machine Learning) and BID (Big Image Data). Matthias Bernhardt's Gugelman Galaxy can certainly be included in this category: an interactive visualisation of over 2300 drawings, prints and paintings by the Shweizer Kleinmeister - masters of 18th century Swiss painting - collected by Annemarie Gugelmann and her brother Rudolf and donated to the Swiss National Library in 1982. The project questions traditional models of categorisation and curatorship, implementing alternative approaches on a prototypical level: arrangements of images can be configured on the basis of colour, technique, description or composition parameters (in other words, metadata collected or extrapolated from the images), and analysed computationally.

At the opposite end are qualitative digital analysis techniques such as virtual reconstructions conducted with the use of software often borrowed from the disciplines of architecture or engineering. The virtual reconstruction of the lost *rood screen* of Santa Croce, the subject of the author's doctoral thesis, can rightly be included in the Close Viewing set: the operations of data acquisition, processing, and presentation were conducted with *reality capture*, post-processing, BIM and native 3D modelling methodologies, and do not presuppose the comparison or interrogation of multiple different databases.

Fig. 6: Virtual reconstruction of the lost rood screen of the Basilica of Santa Croce, Florence (Costanzone, Pescarmona, 2022).

This categorisation between Distant and Close Viewing, albeit briefly introduced, can also be usefully employed for the analysis and classification of digital art: "distant" and "close" image generation can thus be useful concepts for making a significant distinction between artistic products which present substantial differences in the way they are conceived and realised by the artists, although they often share the same medium of presentation (digital screens on which they are projected). A digital work of art realised "up close" (close image generation) will therefore have significantly different characteristics from an AI art product: the former will in fact be the result of techniques that cannot be fully automated, adopted by the artist according to a vertical approach and an irreplaceable human contribution. At the basis of a close image generation work are a small or modest set of data, often unstructured. A concrete example of this approach is the art of Vittorio Bonapace: digital artist, yet manual - i.e. 'close' to the images he produces. Human-driven digital art: from the three-dimensional acquisition of cultural heritage works of art, real assets that populate the scenarios populated by the works, to native 3D modelling (using sculpting, animation, lighting, sound effects). Vittorio Bonapace's art brilliantly exemplifies the importance of the availability of digitised assets of the cultural heritage, another characteristic shared by Digital Art and Digital Art History practices. The enabling potential of digitised resources from cultural heritage is well known: if digitised according to state-of-the-art methods and if accompanied by quality metadata, images and other media can foster creative and academic use and reuse of cultural heritage, promoting the generation of new cultural and economic value [4].

Fig. 7: Vittorio Bonapace, Inferno*, 2022. Courtesy of the Artist.*

The term 'distant image generation' can instead be used to indicate the production of images by means of techniques that can be fully automated, following a horizontal approach. A prominent role in this context is played by generative artificial intelligence systems, which can process and use as input sources immense amounts of data (images or other types of information that can be processed by the computer and transformed into a medium that can be experienced by the human eye).

One of the most successful international interpreters of digital art who can be counted among those who make the "distant image generation" is undoubtedly Refik Anadol, a Turkish artist naturalised in the United States. With the provocatively titled video work *Unsupervised*, Anadol was able to make use of MOMA's database of images and metadata to create images - then combined using AI in an audiovisual product - to make the machine "dream", interpolating the entities of the input dataset in a dynamic and apparently random way. The (apparent) absence of supervision by the artist with respect to the computer-generated output referred to in the work's title should be read in this case as an active search for the unpredictable and unexpected, which projects the poietic process of *Unsupervised*'s generation 'from afar' into the dimension of the technoperformance already explored by Coeckelberg. The distance, or proximity, of the artist with respect to the process of image production can thus be read in the light of the numerosity and articulation of the machine's parameters, and above all can be established on the basis of its ability to control its variables: very high in the case of "close", lower in the case of "distant" image generation.

Fig. 8: Refik Anadol, Unsupervised, 2022. New York, Museum Of Modern Art.

Conclusions

This article tried to outline some of the most relevant viewpoints on Digital Art and Digital Art History and to propose a new framework (the Distant/Close Viewing Continuum, and the Close/Distant Image Generation categories) for the classification and the understanding of research and artistic projects led both by academics and by artists or creators. The boundaries between these categories are progressively getting more blurred, as new operational tools, driven by the transformative power of AI technology, arise. Artists and creators often grasp the opportunity to explore the intrinsic potential of artificial intelligence application by subverting the original purpose of the application themselves, thus paving the way for new discoveries and advancement in the field that can be, in turn, exploited by data scientist to pursue their research goals. In conclusion, evidence suggests that there is room for a more established cross-collaboration between artists and researchers, who both use cultural heritage data and assets for different reasons, but often with comparable - and sometime with same – approaches to the machines.

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INTEGRATING ART INTO THE SCIENTIFIC PROCESS: THE GRIN ACTION

Maria Chiara Liguori – VisitLab Cineca

Introduction

In the Italy of the 1950s, the idea that culture and art could and should be an integral part of the broader system, especially the economic system, had begun to take hold. In 1953, for example, the magazine 'Civiltà delle Macchine', the house organ of Finmeccanica, the state-owned company dedicated to large-scale mechanical production, was born [1]. Under the guidance of Leonardo Sinisgalli, the magazine advocated precisely the combination of big business, culture, science and art. Charles Percy Snow, in 1959, was meanwhile pursuing a reflection on the theme of the 'two cultures', i.e. scientific and humanistic knowledge, and emphasised how the failure to integrate these two worlds was an evil that could lead to the inability to solve human problems. However much his thinking stemmed from the failure to integrate scientific culture into humanistic culture, his thought is also valid in the case where the imbalance is to the detriment of humanistic culture [2]. Adriano Olivetti, although he never wrote on the subject, was actively committed to reconnecting "the two cultures". For him, the visual arts were not simply a tool to be placed exclusively at the service of corporate brand affirmation, to be used, that is, only for image promotion [3].

As the years went by, however, this awareness increasingly weakened, and it would be necessary to wait until years closer to us for attention to return to the subject.

With the European STARTS initiative, launched in 2016 with Horizon 2020, the extraordinary potential for innovation generated at the intersection of science, technology and the arts is recognised. In particular, the arts perspective, combined with science and technology, opens valuable perspectives for both research and business, thanks to the holistic, human-centred approach. Since its inception, through projects organised around the most diverse themes, STARTS has supported hundreds of artistic residencies, which have resulted in as many creations.

The GRIN preparatory action

GRIN - Art-driven innovation for digital and green transition in European Regions, is one such project, a STARTS regional centres preparatory action that aims to develop effective solutions for the digital and ecological transition in Europe. Through an open call, 12 artists were selected from the four host regions: Linz, Austria; Bologna, Italy; Porto and Aveiro, Portugal; and Oulu, Finland. Each region defined the thematic challenges that the artists were to set as the basis of their project.

Fig.1: The promotional image for the GRIN Open Call for artists.

The partners for the Bologna region are Cineca and Kilowatt, and the presence of Cineca favoured the identification of themes such as the digital twin, climate problems and supercomputing, to be placed at the centre of the sustainability challenges, identified as being of key importance.

Starting from the pivotal themes of the digital twin, considered as a synthetic representation of the complexity of reality, and the challenges of the ecological transition, the artists were asked to explore in their proposal:

- the design of technology to enhance the human experience and promote sensory and cognitive capabilities;

- how to promote non-anthropocentric perspectives to decolonise our relationship with nature, society and ecosystems;
- the ethical considerations to underpin the creation and implementation of digital twins, to avoid reinforcing existing power structures or creating new ones;
- and, in general, how art can contribute to the development and use of these technologies to promote a more equitable and sustainable system.

The call collected more than 100 proposals, including 43 for Bologna.

An international jury, composed of Pierluigi Sacco, expert in the economics of culture and lecturer at the University of Pescara; Pierluigi Capucci, lecturer and curator, member of the AICA (Association Internationale des Critiques d'Art); Adrian Eeckel, director of the art&science programme at the JRC; Caterina Benincasa, curator at the JRC and Marco Mancuso, critic, curator, researcher and founder of DIGICULT, was involved in the selection process for the regional centre in Bologna.

Fig. 2 – A meeting held at Kilowatt among researchers and the artist Marco Barotti

At the end of the complex selection process, the artists Salomé Bazin, Calin Segal and Marco Barotti were chosen for a six-month residency, which will lead them to a research and awareness-raising work that, passing through sea and atmosphere, coastline and subsoil, will form an interwoven and continuous narrative.

So far, in addition to the people from Cineca, experts in various fields such as genetics, artificial intelligence, meteoclimate or computer graphics, researchers from various international and national institutions such as ISPRA, OGS, the University of Bologna and CMCC have been involved.

An intense and fruitful dialogue is being created between artists and researchers, and the meetings trigger very interesting moments of multidisciplinary confrontation. Initial hesitations, sometimes shown by researchers, are soon replaced by enthusiasm and a desire to participate and share. The desire of many researchers to valorise the fruit of long studies, the fascinating, useful and interesting results, finds a possible response in art projects.

Conclusions and perspectives

The works resulting from the residencies will be exhibited both in Bologna (during Resilienze Festival, ArtCity and during other events that have not yet been defined), and during international exhibitions and festivals, such as Sonar D+, KIKK, LUMO Festival of Lights and Ars Electronica, one of the most important festivals on the contemporary art scene. Insofar as the scientific data will be subjected to an artistic interpretation, it will be able to reach a much wider audience than is usually the case and, in the meantime, may have given rise to fruitful exchanges of ideas between the researchers themselves. Which is, ultimately, exactly the aim of projects such as GRIN.

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DELEGATING CREATIVITY

Pier Luigi Capucci – Noema

Generative Artificial Intelligence, Simulation, and Referentiality

Today, much discussion revolves around Artificial Intelligence, a very extensive field that includes Robotics and Artificial Life [1]. However, the focus is mainly on "Generative Artificial Intelligence," referring to Deep Learning models capable of generating text, images, videos, music, and other content based on the data on which they are trained.

The creation of photorealistic images, particularly in the simulation of the human figure, has gained new possibilities with Generative Adversarial Networks (GANs), introduced by Ian Goodfellow and colleagues in 2014 [2].

Fig. 1 - Pier Luigi Capucci, Emma Watson*, 2023, image generated with Stable Diffusion (Courtesy of the author)*

Thanks to Generative Artificial Intelligence, it is possible to obtain images indistinguishable from photographs of existing people, such as this portrait of Emma Watson [Fig. 1], generated with Stable Diffusion, or entirely invented. *The Electrician* [Fig. 2], presented by Boris Eldagsen, won the "Sony World Photography Awards 2023" but was created using Generative AI. In rejecting the award, Eldagsen argued:

"AI images and photography should not compete with each other in an award like this. They are different entities. AI is not photography. Therefore I will not accept the award. We, the photo world, need an open discussion. A discussion about what we want to consider photography and what not. Is the umbrella of photography large enough to invite AI images to enter – or would this be a mistake?" [3].

Fig. 2 - Boris Eldagsen, The Electrician*, 2023, Winner of the Sony World Photography Awards 2023 (From Boris Eldagsen website).*

In the discussion on the nature of photography, the schema distinguishing images between "referential" and "non-referential" [4; 5], based on how they are created, can be useful [Fig. 3]. The adjective "referential" comes from the Latin expression *res ferens*, meaning "that carries the thing," since referential images require the material presence of the object or physical phenomenon during the image [4; 5]. Referential images are obtainable only in presence of the referent (from which they are inseparable, "they carry it with them"). The subject or object to be represented

must physically exist and be present during the image creation. This category includes casts and analogs (imprints, molds...) and images obtained using light, such as photography, cinema, and video "from reality," and holography, which require the physical presence of a subject or object capable of reflecting or emitting light during the image generation process. In referential images without a subject/object there is no image.

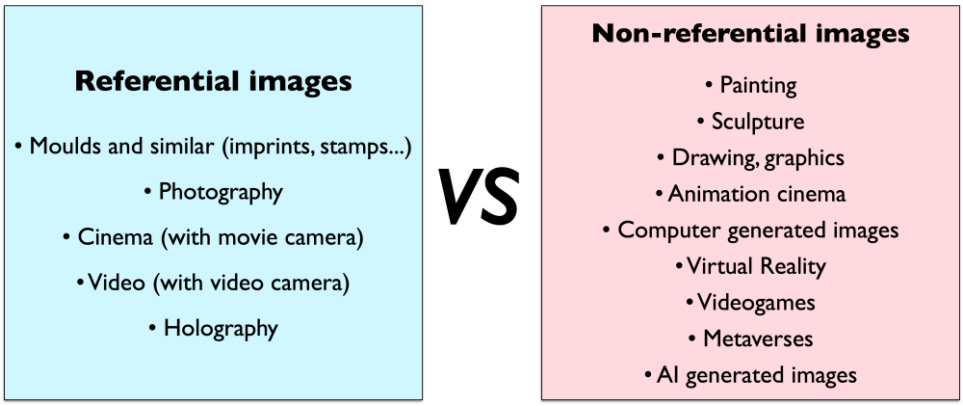

Fig. 3 Pier Luigi Capucci, Referential and non-referential images *(Courtesy of the author)*

Conversely, non-referential images do not have the constraint of the co-presence of the referent, so they can represent things that do not physically exist or are not present at the time the image is created. Thus, painting, sculpture, drawing, graphics, animations, computer images, Virtual Reality, video games, metaverses, images created with Generative AI..., belong to this category. Consequently, photographic images and photorealistic computer-generated images belong to two different categories and should not be confused.

Starting from the 1820s and then gradually with its diffusion, photography allowed an increasing number of people without manual talent to create realistic (referential) images. On "photographic realism" in 1859, in his letters to the *Revue Française*, Charles Baudelaire wrote:

> "In these sad days, a new industry has emerged that has contributed not a little to strengthen in its faith the flat stupidity... according to which art is neither nor can be anything but a precise representation of nature... A vengeful God has listened to the voice of this mass. Daguerre has become its messiah. (...) If photography is allowed to integrate art into some of its functions, the latter will soon be supplanted and ruined by it, thanks to its natural alliance with the multitude" [6].

The prophecy proved partly true and partly false. False, because fortunately, with the spread of photography, art, and more precisely, painting, did not disappear; it followed a different path, for example moving towards abstraction, which is precisely what photography cannot do (there are no abstract photographs). True, because it shows that Baudelaire understood, ahead of his time, that photography was destined to become a mass communication medium "thanks to its natural alliance with the multitude."

Also, with Generative Artificial Intelligence it is possible to create realistic or interesting images without any manual talent. However, unlike photography, these images are non-referential. Generative AI adds therefore another expressive possibility: without knowing how to draw it is now possible to create any type of image, whether referential and non-referential.

Fig. 4 - Pier Luigi Capucci, Landscape with people and strange animals*, 2023, image generated with Stable Diffusion (Courtesy of the author).*

Errors, Semantic Disorientation, and Copyright

One interesting aspect from an artistic point of view is the errors that Generative AI systems produce: distorted hands and faces, improbable postures, are the most evident. But also images devoid of apparent meaning, improbable, or semantically indefinable, which I have called the "almost-like-images," constitute interesting cases. For example, I find image n. 4 intriguing [Fig. 4], but beyond a generic description of the surroundings, I cannot tell what it represents. There

are many objects, but none are recognizable as representations of existing objects. Images that defy description and generate semantic disorientation recall, often exaggerating, poetic modes and stylistic characteristics typical of Surrealism.

One more interesting aspect of Generative AI is the transduction from text to image. In picture 5 [Fig. 5], I used as prompt a long post in Italian written in response to a friend on a topic of common interest (the new direction at the ZKM in Karlsruhe after the passing of Peter Weibel). Midjourney generated this image, whose style resembles illustrations from the 1960s. What elements of my text did it consider to generate the image? And again, the "almost-like-situations" are present: it is not clear what the seated woman in the foreground on the right is doing, the balconies on the street lack railings, some doors are too small, others are placed in unlikely positions.

Fig. 5 - Pier Luigi Capucci, A volte ho l'impressione che le persone non capiscano, o non leggano, quello che scrivo […]*, 2023, image generated with Midjourney (Courtesy of the author).*

Legal issues related to copyright in images created with Generative AI add an additional layer of uncertainty. The U.S. Copyright Office has twice rejected an application to register an image created using Generative AI:

> "But copyright law only protects "the fruits of intellectual labor" that "are founded in the creative powers of the [human] mind." (the Office will not register works "produced by a machine or mere mechanical process" that operates "without any creative input or intervention from a human author" because, under the statute, "a work must be created by a human being")" [7; 8].

This decision was reiterated in 2023.

However, works created by artificial intelligence can be awarded. *Théâtre D'opéra Spatial*, created in 2022 with Midjourney by Jason M. Allen [Fig. 6] [9; 10; 11] raising many criticisms but also highlighting the growing importance of Generative AI in the artistic domain. At least for now in the United States, Generative AI images cannot be copyrighted but can win artistic competitions.

Fig. 6 - Jason M. Allen through Midjourney, Théâtre D'opéra Spatial*, 2022, Winner at Colorado State Fair Digital Arts Competition (Courtesy Wikipedia).*

The Precedent of Generative Art

Generative Art can be considered a precedent for Generative AI. According to Philip Galanter:

> "Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art" [12].

Generative Art has a history dating back to the 1960s. In its broadest sense, it includes visual, textual, sound and audiovisual forms of expression generated through many kinds of more or less autonomous systems and processes: mechanical, electronic, computer-based, biological, natural... Artists like Frieder Nake, Georg Nees, Vera Molnár [Fig. 7], Michael Noll, Hans Haacke are considered precursors. Harold Cohen, one of the pioneers, highlighted the evolution of the computer's role:

> "My whole history with information technology has had to do with a shift in the notion of the computer as an imitation of the human being, towards a recognition of the computer as an independent entity with its own capabilities, fundamentally different from those we have (Harold Cohen, 2011)" [13].

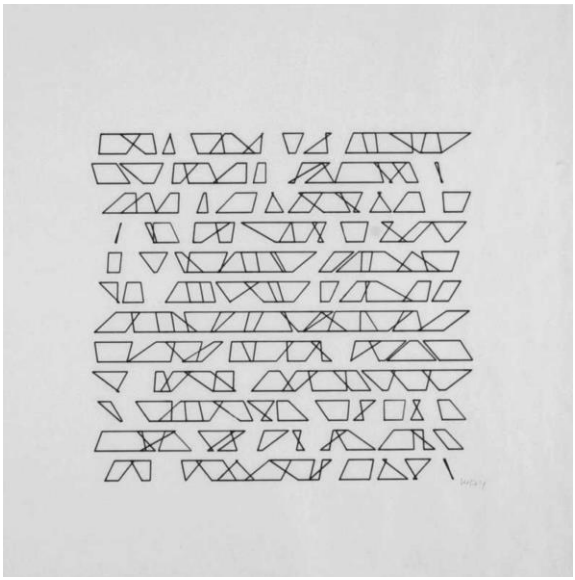

Fig. 7 - Vera Molnár, 144 Trapèzes (144 Trapeziums)*, computer graphics, 16 variations, print, 1974 (Courtesy Digital Art Museum).*

With the advent of Generative AI and technological-scientific evolution, Generative Art experiences a second youth. Many exhibitions are ongoing, and other initiatives are in preparation; Whitney Museum will dedicate a retrospective to Harold Cohen in 2024.

Art and Multiform Artificial Intelligences

More recently, Generative Art can be found in Genetic Algorithms made applications, like William Latham's works [Fig. 8], and in the works made with Robotics. In this slide, Paul, a drawer robot created by Patrick Tresset, creates low-resolution pen portraits, opposing the pervasiveness of high-resolution photorealistic images. On the left is the portrait he made to me in 2011 in Istanbul, at ISEA [Fig. 9]. He has represented me bald, maybe imagining how I will be in the future.

Fig. 8 - William Latham, Mutation Room*, computer animation installation with genetic algorithms, 1994 (Courtesy ACM Siggraph).*

In the field of Robotics, Leonel Moura builds these small painting robots that are free to move and trace marks on canvases or sheets of paper, which are then hung. They are autonomous; just charge the batteries and inks at the beginning of each day.

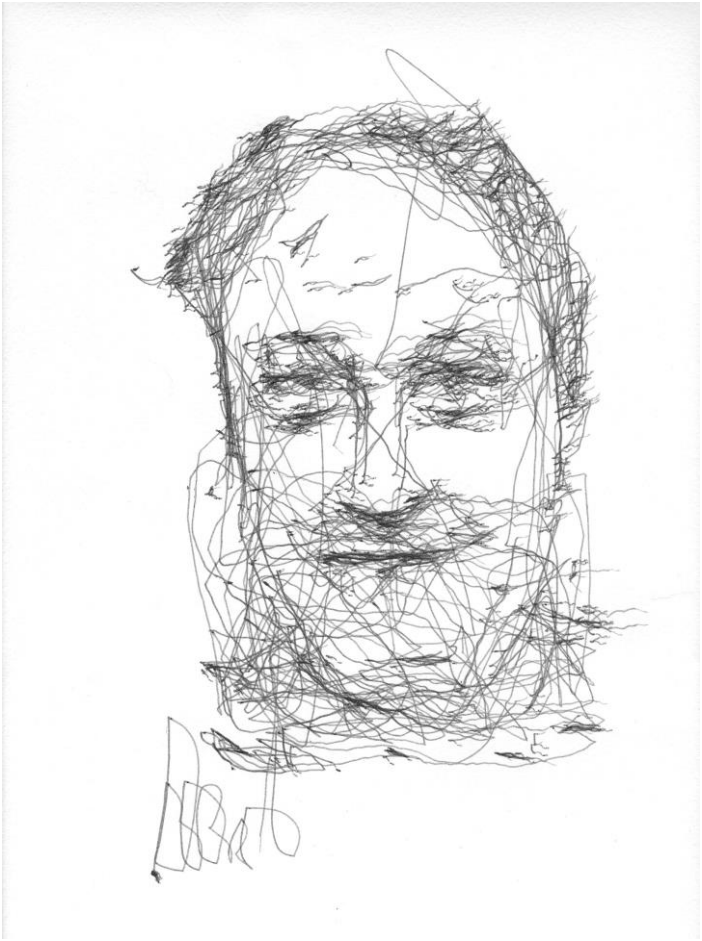

Fig. 9 - Paul, robot created by Patrick Tresset, Portrait of the Author*, ballpoint pen drawing on paper, 2011, ISEA 2011, Istanbul (Courtesy of the author)*

Creative autonomy does not belong only to computer and digital-based devices, as the ones made through Artificial Intelligence and Robotics. Australian artist Guy Ben-Ary, collaborating with scientists, engineers, artists, and musicians, created *CellF*, the first neural synthesizer [Fig. 10]. It is a device based on a biological network of neurons that controls in real-time a system of custom-built analog modular synthesizers (according to the artist, analog synthesizers process signals similarly to neural networks). *CellF*'s neural network was created from a biopsy taken from the artist's skin. Using Induced Pluripotent Stem Cell (iPSC) technology, these cells were transformed into pluripotent cells and then evolved into neural stem cells to create a network of about 100,000 neurons.

Fig. 10 - Guy Ben-Ary, CellF*, bioart installation, 2015, Performance at Ars Electronica, Linz, 7 September 2017 (Courtesy of the author)*

Although this number is much lower than the neurons in the human brain, interconnected by trillions of synapses, this "biological artificial intelligence" generates large amounts of data, responds to external stimuli, and shows plastic properties [14]. And it can interact with human musicians and play alongside them: the sounds created by the musicians are sent to *CellF*'s neural system, which responds by controlling the analog synthesizers and creating its own sounds.

CellF's "biological artificial intelligence" problematizes biotechnologies and contextualizes them in an artistic framework. Ben-Ary writes:

> "It started with a new materialist question underpinned by the belief that artistic practice can act as a vector for thought: What is the potential for artworks using biological and robotic technologies to evoke responses in regard to shifting perceptions surrounding understandings of "life" and the materiality of the human body?" [15]

The artistic use of Artificial Intelligence emerges spectacularly in the work of Refik Anadol, who creates installations in which he transforms data into dynamic "sculptures" (Data Sculptures) [Fig. 11], one of which has recently been acquired by MoMA.

Fig. 11 - Refik Anadol, Machine Hallucinations. Nature Dreams*, 2021, A.I. Data Sculpture (still frame) (From Refik Anadol's website).*

In the installation *Chronolalia. Towards an oscillating truth* by Austrians Klauss Spiess, Emanuel Gollob, Paul Gründorfer, along with Jens Hauser, Artificial Intelligence is not used to create images but generates sounds from the interaction between the voice and the bacteria that naturally coexist in the oral and nasal cavities [16] [Fig. 12].

Fig. 12 - Klauss Spiess, Emanuel Gollob, Paul Gründorfer, with Jens Hauser, Chronolalia. Towards an oscillating truth*, bio-multimedia installation, 2023 (Courtesy of the author)*

Oral language consists not only of mechanical vibrations generated by the movement of the parts of the human speech system but also includes a broader biological substrate that involves the body and especially the populations of bacteria in the oral and nasal cavities. These bacteria are influenced by voice frequencies, which alter their environment both through the movement of parts of the mouth and through the acoustic vibrations (sounds) produced, changing the acoustic and physical conditions in which they live. Certain frequencies promote their multiplication; for example, the tonal part of the voice strengthens their cytoskeleton and increases reproductive activity. Reciprocally, bacteria influence the sounds of speech by absorbing certain frequencies [17; 18], those that are most useful to them. Thus, in human vocalization, they actively intervene between vocal-linguistic emissions and the sounds that are generated. The sound of the voice, such a personal element, is also the result of biological interactions between the body and these microorganisms, which play an active role, defined as "Microperformativity" [19].

In *Chronolalia. Towards an oscillating truth*, one must speak, sing, or whisper into a microphone, altering the rhythm, tone, and intensity. The vibrations generated by the voice are transmitted to a plate on the floor and then to the bioreactor containing the microbiome, which extracts the frequencies it can use best for its growth. These "vibrational needs" are then sent to a vocal articulator that emits the filtered voice. If this voice is imitated in a way similar to an echo, enough data is provided to the Deep Learning process to constantly adapt vocal frequencies to the microbiome's needs. Together with the voices of previous users, a polyphonic, vibrational, hybrid chorus of a new interspecies intelligence is created, combining microbial and anthropovocal interests: a kind of meta-organism. This installation offers a multi-perspective and less anthropocentric view of life.

The Externalization Process. Towards an Art for the Non-uman?

Generative Artificial Intelligence is a more general process of progressive externalization outside the body of human functions and activities [20], underway since the origins of humanity [Fig. 13]. Through simple tools used as utensils and weapons, human culture began to externalize parts and activities of the body. Then, with images and writing, it recorded knowledge and memories outside the body. Then, with the use of more or less automatic machines and devices, physical work and many related activities were externalized. Finally, with Artificial Intelligence, Robotics, and Artificial Life, narrow reasoning abilities and autonomous actions were

externalized. If this trend continues in the future, an increasing number of more and more complex human activities will be externalized.

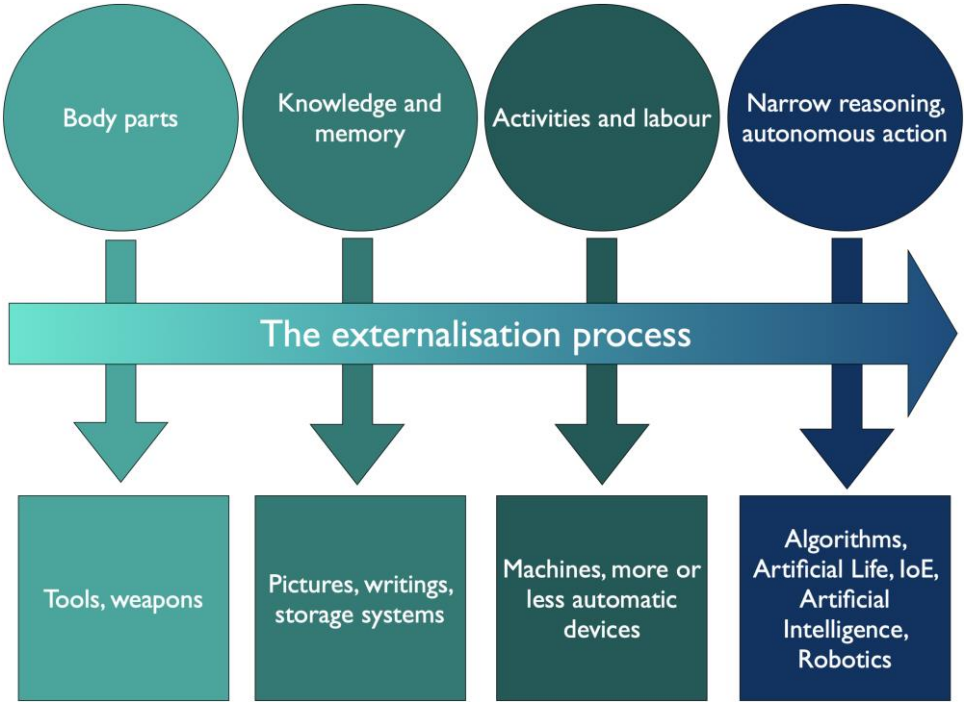

Fig. 13 - Pier Luigi Capucci, The Externalization Process *(Courtesy of the author)*

The process of externalization is also underway in the arts. Initially, it involved simple devices to assist artists, but with scientific and technological advances, increasingly autonomous systems have emerged, raising, among others, the issue of "art made by machines." The process of externalization does not diminish the human presence and responsibility in art; at most, it reduces the human intervention in the creation of the work of art [21].

Is it possible to extrapolate this process further towards expressive forms not intended for humans but for technoscientific devices? Art is deeply embedded in the essence of humanity, so does it make sense to have an "art of machines for machines"? Could technoscientific devices get an aesthetic sensibility? Is there any possibility of art for the "non-human"?

Denisa Půbalová, Lea Luka Sikau, Michael Artner, and Julia Wurm have tried to provocatively answer these questions with the installation Ars for Nons ("Ars for Nonhumans"), inviting people to sit in a waiting room while their cell phones participate in an interactive event involving sounds, vibrations, and images [Fig. 14]:

> "The installation Ars for Nons creates art for technology – which essentially is a part of society already. Art is not made by nonhuman technology for humans, but with technology for nonhumans.
>
> It asks why and how to create art for other-than-human beings. […] Ultimately, the installation stretches the human perspective, deconstructing and rethinking our relationship with art" [22].

Fig. 14 - Lea Luka Sikau, Denisa Půbalová, Michael Artner, Julia Wurm, Ars for NONS*, installation, 2022 (Courtesy Denisa Půbalová)*

Provocatively I end my speech with this quote by George B. Dyson:

> "In the game of life and evolution, there are three players at the table: human beings, nature, and machines. I am firmly on the side of nature. But nature, I suspect, is on the side of machines" [23].

Thank you for your attention.

Lecture at the Workshop "AI, Cultural Heritage, and Art: Between Research and Creativity," CINECA, Bologna, Fibonacci Hall, September 22, 2023

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PLANT

Debora Hirsch – Hutchinson Modern & Contemporary, New York; Bocanera Gallery, Trento and Milan; Il Chiostro Arte Contemporanea, Saronno; Galerie Lisi Hämmerle, Bregenz

> "When you take a flower in your hand and really look at it, it's your world for the moment. I want to give that world to someone else. Most people in the city rush around so, they have no time to look at a flower. I want them to see it whether they want to or not."
>
> Georgia O'Keeffe

Plants represent the transitory nature of life and death, but they are also symbols of fertility, prosperity, regeneration, rebirth, and renewal in the cosmic cycle of Nature. Mario Peixoto, the author of 'Limit,' considered one of the most significant masterpieces in the history of Brazilian cinema, used to convey that 'Any human action against Nature is useless.' The Romans believed that Man may change, but Nature remains the same.

Biodiversity however is far from static. Biodiversity depends on a conjunction and equilibrium among elements. Unfortunately, Earth's biodiversity is experiencing a steep reduction in plant diversity.

Agriculture based on global markets generated by gigantic conglomerates favours monocultures. Monocultures represent the main threat to biodiversity. It is crucial to delve into the ecological impact of monoculture, a prevalent practice in agrochemical-dependent agriculture. Monoculture, characterized by cultivating a single crop over large expanses, poses a substantial threat to depleting soil health and disrupting natural ecosystems. The damage inflicted by monoculture extends beyond the immediate agricultural context, affecting broader ecosystems and wildlife. The simplified landscape created by large-scale monoculture destroys habitats essential to various species. As we navigate the complexities of the agrochemical supply chain, addressing the environmental ramifications of monoculture becomes paramount. Encouraging sustainable agricultural practices that prioritize biodiversity can mitigate these adverse effects and promote a more resilient and ecologically sound food production system, besides preserving culture.

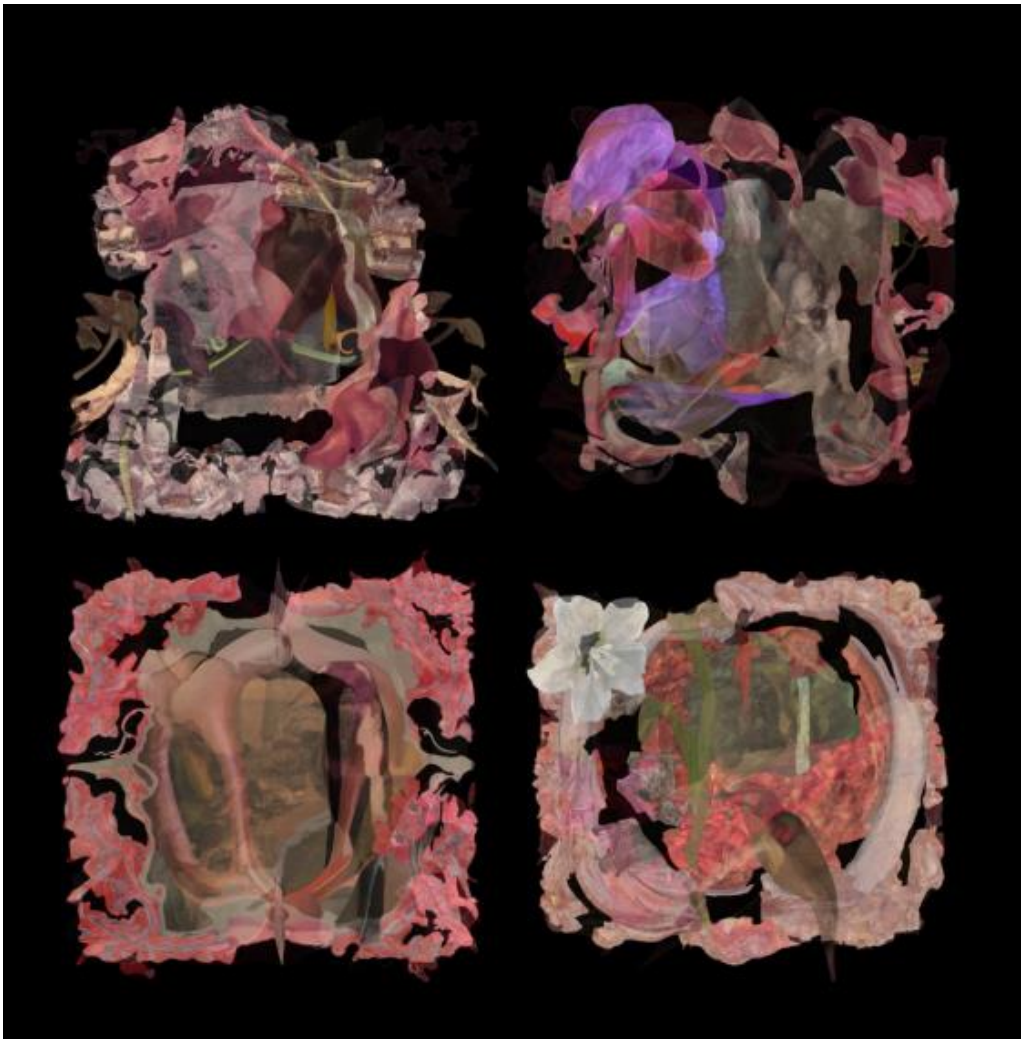

Fig. 1 - PLANTALIA*, 2023. MP4 4320 x 4320 pixels, 1'04" loop (Created using acrylic painting, coding, AI, animation)*

Species with potential value as food, medicine, fibres, or for their ecological roles are vanishing before we can fully understand their characteristics. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is the global gold standard for assessing species' extinction risk. Plants are classified into categories: Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, or Data Deficient. Assessments like the IUCN Red List play a crucial role in providing valuable guidance in establishing protected areas, allocating funds, and influencing decisions like avoiding activities that could harm endangered species. Despite being the most comprehensive source on global extinction risk, the Red List covers only approximately 6% of the estimated 2.1 million plants, fungi, and animals.

Fig. 2 - PLANT (Calopogon multiflorus)*, 2023. JPEG 4320 x 4320 pixels, inkjet print 35 x 35 cm. (Created using acrylic painting, coding, AI)*

Following the protocols of the blockchain that define a space protected from destruction, manipulation, and the passing of time, I decided to bring to life and preserve nearly extinct plants within the realm of AI and physical painting.

In my research PLANT, endangered species are being recorded on the blockchain, granting them an eternal virtual existence and serving as a symbolic memory of what we have lost and what we risk losing.

I paint fragments as they are more eloquent to present my statement, giving a sense of the complexity of natural systems and the interrelation of its parts. I began with acrylic paint, ink, and paper, and then I moved to digital. I use a pre-trained AI model that I fine-tune to my datasets. I produce digital outcomes to later use them in my compositions.

Fig. 3 - PLANT (Dianthus guliae)*, 2023.JPEG 4320 x 4320 pixels, inkjet print 35 x 35 cm. (Created using acrylic painting, coding, AI)*

I am not aiming at literal interpretations of the selected plant species; these remain as merely references. Plant compositions may include frames, caves, landscapes, architecture details, monolithic birds, that altogether emphasize the complexity of interconnections that belong to ecosystems evoking the delicate equilibrium and transience of nature. Birds have significance as messengers, a conduit between sky and earth, and they also represent the soul. The plant representation lacks seasonal consistency to favour their most typical and recognizable elements.

The context is not descriptive of the plant's real ecosystem. My plants know no borders; they live in imaginary worlds. The plants have clear and special presence in the composition, and a high visual relevance as the true protagonists of the scene.

My decision on which plants to represent hinges upon a range of factors, including available information about their history, utility, the cause of their extinction, but above all, their beauty or peculiarity, to make my rendition artistically and aesthetically intriguing.

In the process of elaborating these images, the representation is deliberately abundant. This collection is open and can constantly be enriched with some other endangered species, ultimately reinforcing the message of the PLANT series, linked to the fragility of the flora and the neglect with which it is often treated.

Fig. 4 – PLANT (Symphytum tanaicense)*, 2023. JPEG 4320 x 4320 pixels, inkjet print 35 x 35 cm. (Created using acrylic painting, coding, AI)*

Some of these plants have found representation in Roman bucolic frescoes and medieval recreations of the primordial paradise. A few of the chosen plants are only known through descriptions and a few remaining visual records of their existence. In these cases, and based on these materials, I recreate images that take us back in time, offering a glimpse into an imaginary lost world.

With this project, and through beauty and harmony, I aim to bring attention to the loss of biodiversity and valuable ecological resources essential to our physical existence, balance, and spiritual development.

Fig. 5 - PLANT (Asimina tetramera)*, 2023. JPEG 4320 x 4320 pixels, inkjet print 35 x 35 cm. (Created using acrylic painting, coding, AI)*

Fig. 6 - PLANT (Physoplexis comosa)*, 2023. JPEG 4320 x 4320 pixels, inkjet print 35 x 35 cm. (Created using acrylic painting, coding, AI)*
https://gallery.manifold.xyz/0xdf97bca587bdd59dc2ac720a8afd821e4ec3009c/10

Blockchain technology creates a secure and transparent archive of these resurrected plant species, and each recreated plant is meticulously documented, and its digital twin is registered, ensuring an immutable record of its existence.

Fig. 7 - PLANT (Lathyrus odoratus)*, 2023. JPEG 4320 x 4320 pixels, inkjet print 35 x 35 cm. (Created using acrylic painting, coding, AI) https://gallery.manifold.xyz/0xdf97bca587bdd59dc2ac720a8afd821e4ec3009c/11*

Therefore, this blockchain archive not only serves as a repository of artistic expression but also as a dynamic testament to the ongoing struggle for biodiversity conservation. By combining the ephemeral nature of art with the immutable qualities of blockchain, the project transcends the

boundaries of traditional artistry, becoming a living, symbolic testament to the impermanence of our endangered flora.

As society grapples with the consequences of environmental negligence, this artistic research not only captures the essence of endangered plants but also envisions a future where technology and creativity collaborate to safeguard the richness of our natural world.

The archive is officially registered through a decentralized contract, Manifold, that ensures the mint of immutable and secure tokens on self-deployed creator contract, allowing the retention of true ownership and maintaining the highest level of provenance of the artwork.

Links

Debora Hirsch website

https://www.deborahirschstudio.com/

PLANT website

https://www.deborahirschstudio.com/contemporaryplant

I.A.M. - INTELLIGENZA ARTIFICIALE MUSICALE: A LOOK AT AI FOR MUSIC AND SOUND

Andrea Dell'Innocenti, Francesco Zuccarello– AION Collective

Abstract

I. A. M. - "Intelligenza Artificiale Musicale"- is an innovative project conceived by Aion Collective that aims to create a bridge between Artificial Intelligence and music in a synchronized way. This project consists of three different projects: the first is a musical set created by the fusion between music and the Magenta plugin on Ableton, an AI capable of generating music from an input, the second is a generative constellation that arises from sound and the third that is an AI that generate midi file from another file midi. Thanks to "I. A. M.", the audience can experience the interaction between AI and music in a new artistic dimension.

DJ AI

The integration of Magenta with an Ableton setup has enabled the creation of an auto-generative DJ set, merging technology and music to produce a unique and innovative experience.

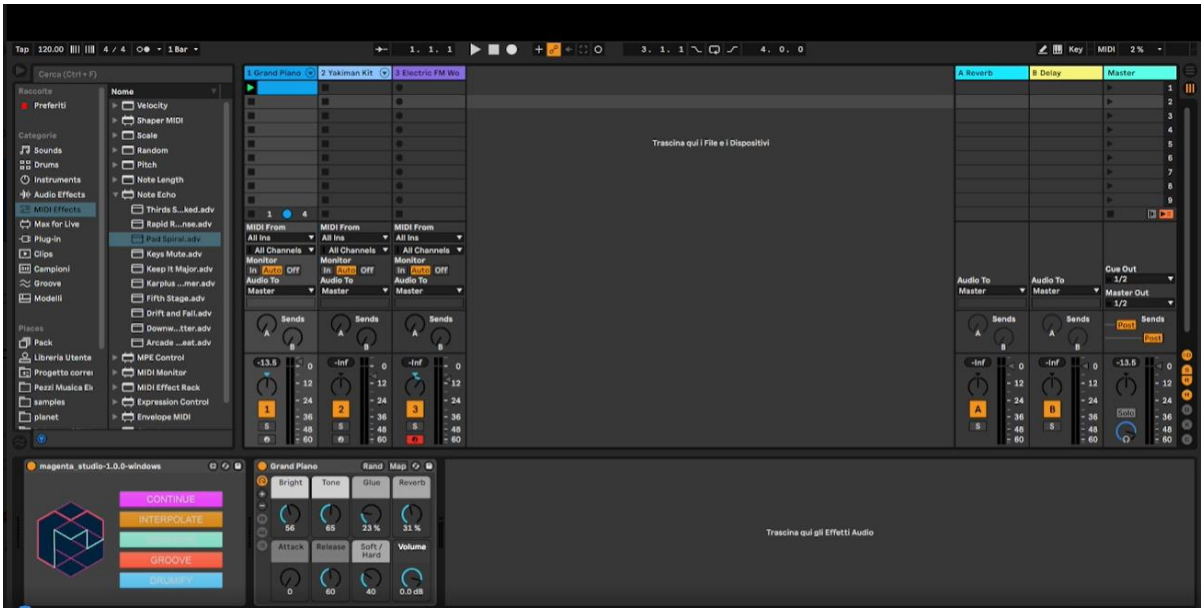

Fig. 1 DjAI

As noted by the author: "The project aimed to explore the possibilities of integrating AI and music creation, resulting in a self-generating DJ set that creates sounds and melodies in real-time,

providing the audience with a completely original and surprising musical experience." The use of AI in music production has opened up new possibilities for artists and musicians, allowing them to experiment with new techniques and explore new creative horizons. According to [1], "AI music generation systems have the potential to revolutionize the way we create and consume music, by providing new tools for musicians to explore and experiment with." In conclusion, the integration of Magenta with Ableton has resulted in a groundbreaking project that showcases the potential of AI in music production. The self-generating DJ set provides a unique and innovative musical experience, demonstrating the possibilities of technology and art working together. "The integration of AI and music has the potential to create new forms of musical expression and transform the way we experience music." [2]

HZ Genesis

Hz Genesis is an innovative generative artificial intelligence that creates an explorable galaxy from environmental sounds using a joystick. According to the project's website, "The system uses a node-based scripting system called Niagara to take the spectrogram of the room where a microphone is inputted. Then, it generates a particle system using Niagara.

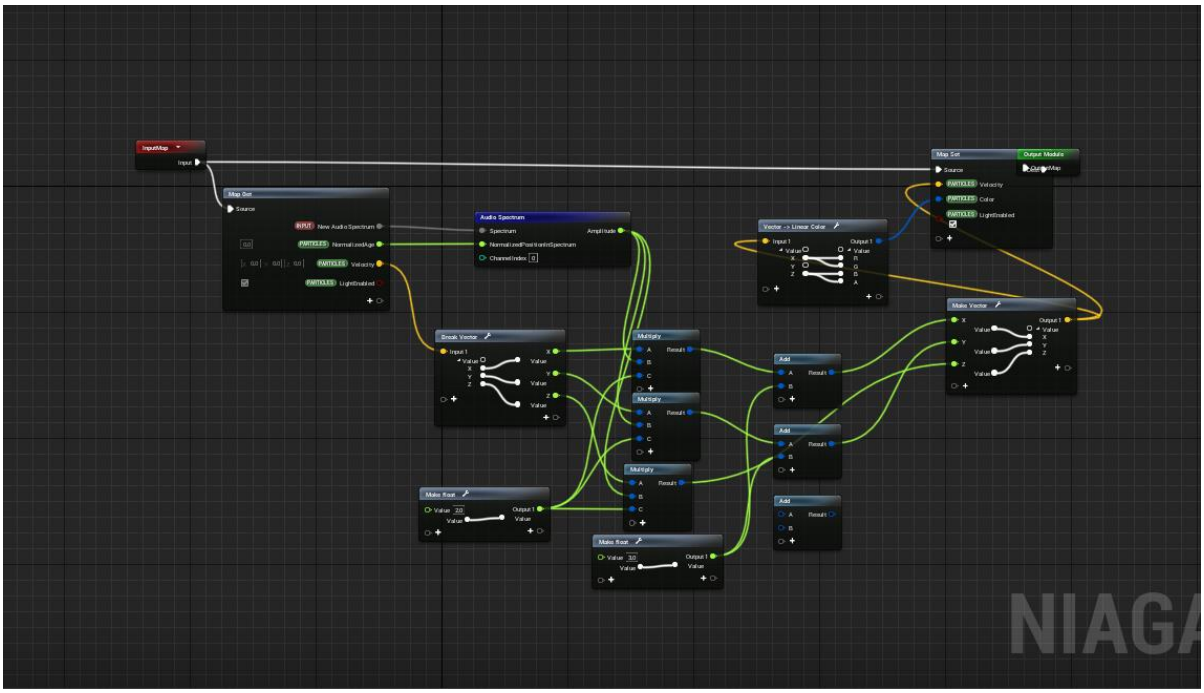

Fig. 2 HZ Genesis

Finally, the script is inputted into the Niagara particle system and connected to the incoming audio, evaluating emission, number of particles, etc. The result is a galaxy that is born from the sound of the audience, with a unique result every time the application is launched. This project

represents an important step in the integration of artificial intelligence and music, allowing for new forms of musical expression to be explored. As noted by [3], "The use of AI in music production has opened up new possibilities for artists and musicians, allowing them to experiment with new techniques and explore new creative horizons." In this case, when we talk about horizons, we are referring to the universal horizon.

Fig. 3 HZ Genesis

AI for Contemporary Music

This artificial intelligence consists of a Python program designed to generate new musical pieces based on an input MIDI file. Building on the concept of harmonic field (i.e., the notes used) commonly used in contemporary music, we have extended it to also include the selection of note durations and intensities. During the analysis process, issues related to poorly formatted MIDI files may arise. Fortunately, after identifying these problems, we have managed to either prompt the program to report the issue and stop or have it automatically corrected the problem. Following the analysis, there is a composition phase in which the user can choose the key, meter, BPM, and, most importantly, the number of notes. The decision to use the number of notes instead of measures was inspired by comparisons with the compositions of many contemporary musicians who often work with free time signatures. Once the user finishes inputting the required parameters, a new MIDI file is generated, incorporating all these characteristics derived from the chosen input piece. In the realm of music composition, artificial intelligence (AI) techniques have been increasingly utilized to generate original musical compositions. This paper

presents an AI system developed in Python, designed to create new musical pieces based on an input MIDI file, while incorporating contemporary compositional concepts. Drawing inspiration from harmonic fields [3], this system extends the idea to encompass the selection of note durations and intensities, providing more nuanced control over the compositional process. One of the key challenges in this endeavour is the analysis of input MIDI files, where issues related to file misformatting can be a significant hindrance. This system employs robust error handling mechanisms, either gracefully handling these issues or providing clear user notifications [4]. The compositional phase of the system allows users to specify parameters such as key, time signature, BPM, and the number of notes to be generated. This choice of using the number of notes instead of traditional bar-based structures is inspired by contemporary musicians who frequently compose with free time signatures [5]. The resulting output is a new MIDI file, tailored to the user's preferences, while retaining the characteristics of the original composition.

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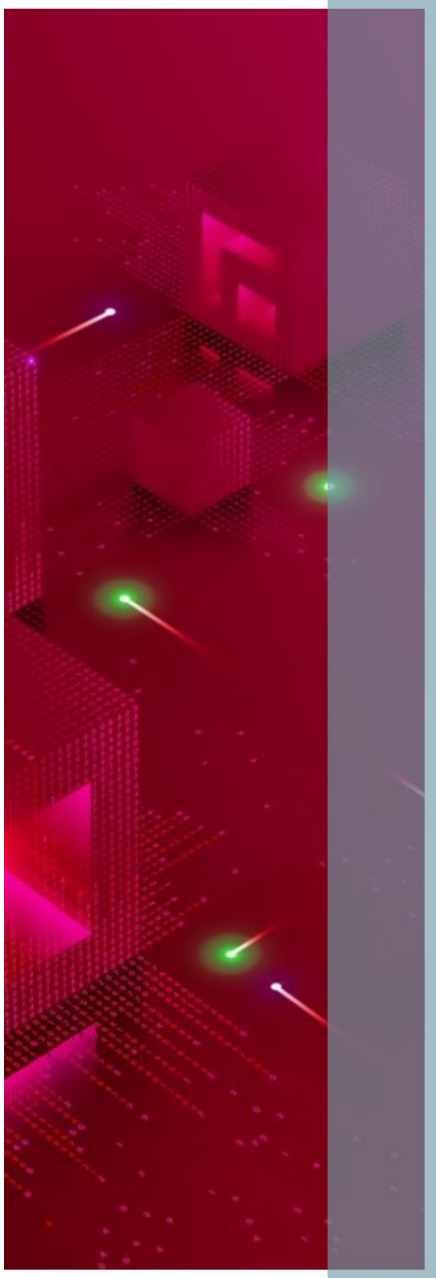

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