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# The Convergence of the Digital Virtual World and Artificial Intelligence – Or What the Future Symbiosis Brings in the Synergy of the Metaverse and AI

## Abstract

*Utopia, fiction or tangible digital reality, a projection of the physical world in virtual space? The metaverse, as a phenomenon, as another milestone in the revolution of technological development speeding along the digital superhighway, is much more in today's information-digital society than just another big hit in the service, gaming and entertainment industry. It is far from being in its infancy, with antecedents linked to, among others, Neal Stephenson's cyberpunk novel Snow Crash or Ernest Cline's novel Ready Player One.*

*It has surpassed its time, exceeded its limitations, and has long since left the ranks of primitive implementations such as the WoW, Fortnite, Roblox or Minecraft game softwares that can be considered the predecessors of its technological evolution. The investments of the technological giants and startups of our time, which at their inception took the form of implementations such as Horizon Worlds, Workrooms, Home, Venues, Microsoft Mesh, Roblox, Fortnite, XiRang, Decentraland, Sandbox, TCG World, Next Earth, Axie Infinity, Neos, Yield Guild, Genesis Worlds, MetaverseZ, vPark, OVR, Bizverse, Challau, Meta-vice, Blankos Block Party, My Neighbor Alice, Somnium Space video games, already seem to be paying off. Nowadays, AI is one of the pillars of the metaverse. The big data available in the metaverse is like oil that fuels AI, as the digital engine of the virtual world, which operates and advances the digital projection of physical reality. Their technological integration is inevitable in order to further blur the boundaries between the real and virtual worlds. The combined effect of this new digital alloy<sup>2</sup> can be the driving force behind the increasing spread of digitalisation,*

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<sup>2</sup> In my own interpretation, I use the term to refer to a new type of digital environment created by the convergence of metaverse and artificial intelligence, based on existing technologies. Their synergy results in new technological and service opportunities for users.

*the emerging new era, the revolution of newer and newer technological possibilities, and the development of ever-higher levels of connectivity in the digital space. Technological synergy can bring mutual benefits to these emerging and disruptive technologies for their future development.*

*Keywords: metaverse, digital world, virtual and physical reality, artificial intelligence, convergence, synergy, fusion, digital alloy, connectivity, symbiosis, digital hybrid technology*

## Introduction

At the outset, I would like to make it clear that I do not want to look at the subject under consideration through the lens of engineering, by examining it in depth. Rather, I would like to give a general, summary outlook and vision of the future, without claiming to be exhaustive, by reviewing and analysing current technological trends and expert predictions, and supplementing this with subjective insights and thoughts.

Metaverse and Artificial Intelligence (AI) are two Emerging and Disruptive Technologies (EDT)<sup>3</sup> that are fundamentally no longer new entities in the technological repertoire of the digital world, but their impact is all the greater. They are prominent milestones in the evolution of different digital technologies that are having a huge impact on the digital transformation of the globalised world around us, on all aspects of the daily lives of digital citizens. Their introduction, deployment, technological evolution and, as a result, convergence are inevitable.

However, it is a different matter to apply them responsibly and judiciously for the benefit of humanity, with positive effects in the information-digital society they permeate. It is important to mention this, among other things, because today, in the age of the 4<sup>th</sup> generation warfare, as a result of the information-digital theatre of war that has emerged, the primary use of all new technological waves is typically in the defence sphere. Although it is also true that today the vector of development has reversed. This means that new technologies are increasingly being developed in the civilian sphere and then adapted or further developed in the defence sphere. Evidence of this can also be found in the case of one of the current military conflicts, the Russian–Ukrainian confrontation, which presents experts with a picture of a multi-faceted war. Looking at the situation through the lens of technology, we can observe, for example, that the Ukrainian army has been greatly helped on the battlefield by the crowdsourcing database system provided by the U.S. Company Palantir Technologies.<sup>4</sup> With the help of this system, the Ukrainian forces were able to attack

<sup>3</sup> A collective terminology for technological innovations that strengthen the digital achievements of today. Basically, we can include not only new technologies here, but also already introduced but constantly developing and transforming technologies, such as cloud computing, 5G–6G technologies, various xR solutions (VR, AR, MR implementations), big data, autonomous systems (AS), quantum computing, which, in a good sense, fundamentally shake up almost every segment of the information-digital society of the 21<sup>st</sup> century (PORKOLÁB–HÖNICH 2024).

<sup>4</sup> A mysterious American commercial data analytics and software development company that offers technological implementations for the defence sector, among other things, and is at the forefront of AI development (Palantir Technologies s. a.).

with much greater precision, they had much more information about the opposing side, and they could see Russian positions much better than before.

Previously, the opposite trend was observed. Although it is true that it is not possible to draw such a sharp line in terms of the flow of technology, the transfer of the knowledge base (know-how), because, for example, in the case of AI, the U.S. Department of Defense's research arm, the Defense Advanced Research Projects Agency (DARPA), has also had AI developments in the last 10–15 years.

So, to return to the basic idea, why is it reasonable to say that we are talking about technological innovations that are not so recent? In the case of AI, this factual statement can be based, for example, on the fact that, by turning back the clock, we can recall events that led to the opening of a certain Pandora's box. Namely, that the first AI conference was convened on the East Coast of the United States of America as early as 1956, at which the basic idea of creating AI that would be equivalent or even rival human cognitive abilities was already being mooted.

Similar evidence can be found for the metaverse. The digital world, the virtual projection of physical reality is not without precedent. Although we may not have used this technological terminology at the time, experts agree that WoW, Fortnite, Roblox and Minecraft are already a kind of rudimentary, primary metaverse implementation, which are certainly familiar buzzwords for all Generation Y, Z and Alpha players.

## In the conceptual maze of interpreting the metaverse and AI

In light of all these introductory thoughts, in view of the continuous and exponential technological evolution that has been going on for decades, it is difficult to paddle into the waters of conceptualisation. Regardless of this, however, in order to have a unified interpretation, complex, systemic thinking, and to examine the convergence of these two areas, it is necessary to define a basic terminology for both of the issues examined.

Thus, if we first examine the issue of the metaverse, we can rely on the previous basic concept explanation, which was defined based on my own interpretation. In general, the

"metaverse can be interpreted as a new, large and unprecedented digital world, offering new user experiences and countless opportunities, the next major development milestone of the internet, web 3.0, a virtual universe, partly a digital projection of the world around us, a utopian world influenced by the interaction of users' metacloves (digital twin)".<sup>5</sup>

<sup>5</sup> JOBBÁGY 2022: 134. Digital twin, avatar, metacloves: In my own interpretation, these synonymous terms can be interpreted in various ways depending on their application and usage areas. However, their common characteristic, which helps to define them, is the following: an accurate, virtual representation of a physical object, system, process, etc. in the metaverse, in the virtual space, in such a way that it copies and carries with it almost all the characteristics of the thing it represents. It must 100% reflect what happens in physical reality. Their size can be of different magnitudes depending on their application area and the physical pair to be represented digitally. We can interpret them in terms of the size of a user, an object, a process, or even an entire city.

In an initial interpretation by Mark Zuckerberg, the brainchild of Meta, the metaverse is a vision that is much more than VR, which will affect countless companies that will affect the entire industry and that will not just be about gaming. The metaverse, which is being talked about as the successor to the mobile internet, can also be seen as the internet incarnate, where instead of just looking at content, the user can be part of it, interacting with others. Connecting to it on different device platforms, they can have experiences that are not possible through two-dimensional applications and websites, although he believes that people will first see the potential of the internet through these, in commerce and entertainment. In the metaverse, many physical objects will be mere holograms and users will be able to teleport as holograms.<sup>6</sup>

However, despite all the technological evolution and the billions of dollars spent, Zuckerberg is starting to retreat from the meta-future concept of the metaverse. The reason for this is not so much prosaic as technical: there are still a number of problems, many of which remain unresolved, in terms of creating a fully-fledged, practical utopian world that permeates all aspects of the daily lives of digital users. Furthermore, the main focus of future developments will clearly shift to AI, which is also a more tangible and meaningful EDT technology for the average digital user, much, much closer to their interactions in the digital world. However, we can only make cautious predictions about this, as there is a lot of hype around this tech craze, and we are currently in the summer of the AI seasons.<sup>7</sup> On top of this, at the altar of marketing, developers often sacrifice real technological content in order to make a newer implementation more marketable or to get that coveted superintelligence tag.

This shift in the technological balance is not only the case for Meta, but also for many other technology giants, startups and all the technology-related players that were previously among the biggest advertisers in the metaverse, such as Microsoft, Tencent,<sup>8</sup> Decentraland<sup>9</sup> or even Disney.

Perhaps it is at this point that the basic idea of the present paper might make sense, that it is precisely AI that might save the metaverse from technological extinction, from evolutionary dead-end. Maybe it is the convergence and synergy of the two technologies that could bring the big breakthrough for metaverse, which could be an excellent digital atmosphere, an ecosystem, for a possible use of AI. These may seem bold and overly presumptuous statements, as if they were coming from a futurologist. The explosive development of these technologies cannot be treated as a *fait accompli*, and now we can only envisage the likely technological direction and product, depending on their current development. In any case, the spectacular decline in the number of users of various metaverse implementations and the Google Trends search statistics shown in the picture (Figure 1) all prove that the concept

<sup>6</sup> NEWTON 2021.

<sup>7</sup> Experts often compare the major milestones and intensity of AI technological development to the change of seasons, which is synonymous with its momentum, the hype surrounding it, etc.

<sup>8</sup> It is one of the largest Chinese-owned video game publishers in the world (Tencent s. a.).

<sup>9</sup> A web platform-based 3D virtual world in which users can purchase land for themselves using various virtual currencies (Decentraland s. a.).

of metaverse is in its current state increasingly distancing itself from reality and its rate of development has slowed down. It is in a kind of lifeless state, perhaps due to poor communication, creating a kind of misconception about it in the minds of users, making it difficult for it to penetrate digital society.<sup>10</sup>

For the sake of a broader interpretation, referring to a previous article I wrote on this topic, which at that time was still a completely different guise of ideas related to the metaverse, the following terminology explanations were previously formulated.

According to David Baszucki, CEO of Roblox, the metaverse is a persistent, shared universe of virtual worlds, an online place where users from different walks of life work, play and have fun. According to him, the future metaverse should have eight defining characteristics: an avatar with a virtual identity, social connections, an immersive, reality-destroying experience, high-speed connections, the possibility of adventuring in the virtual world without geographical boundaries, diversity, a vibrant economy, and security and stability. All of these will put the possibility of connecting people on a completely new basis.<sup>11</sup>

Epic Games CEO Tim Sweeney's vision for the metaverse was an expansive, digitised community space, a kind of online playground, the virtual equivalent of the real world, where people could interact with each other and engage in a myriad of activities. He agrees with David Baszucki's view that the metaverse will be created and shaped by users, and that interoperability and a unified technological regulatory framework are essential to achieve this.<sup>12</sup>

Finally, I would like to conclude my thoughts on the terminological discussion with a conceptual interpretation by Jensen Huang, the head of Nvidia. Huang also characterises the metaverse as a kind of virtual world universe, for the realisation of which artificial intelligence (AI) and the evolution of graphic innovations are indispensable, because of which we can reach the 3D extension of the internet.<sup>13</sup>

All these initial conceptual definitions clearly show what kind of future was once envisioned for the metaverse, and what is even more striking is how the development of this technology was transformed in the period following its explosion, which, relying fundamentally on various xR technologies, considered the gaming, entertainment and service industries its primary field of application. Furthermore, there was no real talk at the time about its intertwining with AI technology, although Nvidia's CEO already envisioned such a development trend. In light of the AI developments that are booming today, in my opinion, the need for a joint, mutually influencing examination of these two areas may rightly arise.

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<sup>10</sup> FLACHNER 2023.

<sup>11</sup> TAKAHASHI 2021a.

<sup>12</sup> PARK 2021.

<sup>13</sup> TAKAHASHI 2021b.

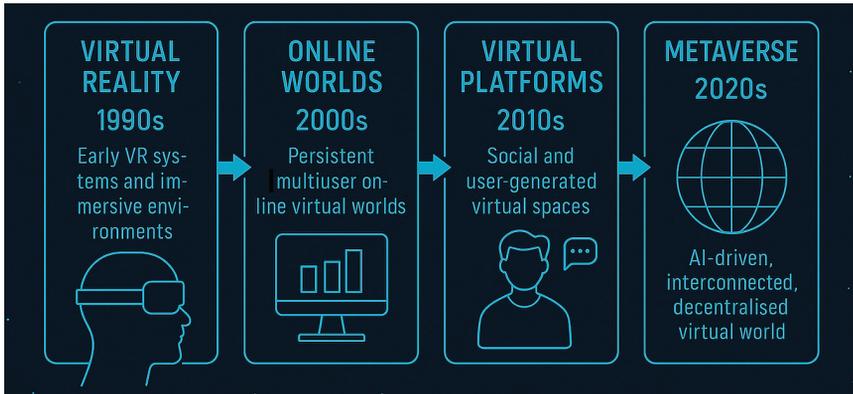


Figure 1: The history of the development of metaverse

Source: Microsoft Copilot

However, before I do all this, I consider it necessary to provide a terminological interpretation of AI, similarly to the conceptual definition of the metaverse. All this in order to be able to map out possible areas of connection and joint development. Furthermore, let us envision a kind of future, taking into account the opinions of experts and the trends of current developments.

Although AI technology has only recently become widely known, like the metaverse, it is not a completely new technological trend. AI developments, although once only in rudimentary form, have been the subject of technological development for several decades. Researchers, developers and professionals are still primarily motivated to try to model human intelligence with the help of machines and to try to automate activities that require human intelligence, such as decision-making, problem solving, or recognising repeating patterns and drawing conclusions based on them. Of course, the goal of mechanising and automating these activities, like the metaverse, was to make people's everyday lives easier and revolutionise certain industries. The first results in this regard were published as early as 1943. Subsequently, more and more innovations appeared in this field, starting with various learning models and ending with the creation of rudimentary neural network computers.

As a result of the increasingly rapid pace of research and development, experts have come to the conclusion that AI should be separated from cybernetics. In response, in 1956, a cybernetics conference held at Dartmouth University in New Hampshire accepted the proposal of John McCarthy, a pioneering expert and visionary of AI, who played a key role in laying the foundations of AI, in a paper. As a result, the term artificial intelligence, which he proposed, is still used today to describe this technology. The essence of this is a machine with intelligence similar to human intelligence, which is able to learn, recognise patterns and make decisions.

The aim of the conference, organised by a specialist with a doctoral degree in mathematics, was precisely to examine the basic philosophy related to AI, the creation of machines capable of intelligent behaviour, with scientific demands. Based on unanimous opinions, we can consider this event as the birth of thinking about

AI, which acted as the engine and driving force of later research and development advances. Among other things, he is credited with developing the LISP (LISt Processing) programming language<sup>14</sup> and creating numerous mathematical models and algorithms. Despite his professional status, or even in parallel with it, he consciously sought to convince and familiarise society with this new technology. Reacting to the criticisms and negative suggestions he received, he sought to draw attention to its responsible, fair, ethical and human values-oriented application and development, taking into account many aspects.

McCarthy thus provided the conceptual and technological framework for AI, which meant the formulation of a vision, the need for a kind of striving for innovation, and the laying of the foundations for the necessary inspiration for this. He created the term itself, designated the main direction in terms of the history of the development of AI, the related dream, the creation of machines with human-level intelligence, the development and creation of general artificial intelligence, superintelligence, is for now only a long-term goal.<sup>15</sup>

After the initial conceptualisation, let us review some of the terminological interpretations used today, highlighting the changes this field has undergone during its nearly 80-year development history, and what factors influenced its development. Another pioneer of great importance in terms of the rise of AI is the British–Canadian computer scientist Geoffrey E. Hinton, Professor Emeritus at the University of Toronto, who received the Nobel Prize in Physics in 2024 for his research on AI. He is one of the three people who are called the godfathers of AI, and who also received the ACM (Association for Computing Machinery)<sup>16</sup> A.M.<sup>17</sup> Turing Award,<sup>18</sup> the computer science equivalent of the Nobel Prize, for his work. In Hinton's formulation, AI is defined as computer systems that perform tasks that typically require human intelligence. Like McCarthy, he also emphasises his concerns about the development of technology, its risks, stating that he is shocked by the intensity of its development rate. According to his statement, contrary to previous forecasts, AI is developing at a much faster and more advanced pace than anyone would have ever thought. This is one of its greatest dangers, which may also carry the possibility that the technology will slip out of human control and, above all, out of the regulatory frameworks aimed at safe application. Therefore, in his opinion, great emphasis should be placed on the regulatory background, which requires a behaviour expected from all actors involved in the technology, whether we look at the technology from the government side, from the developer side, or from the user side. The development of a system more intelligent

<sup>14</sup> It is the oldest programming language developed to facilitate AI research and is still of decisive importance today (LISP s. a.).

<sup>15</sup> SZABÓ 2024.

<sup>16</sup> U.S. based international scientific society, the world's largest scientific and educational computing society (ACM s. a.).

<sup>17</sup> The ACM A.M. Turing Prize is also often referred to as the Nobel Prize in Computer Science. The prize is named after Alan M. Turing, the British mathematician who laid the mathematical foundations of computer science (The ACM A.M. Turing Prize s. a.).

<sup>18</sup> Although John McCarthy is also cited as one of the pioneers of AI, surprisingly his name is not included in this triumvirate. The three pioneers in this respect are Yann LeCun (a leading AI scientist at Meta, staff member of New York University), Geoffrey E. Hinton and Yoshua Bengio (staff member of Microsoft, IBM and McGill University) (The ACM A.M. Turing Prize s. a.).

than humans, the creation of so-called superintelligence, carries enormous dangers if it is not used properly and in a sufficiently regulated, safe manner, not to mention the possibility of it falling into the wrong hands.<sup>19</sup>

We could continue the endless list of the most famous AI experts and their opinions on the definition of technology. Instead, let us take a brief look at the situation in Hungary in this regard.

One of the documents of decisive importance in this regard is the Artificial Intelligence Strategy of Hungary 2020–2030, which, among other things, uses the following two conceptual definitions regarding AI: “Artificial intelligence (AI) as a set of algorithmic systems capable of learning and improving themselves based on input data.”<sup>20</sup> On another page of the strategy, we can read the following terminological interpretation:

“Artificial intelligence is software suitable for mapping some part of human intelligence, which is able to support or autonomously perform perception, interpretation, decision-making or action processes. A technology that has special capabilities, nevertheless receives special attention both at the economic and social levels.”<sup>21</sup>

The strategy also clearly states that when it comes to the interpretation of AI, we mean narrow AI systems capable of mapping only one area of human intelligence. Research on general AI is still so rudimentary and underdeveloped that these conceptual explanations are probably not clearly equivalent to it.

We can also read numerous terminological explanations in relevant documents on the international scene regarding the interpretation of AI. One of the prominent regulators is the EU AI Act issued by the European Union, which states as follows:

“‘AI system’ means a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments.”<sup>22</sup>

The significance of AI's impact on the defence sphere is demonstrated by NATO's strategic engagement with the technology. As a result, in October 2021, following a meeting of member countries' defence ministers in Belgium, it published the first version of this strategy, followed by a second revised version in 2024. In the alliance's short, concise and to the point definition, “AI is the ability of machines to perform tasks that typically require human intelligence”.<sup>23</sup> Based on NATO's dual view, this new technology will have a fundamental impact on both the global defence and security environment, as a result of which it can provide a technological advantage on the one hand, but also present member countries with new challenges and threats, with a combined impact on the pillars of collective defence, crisis management and cooperative security. What is also a welcome moment in this strategic framework,

<sup>19</sup> MILMO 2024.

<sup>20</sup> Ministry of Innovation and Technology 2020: 6. Translated by the author.

<sup>21</sup> Ministry of Innovation and Technology 2020: 9. Translated by the author.

<sup>22</sup> European Parliament 2024.

<sup>23</sup> STANLEY-LOCKMAN – HUNTER CHRISTIE 2021.

as a formulated strategic goal, is, among other things, the safe and responsible application of technology for defence and security purposes, emphasised as the stated intention of all experts, researchers, developers and all stakeholders. In addition, this principle is accompanied by strategic objectives such as the acceleration and general dissemination of the application of AI in capability development, the need to protect self-developed AI technologies and related innovation capabilities, and the need to identify threats arising from the malicious use of AI by state and non-state actors and to create effective protection against them.<sup>24</sup>

Starting from all this terminological reasoning, it can be seen that almost all definitions and explanations include the main characteristics attributed to this technology – mapping human intelligence, pattern recognition, decision-making, etc. –, which sufficiently define and, in their complexity, frame its nature and perhaps its right to exist. In addition to all this, what perhaps all unanimous opinions welcome is that we must strive for the possibility of using this new opportunity responsibly, safely, consciously and in a way that serves the purpose of humanity.

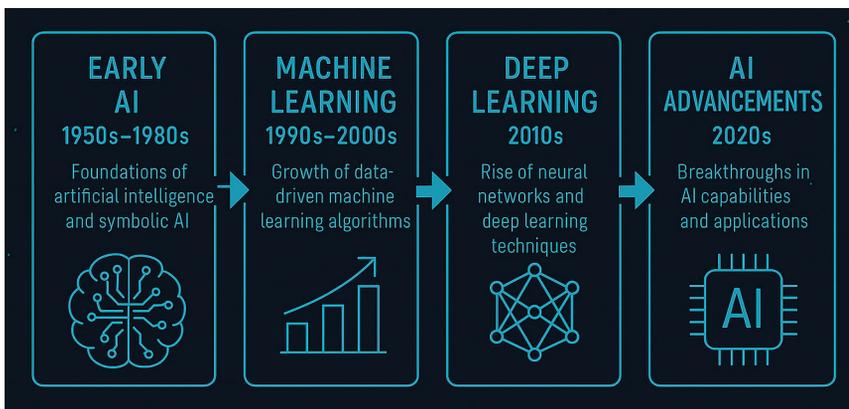


Figure 2: The history of the development of AI

Source: Microsoft Copilot

## The synergy of the metaverse and AI

After we have managed to put some order in the conceptual maze of the metaverse and AI, and to establish the underlying content of the technologies involved on a theoretical level, in connection with the ideas formulated in the introduction, let us review what new opportunities and possible directions these two innovations, which have permeated and defined our time to such a significant extent, offer each other. Do they need each other at all, do they give each other something new and different, is there a new potential brewing, or is it just another great epoch-making madness that, after a while, will suffocate under the current over-mystified state, leading to a dead end and sinking into stagnation and complacency?

<sup>24</sup> NATO 2021.

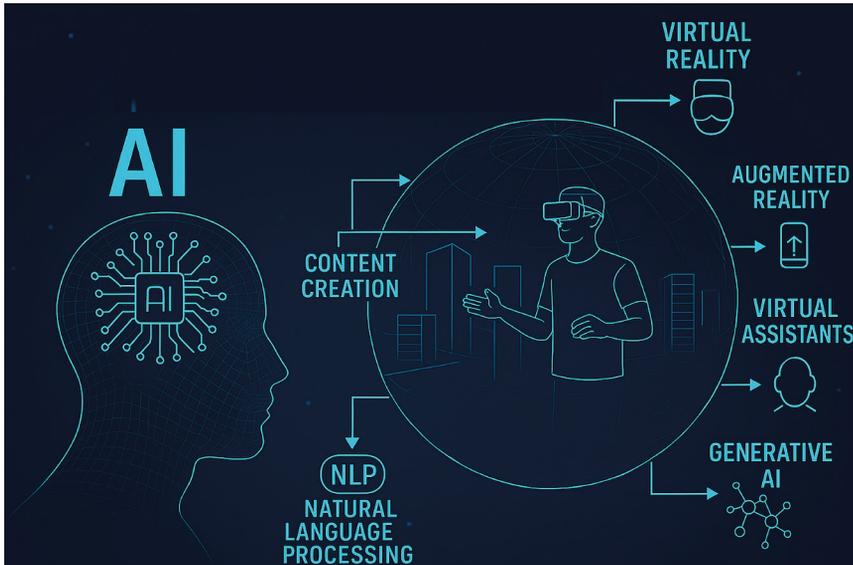


Figure 3: The convergence of AI and the metaverse

Source: Microsoft Copilot

As Figure 3 tries to illustrate in a simplified way, we can certainly conclude that we cannot draw a sharp and clear dividing line between them, as they each carry with them a myriad of new technological opportunities and perspectives, which, through their synergy, could lead to significant breakthroughs in almost all areas of our digital world. In my opinion, their technological impact on each other is unquestionable. It is obvious to everyone that one of the main building blocks of the metaverse is the digital projection of our real physical being, the appearance of our own digital clone in a collective virtual space, connected with the help of the new great era of the internet, Web 3.0, realised as a result of physical reality and virtual space, relying on various xR technologies. The interaction of these digital avatars, interwoven with intelligent behavioural patterns, with each other or with real users in the metaverse, controlled by AI, can result in the implementation of an ever more enhanced, more lifelike digital user experience.

With the help of AI, we can generate significantly more realistic, complex, dynamically changing, intelligent digital environments than before. In contrast to the previous manual planning, design and 3D modelling, these processes can be automated and optimised with the help of generative AI. As a result, digital content production becomes significantly simpler and more diverse in terms of customising both the world of the metaverse and the digital characters appearing in it.

At the same time, this digital space can offer, among other things, an excellent development environment, a kind of digital ecosystem for the development and improvement of AI. It can result in a data set, big data and a continuous data flow for AI professionals, who as a result can test the self-learning process of AI much

more freely, flexibly, and by pushing the physical or virtual limits of the available possibilities in a way never seen before. All the training sets, generated or injected data that are essential for teaching AI can be generated, injected and transformed much more easily in such a digital environment according to the needs and the pace of development of technology. Overall, the metaverse can be an excellent teaching and simulation incubator for technologies, tools and services permeated by AI.

We can witness this kind of powerful intertwining in everyday life because of the emergence of AI and metaverse implementations, such as the emergence of various digital assistants and teachers in order to revolutionise language learning, but also any learning and knowledge acquisition process. As a result of this kind of intertwining, in the metaverse, translation programmes supported by different AI models eliminate language barriers between digital avatars of different nationalities, thus expanding the interactions that can be interpreted in it between users.

If we examine the possible application areas of each technology, we cannot draw a clear and distinct boundary line to separate these two technologies. Although initially, as I mentioned in my previous relevant publication, the metaverse was predicted to gain ground in the service, entertainment and gaming industries, this vision has been significantly re-evaluated and transformed today. Because of the various metaverse implementations, its appearance can already be seen to a significant extent in industry, healthcare, education, training, etc., among others. In addition, the impact of AI on the industrial segment, the economy, medical diagnostics or research–development–innovation, etc. is also indisputable. As a result of these developments, for example, in manufacturing processes, in the diagnosis of various diseases, in the planning of treatments, in scientific research, in various economic transactions and processes, the degree of autonomy, efficiency and optimisation of various processes can be increased to an unprecedented extent.

We must also not forget that the convergence of these technologies may result in not only a significant transformation of existing professional fields, but also the creation of new ones because of the creative power of technology. They may result in the development of new professions, specialists, expertise and professional competencies that have not been needed until now, or that must be fundamentally reinterpreted and transformed. It is no coincidence that the need for programmers to identify with the approach that AI should not be programmed, but taught, appears as a new expectation. Moreover, if we interpret all this teaching process under the protective umbrella of security, then the emphasis should be on human-centred teaching of algorithms.

Speaking of ethical behaviour, we can also predict the emergence of new professionals and fields of expertise that will be responsible for developing the ethical behaviour of AI, or for creating a kind of digital legal culture and regulatory environment.

The creativity of professionals, which focuses on creating and shaping virtual worlds, or on how we can harmonise and fine-tune the interactions between digital twins and real users, may also gain new meaning.

The emergence of this kind of creativity will not only be evident in the development of the visual world of the metaverse, but also in the world of fine arts, music and other areas of culture, where average users, supported by these technologies, can

unleash their imagination and creativity, take their self-expression to new heights, and they can realise their full potential.

The synergy of these two technologies will certainly bring about the explosive development of related technologies, the emergence of new devices and the spread of new services. For example, in the case of the metaverse, the technological spread has long been hampered by the development of the necessary equipment – various xR devices – their cost, the supporting software platform, and other technical obstacles, such as the wearability of these devices and their user ergonomic design. Nowadays, all of these are available in an increasingly mature form and at increasingly affordable prices. Moreover, many, mainly Chinese developers – such as DeepSeek<sup>25</sup> cloud-based AI – are trying to circumvent the fact, with more or less success, that the development of AI costs, say, billions of dollars, or that it would require extremely expensive hardware with enormous processing power.

What is certain is that creating an immersive metaverse and operating the AI that supports it necessitates huge computing capacity, a resilient, stable, digitally based and converged network infrastructure, and the availability of hardware and software infrastructure capable of serving it. In the case of AI, such related areas include, among others, the development of certain programming languages, such as Python, as one of the basic pillars of AI development.

The globalisation of the 21<sup>st</sup> century will reach a new level with the help of these technologies, as because of these technologies, almost all obstacles such as geographical borders, physical distances and language barriers will disappear, and collaboration will reach a higher level than ever before. This kind of blurring and mutual, shared thinking, everyday activity and work were already present in the metaverse from the beginning. Let us just think of the previously mentioned service, gaming and entertainment industries, and the creation of virtual shopping malls, virtual concerts or conference rooms in this digital world that still seemed utopian at the time.

In the case of AI, an interesting and increasingly popular area of application in the repertoire of application areas can be its use in global climate research and climate change. In this segment, the technology can help us in processing the available big data, making forecasts, and, let us hope, in creating urgent, effective solutions, if you like, emergency scenarios. Complementing this with the possibilities of the metaverse, as in a simulated laboratory, the causes, results and effects of extreme changes in the weather become interpretable and verifiable in a tangible way, as well as the measures applied against them, the expected results of the decisions made, and various scenarios and their outputs can be tested in a simulated virtual environment. This is

<sup>25</sup> A startup that grew out of the High-Flyer Capital Management hedge fund and was founded in 2023 by Liang Wenfeng. Wenfeng's primary goal was to connect AI and the financial sector. However, he subsequently separated the AI segment from the financial part by founding DeepSeek. He has already introduced new AI implementations such as DeepSeek Coder, DeepSeek LLM, DeepSeek Chat, DeepSeek V2 and V3. However, the real breakthrough was the R1 model, which debuted in early 2025, which is a reasoning-based AI technology (DeepSeek s. a.).

similar to the industrial metaverse,<sup>26</sup> where, for example, various production processes can be designed, simulated, tested, optimised and automated in virtual factories.

## Closing thoughts

The explosive development of AI technology is being hailed as a new industrial revolution. However, one of the biggest differences between this technological revolution and the previous ones is that while in the case of the previous three major industrial revolutions, humanity had time to prepare for the technological and technical innovations that changed their everyday lives, in the case of AI, we can witness an intensity of development that surpasses even the vision of experts, researchers, professionals and developers, for which there is almost no or very little time available to prepare. This creates an interesting paradox, since we ourselves, humans, are the creators of everything. At the same time, what is unusual in this regard is that if the technological singularity<sup>27</sup> (or artificial superintelligence) occurs, which in this case means the creation of an AI that surpasses our capabilities, then how can it be imagined that a creator with a lower level of intelligence will want to control, regulate and keep within limits a system that is much more intelligent than him. We must therefore be very careful in this regard. Furthermore, the much-mentioned lifelong learning will really make sense now, if ever. After all, the development of AI does not require natural resources, but only the available human resource competencies will provide and overcome its limitations.

In addition to all this, we must also keep ethical issues in mind in order to use it responsibly, safely and within a regulated framework. We must raise user safety, data protection, the possibility of attribution and accountability of decisions made by AI in the metaverse to an unprecedented level. Although one of the keys to the survival or renewal of the metaverse is, for example, the pursuit of personalised experiences as a result of the effective application of AI, this can also carry dangers such as the analysis of users' behaviour for non-ethical purposes, the mapping of their personalities, and profiling, which can result in them becoming victims of various attacks, harassment

<sup>26</sup> A metaverse implementation in which the digitalisation and optimisation of the industrial segment, supported by AI technology, with innovative solutions to increase production efficiency and supply chain security is the primary goal. This includes, for example, the mapping of production lines, production processes, manufacturing technology, prototyping, testing, product development, research and innovation, production support, standardisation, quality assurance, business development, etc. into virtual space. In addition, workers, development engineers, industrialists can of course actively and collaboratively engage all these processes, either in their physical reality through the various xR technologies or through the interaction of their digital clones. As a result, for example, unprecedented horizons can be opened up not only for the participation of workers in specific work processes, but also for their training, education and coaching processes (Industrial Metaverse s. a.).

<sup>27</sup> It is a future period during which the pace of technological change will be so rapid, its impact so deep that human life will be irreversibly transformed. Although neither utopian nor dystopian, this epoch will transform the concepts that we rely on to give meaning to our lives, from our business models to the cycle of human life, including death itself. Understanding this Singularity will alter our perspective on the significance of our past and the ramifications for our future. To truly understand it inherently changes one's view of life in general and one's own particular life (KURZWEIL 2006).

and manipulation. All of this can also raise the awareness of a kind of reinterpreted law-abiding behaviour and the dilemma of legal accountability in this case.

One thing is certain, no matter through which lens we examine the potential of the interaction of technologies, one of the most important factors in their adoption and penetration at the level of the information-digital society will be trust in them, unlimited accessibility, the development of user awareness and the acquisition of the necessary competencies.

In my opinion, especially in the case of AI, we can talk about a technological innovation that almost no user will be able to avoid interacting with, regardless of the different user generations. Thus, these technologies will certainly be part of the everyday lives of all ages and social groups in some form. As a result, although in some cases we protest against it, we must at some level know and make friends with the positive effects of these technologies for humanity – let us trust in them. Of course, without falling overboard and becoming completely dependent on these technological innovations.

In terms of the topic under study, one of the key moments will probably be the level and form at which they will be able to develop together, interact with each other, open up new horizons of innovation, digitalisation and connectivity, and revolutionise new major breakthroughs in their own and related technologies. In addition, to do all this in a way that will serve the long-term and lasting benefit of humanity, dominating the course of technological development. We trust that as a result of symbiosis, we will be witnesses and active participants of a technological development that will result in a hybrid implementation in which one technology benefits from the impact of the other, they mutually influence each other's development, and their development and the opportunities they offer will have some positive added value for all involved.

Overall, if we wanted to summarise the expected main benefits of the synergy of the metaverse and AI in a few thoughts, then without claiming to be exhaustive, we could attach the following adjectives to the new technological future that will emerge as a result of their symbiosis: automation, optimisation, efficiency enhancement, creativity, innovation, boundlessness, unrestrictedness, collaboration, connectivity, simulation, decision support and problem solving.

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