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Google Bard Generated Literature Review: Metaverse

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Research Article

Abstract

Literature review articles aim to present studies in a field to researchers in a regular, systematic and meaningful way. It is often a very difficult process to reach all the studies in the field to be reviewed or to identify and evaluate the important ones. With this study, the use of Artificial Intelligence robots and moreover generative artificial intelligence in literature review processes is evaluated. Google Bard was used to detect artificial intelligence's ability to generate a literature review article. First, Bard was asked questions to write about some of the Metaverse-related topics in this article. Some of the texts in the study were generated entirely by the answers given to the questions asked by Bard. In addition, 10 articles on Metaverse published in the last three years (2021, 2022 and 2023) were collected by searching Google Scholar with the word "Metaverse". Afterwards, these studies were interpreted by Bard. Bard was told to paraphrase the summary parts of the related studies and the produced texts were shared in the study. All produced texts were checked through iThenticate and the results were evaluated. In addition, the texts were evaluated semantically. Additionally, a comparison with the capabilities of OpenAI ChatGPT is given. The results are promising; however, it was observed that the plagiarism matching rate of the paraphrased texts was higher when compared to the answers given to the questions. This article is an experiment to show that the collection and expression of knowledge can be accelerated with the help of artificial intelligence. It is considered that the relevant tools will be used more and more effectively in academic literature in the future.

Keywords: Google, Google Bard, Lambda, OpenAI ChatGPT, Artificial Intelligence, Metaverse, Academic writing, literature review

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1. INTRODUCTION

Google Bard AI is a text-based artificial intelligence chatbot. Bard generates real-time answers using natural language processing and machine learning. The company says Bard can help with creative tasks, explaining complex topics, and generally extracting information from a variety of sources on the internet. It can also answer complex questions like finding recipes that fit the ingredients in your fridge. You can't answer such questions today using only a Google search. Bard turns Google from a humble search engine into a capable virtual assistant (Aguilar, 2023).

Google Bard is built on the Pathways Language Model 2 (PaLM 2), a language model released in late 2022. PaLM and its predecessor, Google's Language Model for Dialogue Applications (LaMDA) technology, are a language model released by Google in 2017. The neural network architecture is based on the Transformer. Transformer has served as the foundation for several effective AI tools, like the GPT-3 language model used in ChatGPT, ever since Google made it available as open source. Bard was created by considering search. It tries to make natural language search queries more prevalent in place of keywords. Bard's AI is honed via natural-sounding voice questions and answers. It provides the context of the answers, rather than just giving a list of answers. It's also intended to assist with follow-up queries, which is a novel search feature. In order to grow to many concurrent users, Bard's original edition of LaMDA employed a lighter model version that needed less processing resources. The inclusion of the PaLM language model allows Bard to be more visual in its responses to user queries (Patrizio, 2023).

Studies using different productive artificial intelligence tools (Aydin & Karaarslan, 2022) have taken place in the literature. In addition, in the literature reviews and evaluations, productive artificial intelligence and chat robots may have applications in different areas and the existing applications were grouped according to their operations (Aydin & Karaarslan, 2023). The purpose of this paper is to determine whether an academic literature review article on Metaverse can be written using an artificial intelligence chatrobot and whether the resulting text possesses qualities like originality and academic substance. In this study, all content except the "Abstract", "Introduction", "Method", "Findings and Results" and "Conclusion" subsections was created by Google Bard. The research cited to this article will be reviewed, and the efficacy and academic validity of the article will be interpreted through the citations, after the necessary sample size for the citations to this article is attained (at least 100 journal article citations).

The contribution of this study to the literature can be explained as follows. Artificial intelligence is used in many fields today. In addition, it continues to expand into new areas of use. One of the uses of artificial intelligence is to create academic articles or to assist authors in this process. Preparing especially the literature part of academic articles often costs a lot of effort and time for the authors. At this point, Artificial Intelligence can summarize the studies in the literature for the authors and present the needed information in an organized and concise manner. In this study, it is desired to evaluate this capability of generative artificial intelligence. Although there are examples of ChatGPT in previous studies (Aydin and Karaarslan, 2022; Rahman et al., 2023a, Libório et al., 2023), no study has been revealed about Google Bard yet. In this sense, the deficiency in the literature will be eliminated by evaluating the competence of Google Bard.

2. METHOD

In the method section of the study, it would be appropriate to share the materials, software and tools used in the study and how they were prepared and used, the research process, and how the measurements and evaluations were made.

The Google Bard Generative AI tool was used in the study. The related tool has recently been made available to everyone free of charge. You can access the vehicle via <https://bard.google.com> and access the system with your Google account, if any. If you do not have an account, you can use the system by creating a free



account.

It is helpful to state the study's goal once again. A good illustration of how artificial intelligence may yield outcomes in academic paper writing is Google Bard. I want to make sure that a paper is authored by artificial intelligence at a fundamental level and then I want to examine its academic reliability. For this reason, it was decided that Google Bard should be used to interpret the abstracts of the results from a search on the topic (Metaverse) that I chose as a research approach on Google Scholar. Also "*What is the Metaverse?*" Google Bard was asked to answer the question. These two titles are placed after the literature title in the article.

Google Bard was asked to paraphrase the abstracts of the articles. A question was asked to Google Bard as "*Paraphrase this article abstract 'Abstract text is here'*". Google Bard replied this question as "*Sure, here is the paraphrased abstract: 'Paraphrased abstract is here'*".

An authentic plagiarism detection tool is used to examine texts written by paraphrasing using Google Bard and texts produced by the response of a question. An assessment is made about the degree of similarity to earlier research as a result of the evaluation.

It was decided to assess the academic validity of this study using the following methodology. This paper will be published on preprint environments such as SSRN, Arxiv, Techrxiv, Researchgate, Academia. We'll keep track of citations to this paper. After receiving a predetermined amount of citations (for instance, 100 journal article citations), these papers will next be analyzed and reviewed. The comments and criticisms in these quotations will be used to assess the academic validity of the text created by Google Bard.

3. LITERATURE REVIEW

The metaverse is a virtual universe that merges physical and digital reality. It is a persistent and ever-changing environment that allows users to interact with each other and with digital content in a variety of ways. The metaverse is made possible by the convergence of technologies such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI).

The first iteration of the metaverse was a web of virtual worlds where users could create and interact with their own avatars. The contemporary iteration of the metaverse is more immersive and social, and it features social VR platforms, massive multiplayer online games, and AR collaborative spaces.

The metaverse has the potential to revolutionize the way we live, work, and play. It can be used for education, training, entertainment, and even social interaction. The metaverse is still in its early stages of development, but it has the potential to become a major part of our lives in the future.

Here are some additional details about the metaverse (Ning et al., 2023; Wang et al., 2022; Laeeq, 2022; Damar, 2021; Mystakidis, 2022):

It is a persistent and ever-changing environment. This means that it is always evolving and growing, and there is always something new to explore.

It is immersive and social. Users can interact with each other and with digital content in a variety of ways, including through VR and AR.

It is powered by new technologies. The metaverse is made possible by the convergence of technologies such as VR, AR, and AI.

It has the potential to revolutionize the way we live, work, and play. The metaverse can be used for education, training, entertainment, and even social interaction.

The metaverse is still in its early stages of development, but it has the potential to become a major part of our lives in the future. It is an exciting new technology with the potential to change the way we interact with



the world around us (Mystakidis, 2022).

The metaverse is a new paradigm for the next-generation Internet. It is a fully immersive, hyper spatiotemporal, and self-sustaining virtual shared space where humans can play, work, and socialize. The metaverse is made possible by recent advances in emerging technologies such as extended reality (XR), artificial intelligence (AI), and blockchain.

The metaverse has the potential to revolutionize the way we live, work, and play. However, there are also security and privacy concerns that need to be addressed before the metaverse can be widely adopted.

This paper presents a comprehensive survey of the fundamentals, security, and privacy of the metaverse. The paper first investigates a novel distributed metaverse architecture and its key characteristics with ternary-world interactions. Then, the paper discusses the security and privacy threats, presents the critical challenges of metaverse systems, and reviews the state-of-the-art countermeasures. Finally, the paper draws open research directions for building future metaverse systems.

The paper concludes that the metaverse is a promising new technology with the potential to change the way we interact with the world around us. However, there are also significant security and privacy concerns that need to be addressed before the metaverse can be widely adopted.

Here are some of the key security and privacy concerns that need to be addressed in the metaverse:

Privacy: The metaverse is a highly immersive environment where users can share a lot of personal information. This information could be used to track users, target them with ads, or even steal their identity.

Security: The metaverse is a complex system with many potential attack vectors. Hackers could steal users' data, disrupt the metaverse, or even take control of users' avatars.

Interoperability: The metaverse is still in its early stages of development, and there is no single standard for how it should work. This could make it difficult for users to move their data and assets between different metaverse platforms.

The paper discusses a number of potential solutions to these security and privacy concerns. These solutions include:

Privacy-preserving technologies: These technologies can be used to protect users' personal information while they are in the metaverse.

Security mechanisms: These mechanisms can be used to protect the metaverse from attack.

Interoperability standards: These standards can help to ensure that different metaverse platforms can work together.

The paper concludes that the metaverse is a promising new technology with the potential to change the way we interact with the world around us. However, there are also significant security and privacy concerns that need to be addressed before the metaverse can be widely adopted (Wang et al., 2022).

The metaverse is a hypothesized iteration of the internet as a single, universal and immersive virtual world that is facilitated by the use of virtual reality and augmented reality headsets. The metaverse has the potential to revolutionize the way we live, work, and learn. In education, the metaverse could be used to create new and immersive learning experiences that are more engaging and interactive than traditional methods.

There are four main types of metaverses: augmented reality (AR), lifelogging, mirror world, and virtual reality (VR). AR is a technology that overlays digital information onto the real world, while VR is a technology that



creates a fully immersive virtual world. Lifelogging is a technology that records a person's life in real time, and mirror worlds are digital representations of the real world.

The metaverse has the potential to revolutionize education in a number of ways. First, it can be used to create new and immersive learning experiences that are more engaging and interactive than traditional methods. For example, students could use AR to learn about different historical periods by overlaying digital information onto real-world objects. Or, they could use VR to explore different parts of the world without ever leaving their classroom.

Second, the metaverse can be used to create more collaborative learning experiences. Students can work together on projects in a virtual space, and they can even interact with experts from around the world. This can help students to develop their critical thinking and problem-solving skills.

Third, the metaverse can be used to provide students with access to resources that would not be possible in the real world. For example, students could use the metaverse to visit museums, libraries, and other educational institutions without ever leaving their home.

However, there are also some potential limitations to the use of the metaverse in education. First, the metaverse can be expensive to develop and maintain. Second, it can be difficult to ensure that the metaverse is used in a safe and ethical way. Third, there is a risk that the metaverse could be used to isolate students from the real world.

Despite these limitations, the metaverse has the potential to revolutionize education. With careful planning and implementation, the metaverse can be used to create new and innovative learning experiences that will benefit students of all ages.

Here are some future tasks that are suggested for the educational use of the metaverse:

Teachers should carefully analyze how students understand the metaverse. This will help teachers to design effective learning experiences that take advantage of the metaverse's unique capabilities.

Teachers should design classes for students to solve problems or perform projects cooperatively and creatively. The metaverse can be used to create a collaborative learning environment where students can work together to achieve common goals.

Educational metaverse platforms should be developed that prevent misuse of student data. This will help to protect students' privacy and ensure that their data is used in a safe and ethical way.

The metaverse is a new and emerging technology with the potential to revolutionize education. With careful planning and implementation, the metaverse can be used to create new and innovative learning experiences that will benefit students of all ages.

Here are some specific examples of how the metaverse could be used in education:

In medical school, students could use AR to learn about human anatomy. They could overlay digital information onto real-world objects, such as cadavers, to see inside the body.

In engineering school, students could use VR to design and test new products. They could create a virtual prototype of a product and then test it in a virtual environment.

In business school, students could use the metaverse to simulate real-world business situations. They could create a virtual company and then run it through different scenarios.

These are just a few examples of how the metaverse could be used in education. As the technology continues to develop, we can expect to see even more innovative and exciting applications (Kye et al., 2021).

The metaverse, a new buzzword that has caught the attention of both industry and academia, seamlessly



integrates the real world with the virtual world. It allows avatars to engage in a variety of activities, including creation, display, entertainment, social networking, and trading. The metaverse has the potential to create an exciting digital world and transform the physical world for the better.

This survey explores the metaverse by discussing how blockchain and artificial intelligence (AI) are being integrated into it. We investigate the state-of-the-art research on metaverse components, digital currencies, AI applications in the virtual world, and blockchain-empowered technologies. We believe that further research on the integration of AI and blockchain into the metaverse will require collaboration between academia and industry. We hope that this survey will help researchers, engineers, and educators build an open, fair, and rational future metaverse.

Here are some of the key points from the abstract:

The metaverse is a new virtual world that seamlessly integrates the real world with the virtual world.

Avatars in the metaverse can engage in a variety of activities, including creation, display, entertainment, social networking, and trading.

The metaverse has the potential to create an exciting digital world and transform the physical world for the better.

Blockchain and AI are being integrated into the metaverse to create a more secure, immersive, and interactive experience.

Further research on the integration of AI and blockchain into the metaverse will require collaboration between academia and industry.

We hope that this survey will help researchers, engineers, and educators build an open, fair, and rational future metaverse (Yang et al., 2022).

Previous studies on the metaverse focused on Second Life, a virtual world where users can create their own avatars and interact with other users. However, the current metaverse is based on the social values of Generation Z, who believe that their online and offline selves are not different.

The development of deep learning-based high-precision recognition models and natural generation models has made it possible to create more realistic and immersive metaverse experiences. Additionally, the rise of mobile devices has made it possible for users to access the metaverse from anywhere.

The integration of enhanced social activities and neural-net methods requires a new definition of the metaverse that is different from the previous definition. This paper proposes a new definition of the metaverse that is based on three components: hardware, software, and content. The paper also proposes three approaches to implementing the metaverse: user interaction, implementation, and application.

The paper then describes essential methods based on the three components and techniques to the metaverse's representative Ready Player One, Roblox, and Facebook research in the domain of films, games, and studies. Finally, the paper summarizes the limitations and directions for implementing the immersive metaverse as social influences, constraints, and open challenges.

Here are some of the key points from the abstract:

The current metaverse is based on the social values of Generation Z.

The development of deep learning-based high-precision recognition models and natural generation models has made it possible to create more realistic and immersive metaverse experiences.

The rise of mobile devices has made it possible for users to access the metaverse from anywhere.



The integration of enhanced social activities and neural-net methods requires a new definition of the metaverse.

The metaverse can be defined as a three-component system consisting of hardware, software, and content.

The metaverse can be implemented using three approaches: user interaction, implementation, and application.

The metaverse has limitations and challenges, such as social influences, constraints, and open challenges (Park & Kim, 2022).

The metaverse is a virtual world that has been discussed in the literature since the 1990s. However, it has recently gained popularity due to Mark Zuckerberg's press release about Facebook's plans to invest in the metaverse.

This study presents a bibliometric evaluation of metaverse technology. A field study was conducted to collect data on journals, institutions, prominent researchers, and countries in the field. The study found that there have been few studies on the metaverse in the past, but its popularity has increased in recent months. The study also found that the metaverse is being researched intensively in the fields of virtual reality, augmented reality, education, and digital marketing.

The study concludes that the metaverse is likely to become a major part of our lives in the next 15-20 years. It has the potential to revolutionize the way we work, learn, play, and interact with each other.

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The metaverse is a virtual world that has been discussed in the literature since the 1990s.

It has recently gained popularity due to Mark Zuckerberg's press release about Facebook's plans to invest in the metaverse.

A bibliometric evaluation of metaverse technology found that there have been few studies on the metaverse in the past, but its popularity has increased in recent months.

The metaverse is being researched intensively in the fields of virtual reality, augmented reality, education, and digital marketing.

The study concludes that the metaverse is likely to become a major part of our lives in the next 15-20 years. It has the potential to revolutionize the way we work, learn, play, and interact with each other (Damar, 2021).

The metaverse is a virtual world that people can interact with using augmented and virtual reality devices. It was first conceptualized about 20 years ago, but it has only recently gained popularity due to the efforts of social media giants and big technology companies.

The first applications of the metaverse were computer games that consisted of virtual worlds. Gaming companies were racing to offer more unique experiences to their users. Now, the metaverse is being touted as the future of the internet, and it is attracting the attention of the wider masses.

The concept of the metaverse has been the subject of academic studies in many different fields, from literature to art, from music to education. In this review article, a total of 40 journal articles containing the "metaverse" keyword in all fields in the Web of Science database were examined in terms of content and method. The outputs of this study provide a brief overview of the research area to both researchers and technology developers.

Here are some of the key points from the abstract:



The metaverse is a virtual world that people can interact with using augmented and virtual reality devices. It was first conceptualized about 20 years ago, but it has only recently gained popularity due to the efforts of social media giants and big technology companies.

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The concept of the metaverse has been the subject of academic studies in many different fields.

This review article provides a brief overview of the research area to both researchers and technology developers (Narin, 2021).

Social media data is a popular research subject, as it can provide insights into public opinion on events, situations, and concepts. In this study, the authors analyzed tweets about the metaverse, a virtual world that is being touted as the future of the internet.

The authors collected tweets that were sent in English with the hashtag "#metaverse" on Twitter one week before and after Mark Zuckerberg announced that his company, Facebook, would change its name to Meta. They then used sentiment analysis to analyze the tweets and determine the overall sentiment of the public towards the metaverse.

The results of the study showed that the public's sentiment towards the metaverse was mostly positive. The majority of tweets were either neutral or positive, with only a small number of negative tweets. The authors concluded that the public is generally optimistic about the metaverse and its potential to revolutionize the way we interact with the internet.

Here are some of the key points from the abstract:

Social media data can be used to gain insights into public opinion on events, situations, and concepts.

The metaverse is a virtual world that is being touted as the future of the internet.

The public's sentiment towards the metaverse is mostly positive.

The metaverse has the potential to revolutionize the way we interact with the internet (Ağralı & Aydın, 2021).

The metaverse is a virtual space where users can interact, create, and transact with digital assets. It represents a new frontier in human interaction and commerce, but it also presents a number of legal challenges.

One of the biggest challenges is intellectual property (IP). In the metaverse, users can create and share all sorts of IP-protected content, such as music, art, and videos. It is not yet clear how existing IP laws will apply to the metaverse, or how new laws will need to be created to protect IP in this new environment.

Another challenge is privacy. The metaverse is likely to collect and store a lot of personal data about users. This data could be used for a variety of purposes, such as targeted advertising or tracking users' movements. It is important to ensure that users' privacy is protected in the metaverse.

Finally, there is the issue of jurisdiction. The metaverse is not limited by physical borders, so it is not clear which laws will apply to it. This could lead to conflicts between different legal systems, and it could make it difficult to enforce laws in the metaverse.

The paper concludes by calling for interdisciplinary approaches to understanding and addressing the legal challenges of the metaverse. It also emphasizes the importance of creating specific laws, regulations, and policies that will balance the competing interests of different stakeholders.



Here are some of the key points from the paper:

The metaverse presents a number of legal challenges, including IP, privacy, and jurisdiction.

It is important to develop new laws and regulations to protect users' rights in the metaverse.

Interdisciplinary approaches are needed to understand and address the legal challenges of the metaverse.

It is important to balance the competing interests of different stakeholders in the metaverse (Kalyvaki, 2023).

The metaverse is a digital world where users can interact with each other and with virtual objects. It is often described as a "virtual reality" or "augmented reality" version of the internet. The metaverse has the potential to revolutionize education by making it more immersive, interactive, and accessible.

This study outlines the principles and approaches that can be used to transform education using the metaverse. The study uses a qualitative method to analyze the potential benefits of the metaverse for education. The study also outlines ten key techniques that can be used to create a quality metaverse education experience.

The study concludes by proposing a model of a metaverse classroom that can be used for group discussions, seminars, thesis meetings, and presentations. The study argues that the metaverse has the potential to improve education by engaging more students from developing and under-developed countries, and by providing more facilities and quality education.

Here are some of the key points from the study:

The metaverse has the potential to revolutionize education by making it more immersive, interactive, and accessible.

The metaverse can be used to create a more engaging and interactive learning experience.

The metaverse can be used to provide more personalized learning experiences.

The metaverse can be used to make education more accessible to students from all over the world.

The study concludes by calling for further research into the potential of the metaverse for education (Rahman et al., 2023b, Ning et al., 2023; Chengoden et al., 2022; Talan and Kalinkara, 2022; Han et al., 2023; Kaddoura and Al Hussein, 2023).

4. METAVERSE

Author: "Please define and explain the metaverse for my article"

Google Bard: "Sure, here is a definition and explanation of the metaverse that you can use for your article:

The metaverse is a hypothesized iteration of the Internet as a single, universal and immersive virtual world that is facilitated by the use of virtual reality (VR) and augmented reality (AR) headsets. In colloquial usage, a "metaverse" is a network of 3D virtual worlds focused on social and economic connection.

The metaverse is still in its early stages of development, but it has the potential to revolutionize the way we interact with the internet and with each other. It could be used for a variety of purposes, including:

Socializing: The metaverse could be used to connect with friends and family in a more immersive and engaging way. We could attend virtual parties, go on virtual dates, and even work together on virtual projects.

Learning: The metaverse could be used to provide a more immersive and interactive learning experience. Students could visit historical sites, conduct experiments, and even interact with virtual characters.



Entertainment: The metaverse could be used to play games, watch movies, and listen to music in a more immersive and interactive way. We could also attend concerts, sporting events, and other live performances.

Work: The metaverse could be used to work remotely in a more immersive and productive way. We could collaborate with colleagues on projects, attend meetings, and even give presentations.

The metaverse has the potential to be a powerful tool for connecting people, learning, and entertainment. However, it is important to be aware of the potential risks, such as addiction, privacy concerns, and the potential for misuse.

Here are some of the potential benefits of the metaverse:

It can provide a more immersive and engaging experience than traditional online platforms.

It can be used to connect people from all over the world.

It can be used to learn, collaborate, and play in new ways.

Here are some of the potential challenges of the metaverse:

It can be expensive to develop and access.

It can be addictive.

It can be used for malicious purposes, such as spreading misinformation or propaganda.

Overall, the metaverse is a promising new technology with the potential to change the way we live, work, and play. However, it is important to be aware of the potential challenges before we fully embrace it."

Author: "Please define and explain the metaverse for my article"

OpenAI ChatGPT: "The metaverse refers to a virtual reality-based space that encompasses a collective virtual universe, where users can engage in immersive experiences, interact with each other, and access digital content in a seamless and interconnected way. It is often described as a fully realized, persistent, and shared digital world that merges the physical and virtual realms.

In the metaverse, users can explore and interact with various virtual environments, ranging from social spaces and entertainment venues to educational simulations and commercial platforms. These experiences can include virtual reality, augmented reality, and mixed reality technologies, allowing users to engage with digital content and other users in real-time.

The metaverse aims to transcend the limitations of traditional online platforms by offering a more immersive and interconnected digital experience. It is characterized by its ability to seamlessly integrate different virtual environments and digital assets, creating a cohesive and interactive virtual ecosystem. Users can create and customize their avatars, traverse virtual landscapes, participate in events and activities, and even build and trade virtual assets or currencies.

The concept of the metaverse has gained significant attention in recent years due to advancements in virtual reality, augmented reality, blockchain, and other technologies. Several companies and developers are actively working towards creating their vision of the metaverse, envisioning it as a transformative platform that could revolutionize communication, commerce, entertainment, and various other aspects of our lives.

While the metaverse is still an evolving concept, it holds the potential to reshape the way we interact with digital content and each other, blurring the boundaries between the physical and virtual worlds. However, it also raises important considerations regarding privacy, security, accessibility, and inclusivity, which need to be addressed as the concept progresses."

5. FINDINGS AND RESULTS

The entire paper (excluding the bibliography) has a 30% similarity rate according to the Ithenticate Plagiarism Tool examination. When the texts written by the author and all the writings written by Google Bard are analyzed, this ratio is found. It is possible to break up the analysis of the entire document into three parts:

Part A contains the words authored by the paper's author.

Part B contains the article's abstract texts that Google Bard has paraphrased.

Part C: Google Bard generated text, which includes the response to a specific query

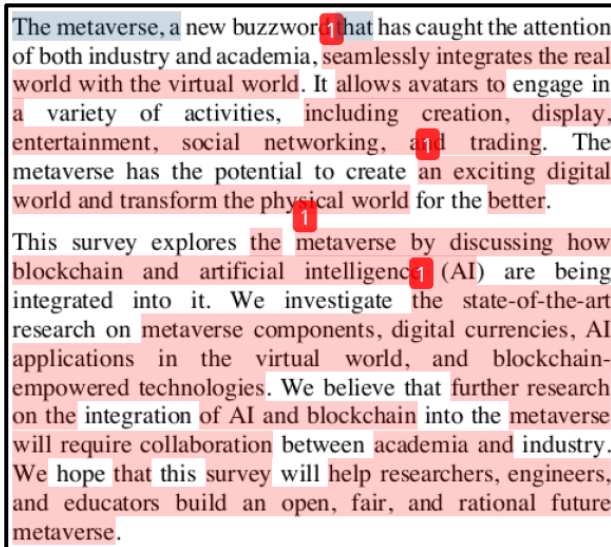


Figure 1. Plagiarism Tool Match Screenshots for Google Bard Paraphrased Abstract

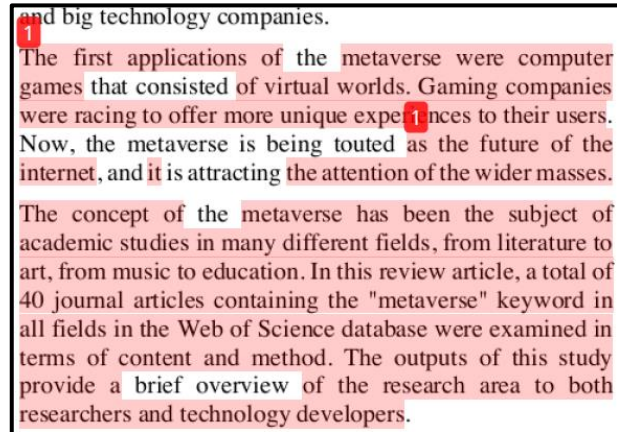


Figure 2. Plagiarism Tool Match Screenshots for Google Bard Paraphrased Abstract

There was no notable match in Part A. Figures 1 and 2 demonstrate a clear match in Part B. In Figure 3, the check of Part C is presented. These texts have somewhat fewer matches than the texts in Part B, but they still match more than the Part A texts. Some sources and matching rates can be seen in Figure 4 and Figure 5.

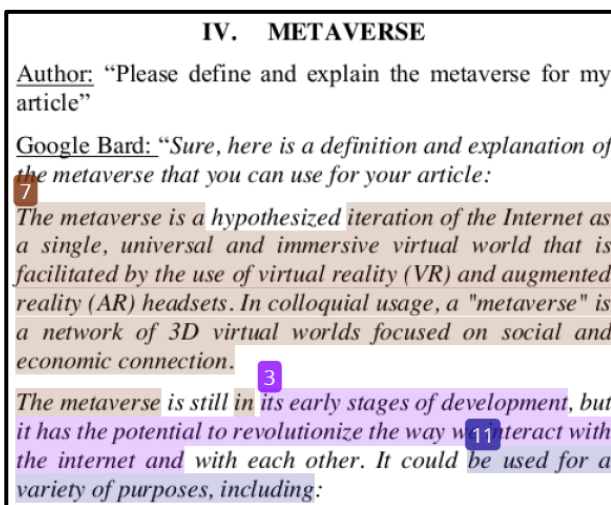


Figure 3. Plagiarism Tool Match Screenshot for Google Bard Generated Text as a Reply to our question

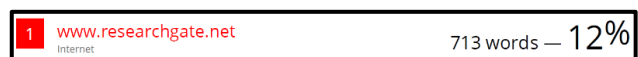


Figure 4. The source to which the matched text in Figure 1 and Figure 2

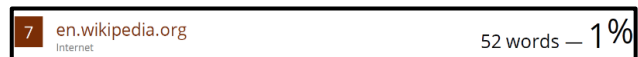


Figure 5. The source to which the matched text in Figure 3



6. GOOGLE BARD vs CHATGPT

When the texts in the article are evaluated, it can be seen that the texts produced by ChatGPT (Talan and Kalinkara, 2023a; Kasneci et al., 2023; Lo, 2023; Talan and Kalinkara, 2023b; Ram et al., 2023; Rahaman et al., 2023) and Google Bard as a result of the paraphrasing process have similarly high matches. For comparison, the study conducted by Aydın and Karaarslan (Aydın & Karaarslan, 2022) was used. When these two papers are evaluated, there is no significant difference in paraphrased texts. Neither of them could produce the abstract texts of the articles in such a way that they could not be detected in the plagiarism tool.

On the other hand, the texts produced for the questions asked by the authors were examined. Considering the match rates of the texts in these two studies, it can be said that the match rate of the texts produced by ChatGPT is relatively lower. Especially in the texts produced with Google Bard, it is seen that one sentence or more than one sentence is matched. It can be said that ChatGPT's matches are in the form of one word or multiple words.

7. CONCLUSION

In this study, we first had Google Bard paraphrased the abstracts of 10 articles about Metaverse written in the last 3 years. The literature review part of the article was created from these texts. Articles published between 2021-2023 were selected by searching on Google Scholar with the keyword "Metaverse". Then, the summaries of these studies were interpreted with Google Bard. Finally, we asked Google Bard a question and shared the answer in the study.

In the light of the findings and results obtained, the plagiarism tool matching rates of the texts written by the study authors are quite low. On the other hand, both types of text produced by Google Bard have a high match rate. When the two texts were compared, it was seen that the paraphrased texts had a higher match rate. From this information it can be concluded that Google Bard does not produce original texts after paraphrasing. In addition, it is thought that he had difficulties in producing original texts in his current form in the answers he gave to the questions. When compared to ChatGPT, a similar result was seen in paraphrased texts. On the other hand, the answers given to the questions showed that ChatGPT produced texts with less match rate.

The paper itself serves as an attractive and impressive illustration of how far artificial intelligence has progressed. With these and similar applications, it appears probable for the scholarly literature to arrive at a different conclusion. Artificial intelligence will speed up the collection and expression of knowledge while reducing the need for human-oriented methods in these operations.

Future references to the study will be made. New research will be proposed to assess the academic validity after this study has received a significant number of citations (for example, 100) from journal papers. The papers referring to this study will be categorized as either good, negative, or neutral. Evaluations of the article's suitability will be explored later. It will be known whether the academic community appreciates Google Bard's ability. The impact of this Google Bard application on the scholarly literature will next be evaluated.



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Precipitation Forecast with Artificial Neural Networks Method

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Research Article

Abstract

Events in the atmosphere from past to present – wind, precipitation, humidity, temperature – have almost always been the subject of research to create a forecast in regions. The rapid development of the technological field in terms of software and hardware brings methods and techniques to be used in research. One of them is Artificial Neural Networks. In this study, precipitation data were estimated using the Feed Forward Backpropagation method of Artificial Neural Networks method using past data of meteorological parameters, and they were compared with the data of multiple linear regression analysis. Based on these models, six different models were studied, and regression and performance evaluations were made. While the error average of multiple linear regression is 0.2413, this value is 0.076 in artificial neural networks, and the correlation average for both is 0.90. As a result of this study, the best model has a coefficient of determination of 0.95 and an error value of 0.18 in multiple linear regression, as well as a coefficient of certainty of 0.99 and an error value of 0.0438 in artificial neural networks; It has been understood that the 1st model, which has 6 data sets as the input layer, exhibits the best performance.

Keywords: Regression, artificial neural networks, precipitation forecast

Cite this paper (APA)

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Precipitation Forecast with Artificial Neural Networks Method

Highlights

- Multiple linear regression comparison with artificial neural network
- Precipitation forecasting models have been created
- No similar study was found in the research field.
- The best precipitation prediction model obtained in the study will contribute to the studies in the similar field.

Graphical Abstract

Among the parameters of the data obtained from the meteorology directorate, models were created with the best correlation, and the models were analyzed with ANN and MLR. All models were compared among themselves, and ANN and MLR were compared with each other. The flow of the study is given in the figure, where h represents humidity, t represents temperature, w represents wind speed and p represents precipitation.

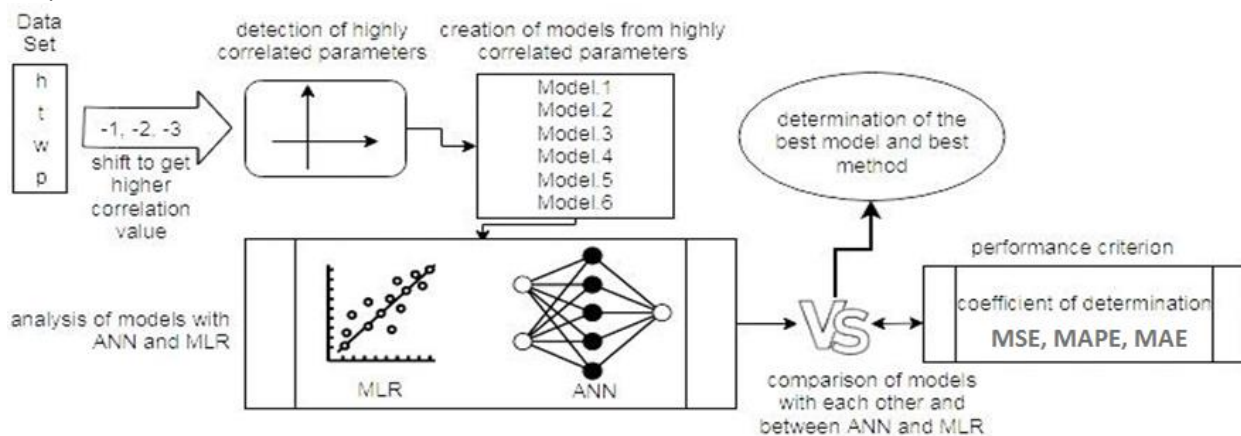


Figure. Flow of work

Aim

The aim of the study is to contribute to those who work in this field by creating a high-accuracy precipitation forecast model.

Design & Methodology

Models were created with high correlation of parameters and models were analyzed with ANN and MLR methods. The performance of the models was measured by the coefficient of determination, MSE, MAPE and MAE.

Originality

It is the first of its kind in terms of the region where the study was conducted in the literature review.

Findings

In this study, it was found that ANN is better than MLR in precipitation forecasting.

Conclusion

The results of artificial neural networks working with feedforward backpropagation algorithm gave more successful results than multiple linear regression analyzes in all models.

It is seen that with the best model obtained, it can be beneficial in many areas that require precipitation forecasting.

Declaration of Ethical Standards

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

1. INTRODUCTION

Water is undoubtedly one of the basic needs of life for the continuation of life. Sufficient water reserves and keeping them under control are essential for the sustainability of the ecological balance. It is inevitable that some parameters must consist of predictions with high accuracy in strategic decisions to be taken to provide and maintain this competence within the scope of hydrological modeling. The way to reach a faster and more accurate result with fewer data will be opened by reaching the prediction model that will be formed by mathematical processing of parameters such as wind, precipitation, humidity, and temperature for several years [1].

Researches and forecasts in the field of meteorology provide benefits in various subjects. With the instant meteorological data of regions, cities, and villages, forecasts of meteorological parameters are made. The precipitation parameter has a vital role in these estimates. The aviation industry benefits from precipitation forecasting in many areas such as the economy, early warning and preparation systems of municipalities, the realization of sports competitions, the production and planning of energy companies, the protection of life and property, the production capacity of hydroelectric power plants, the occupancy rate of dams that provide mains water [2]. In this study, models were created from parameters with high correlation. Prediction models were created by passing these models through Artificial Neural Network and Multiple Linear Regression processes, the coefficient of determination and error rates of the models obtained by both methods were compared, and the best model was tried to be found.

There are various studies on estimation with regression. In a 2016 study, it was concluded that both linear and functional regression outperform professional weather forecasting services, and the performance will increase with the evaluated time [9]. In a study in 2019, precipitation forecasting was discussed with a regression model. It has been tried to prove that the forecast to be made is highly reliable by making a precipitation forecast based on previous records of a geographical area. It has been seen that the model's performance has higher accuracy compared to traditional precipitation forecasting systems [10]. In a study from 2017, linear regression was applied to the data set, and the coefficients were used to predict precipitation based on the corresponding values of the parameters. The advantage of the model is that it predicts precipitation based on the previous correlation between different atmospheric parameters [11]. In a study of 2020, Multiple Linear Regression was applied with various parameters to predict precipitation, and it was seen that this method gave successful results [12].

Various studies have been made with Artificial Neural Networks (ANN) and are continuing. In a study conducted in 2020, it was understood that landslides triggered by precipitation would shed light on future landslides due to the application of ANNs of past data. It has been seen that it provides benefits in this area [13]. A study in 2017 was carried out in an area with heavy flooding, and the ANN method was used. Due to the nonlinear relationships in the precipitation data, it has been revealed that ANN is a preferable approach compared to all existing approaches [14]. In a study of 2015, based on India's dependence on agriculture, research was conducted on various ANN architectures by referring to the importance of precipitation. The study shows that overall, ANN performs well for annual precipitation forecasting [15]. In a study of 2020, the feasibility and success of the ANN approach are demonstrated by developing efficient and reliable nonlinear forecasting models for meteorological analysis [16].

When the previous studies on the subject and the method are examined, studies comparing Multiple Linear Regression (MLR) and ANN are encountered. In a study, models were created with a feedforward backpropagation neural network to find missing current data from previous years. It was understood that the models prepared by using the monthly flow data of the same years gave successful results, and it was seen that the feedforward backpropagation artificial neural network could play an active role in the detection of missing flow data [3]. In a different study, artificial neural networks and multiple linear regression analysis

methods were used to estimate the missing data in 4018-day data obtained from a meteorology station with temperature, relative humidity, and temperature parameters. As a result of the study, it was seen that artificial neural networks gave more successful results [1]. In the studies conducted for the province of Şanlıurfa, 16 models were created using the artificial neural network method to estimate the previous index values of the Standardized Precipitation Index values. In this study, which consists of monthly data of 78 years, the 16th model gave more successful results than other models in terms of Mean Squared Error (0.12) and Mean Absolute Error (0.23) values formed in terms of post-test with Artificial Neural Networks method after formulating the Standardized Precipitation Index [4]. In a study in 2018, the daily evaporation amount in the Cambridge basin was estimated using Hargreaves-Samani, Ritchie, and Turc methods and Artificial Neural Networks methods. As a result of the studies with 1081 daily data taken from the USA Massachusetts station, it has been understood that artificial neural networks can succeed in similar models [5]. In the studies carried out in 2019, the artificial neural network method was used for the monthly total precipitation data of 56 years and the estimation of the drought. It is stated that the neural network model is highly flexible and can be used as a very powerful tool for accurate simulation prediction [6]. In his thesis in 2019, Sezer performed the load estimation in Zonguldak province with the methods of Regression, Backpropagation Artificial Neural Networks, and Radial Based Artificial Neural Networks. A total of 8 different models were created and analyzed using the same independent variables in all developed models. The best model was found with the model's R^2 (determination) value [7]. In a study on air pollution in 2020, regression and artificial neural network models were created. According to the results of the study, it was understood that artificial neural networks are more efficient than regression analysis [8].

Looking at the studies carried out in this field by scanning the literature, no study was found for the province of Aydın. Aydın is a city with low annual average precipitation, intensive agricultural activities, and steam energy is used due to its geological location, and a need to inform the public, prevent possible flooding, and take precautions according to the occupancy rates of the dams, as in every province. For this reason, it is crucial to make accurate and fast precipitation forecasts. In this study, Artificial Neural Networks Method was used to achieve this. The best model was found among the models formed from the hourly data of various parameters obtained from Aydın Meteorology Directorate with high correlation.

2. MATERIAL and METHOD

2.1. Feedforward Backpropagation Neural Networks

The learning process takes place through neural networks in the human brain. The neural networks in the human brain consist of approximately 6 billion neurons and around 60 trillion connections called synapses responsible for interneuron communication. The action of each neuron is shaped by the signals from other neurons through the synapse. The learning process to understand the working principle of the human brain has been investigated, and studies have been made to convert it into a numerical model and are continuing. Various artificial neuron and network models have been developed in these studies to translate the way neurons work into a model. Artificial Neural Networks (ANNs), as a branch of science different from the computation method of computers, are expressed as complex information processing structures formed by the combination of parts that are related to each other by weight, the method of the human brain to perform a task[17]. Figure 1 shows the working logic of the artificial neural network. The input layer is the layer where the data that needs to be learned into a network is defined. The hidden layer is located between the input and output layers, and the number of layers and neurons varies according to the problem. Backward error propagation occurs at the same time as forward calculations are made in the hidden layer. The output layer is the layer where the sample data to be learned in the ANN is calculated as output [18].

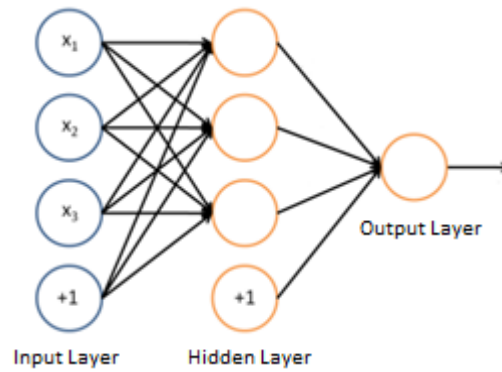


Figure 1. Artificial neural network

Studies on ANN started in the first half of the 20th century and have been used in many fields until today. When we look at the development process, it is compatible with many models and algorithms [19]. Single-layer models have left their place to multi-layer models over time. With the emergence of the backpropagation neural network, research has moved to the development phase of more active and fast learning algorithms. With the support of processes, new methods, and network types, ANN is a model in which applications are made in many areas such as modeling, learning, simulation, identification, and estimation [20, 21].

Each method of the ANN model aims to determine the network that can be best analyzed with the data at hand. In this study, for the nonlinear parameter estimation, Feed Forward Back Propagation neural network and functions called the activation function of the intercellular weight value inputs and the sigmoid activation function, which work efficiently at the point of transferring to the output layer, are used [22].

Feed Forward Backpropagation neural network consists of input, output, and at least one hidden layer. While the input layer has the workspace data count, the output layer has the same data count. The number of hidden layers; is determined by trial and error, considering various parameters (such as the number of data and correlation of data). Likewise, a trial and error process determines the number of hidden layer neurons. During the training process of the network, forward scanning is performed along the network, and the output of the consecutive node is calculated and transferred to the output layer. The desired values are compared with the values transferred to the output layer. In order to reduce the error rate, the network returns to the beginning, arranges the weight values between the layer elements, and repeats the process. The artificial neural network aims to minimize the error between the output layer weight values and the desired result values [1].

To minimize the errors, the weight values between the mesh cells should have the optimum value. As shown in Figure 2, the weighted input data obtained with the input data are summed with the transfer function. The network value, called net in ANN, is processed in the activation function, and in this way, the activation process is completed, and the data is transferred to the output layer.

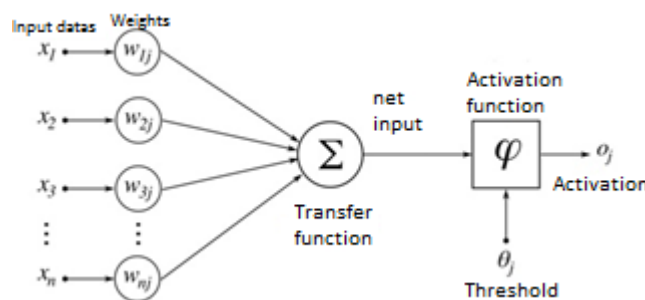


Figure 2. Mathematical structure of artificial neural network [23]

$$z_i = \sum_{i=1}^n (w_{ij}x_i + b_j) \tag{1}$$

Net inputs to the cell in the transfer function are calculated using Equation (1) formula. n is the number of entries; w weights; x represents the inputs, and b represents the threshold (bias) value. Since the activation function provides curvilinear matching between input and output, it significantly affects the network's performance. The most used activation function is the sigmoid function because it keeps the error at a minimum, and its equation is included in Equation (2).

$$f(z_i) = \frac{1}{1 + e^{-z_i}} \tag{2}$$

The value obtained as a result of the sum function in Equation (1) is passed through a linear or nonlinear differentiable activation function, as seen in Figure 2, and a result value is obtained as shown in Equation (3) [24].

$$y = f(z_i) = f\left(\sum_{i=1}^n (w_{ij}x_i + b_j)\right) \tag{3}$$

2.2. Multiple Linear Regression

Regression is known to obtain a mathematical model with the correlation between two variables. Its general expression is given by Equation (4).

$$y = a + bx \tag{4}$$

In Equation (4), x represents the value of the selected independent variable, y: the y value for the chosen x value, a: the value of the point where the line intersects the y-axis, b: the slope of the line, a and b: the regression coefficients [22]. The regression graph containing this information is shown in Figure 3. This model is also known as the simple linear regression model.

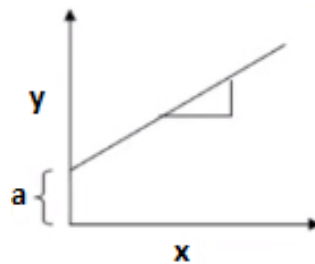


Figure 3. Linear regression graph

As shown in Figure 3, if the independent variable x is more than one, the y value can be calculated with MLR. The related regression equation is shown in Equation (5).

$$Y_i = a + a_1X_1 + a_2X_2 + \dots + a_nX_n + e_i \tag{5}$$

In equation (5), a represents the constant coefficient, a_1, a_2, \dots, a_n regression coefficients, a_i coefficients the effects of changing the value of the independent variable Y_i , and e_i the error term [25]. In Equation (5), p is the output data. Input data is obtained by shifting the data of t (temperature), humidity (h), p (precipitation) and w (wind) parameters up to 3 hours.

2.3. Performance Evaluation

In the study, performance is evaluated in 3 different criteria.

2.3.1. Correlation analysis

Correlation indicates the direction and strength of the linear relationship between two random variables in probability theory and statistics. In general, statistical use, correlation indicates how far away from independence has been achieved. The relationship of a variable with two or more variables is calculated through multiple correlations; One of these variables is fixed, and partial correlation techniques calculate its relationship with other variables. The correlation coefficient takes values between -1 and +1. If it is -1, there is a wholly negative linear relationship. If it is +1, there is a wholly positive linear relationship. If 0, there is no relationship between the two variables. It is expressed with R in the literature.

2.3.2. Mean squared error (MSE)

It is a type of statistics used primarily in cases where the magnitudes of error values are similar. Its formula is shown in Equation (6), and it is the process of summing the squares of the error between the actual output (y) and the expected output (d) and averaging [18, 26].

$$MSE = \frac{1}{N} \sum_{i=1}^N (d_i - y_i)^2 \quad (6)$$

2.3.3. Mean absolute percentage error (MAPE)

MAPE is an error measure calculated as an absolute percentage error between predicted values and actual values. MAPE is often used to evaluate the accuracy of prediction models. The MAPE value is usually expressed as a percentage (%). It is calculated by Equation (7).

$$MAPE = \frac{1}{N} \sum_{i=1}^N \left| \frac{(d_i - y_i)}{d_i} \right| \quad (7)$$

There are some general assumptions for the interpretation of the MAPE value.

- If the MAPE value is between 0% and 10%: This indicates that the prediction is quite good and has high accuracy.
- If the MAPE value is between 10% and 20%: This indicates that the estimate has a reasonable accuracy.
- If the MAPE value is greater than 20%: This indicates that the forecast has low accuracy and needs improvement. Higher MAPE values reflect larger errors and lower prediction accuracy.

2.3.4. Mean absolute error (MAE)

MAE, an error measure that measures the absolute amount of error between available forecasts and actual values, is a common measure used especially to evaluate the performance of forecasting models. Equation (8) is used to calculate the MAE.

$$MAE = \frac{1}{N} \sum_{i=1}^N |d_i - y_i| \quad (8)$$

Lower MAE values indicate that the predictions are closer to the true values and have better predictive performance. MAE is particularly useful for evaluating the performance of prediction models because it uses absolute values of errors. This means that negative and positive errors do not affect each other.

2.3.5. Coefficient of determination (R²)

After calculating the regression coefficients, the coefficient of determination is calculated after the regression

estimation model is established. Thus, the coefficients' significance and the model's suitability will become understandable. The coefficient of determination showing the suitability of the multiple regression model is calculated by Equation (9) [27].

$$R^2 = 1 - \frac{\sum_i^n (y_{i(real)} - y_{i(estimated)})^2}{\sum_i^n (y_{i(real)} - \text{mean}(y_{real}))^2} \tag{9}$$

2.3.4. t-static

The t test is a hypothesis test used in statistical analysis. It is used to compare means between two groups. The t test is used to determine whether the difference between groups is statistically significant. The t-test is based on a null hypothesis and an alternative hypothesis. The null hypothesis states that there is no difference between the groups or that the mean of the two groups is equal. The alternative hypothesis states that there is a difference between the groups. The main purpose of the t-test is to test the validity of the null hypothesis. This test is based on the means and variances of sample data between groups.

As a result of the t test, the t value is calculated. This t value expresses the size and statistical significance of the difference between groups. Also, the p-value is calculated. The p-value is a statistical measure that evaluates the validity of the null hypothesis. The p value is compared with the acceptable error level (alpha level) to determine whether the null hypothesis will be rejected.

In conclusion, the t-test is a hypothesis test used to compare means between groups and to evaluate the statistical significance of the difference. This test assists in the analysis of statistical results and decision making.

2.3.5. Introduction of input parameters

For the study, 45384 data from Aydın numbered 17234 meteorology stations recorded between May/2016 - May/2021, for which humidity, temperature, wind, and precipitation values were not recorded, were eliminated, and the remaining 9639 hours of data were used. The distribution of these data according to the humidity data is given in Figure 5, the distribution according to the temperature data in Figure 6, the distribution according to the wind speed data in Figure 7, and the distribution according to the precipitation data in Figure 8.

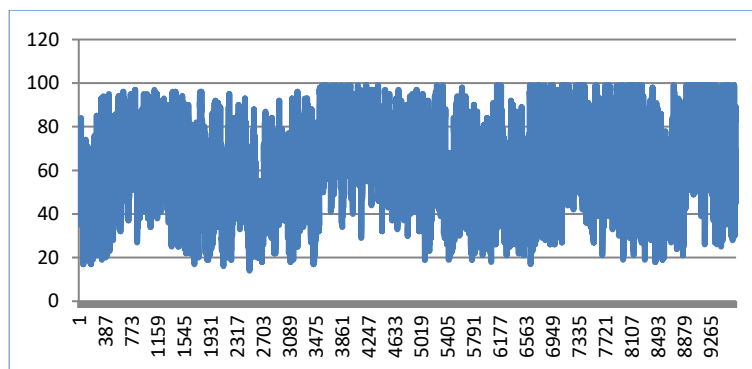


Figure 5. Humidity chart by data

In Figure 5, it is understood that within the scope of the available data, the humidity reaches 100%, which is the saturation ratio, often between 40% and 60% on average. The lowest humidity rate is between 15% and 20%.

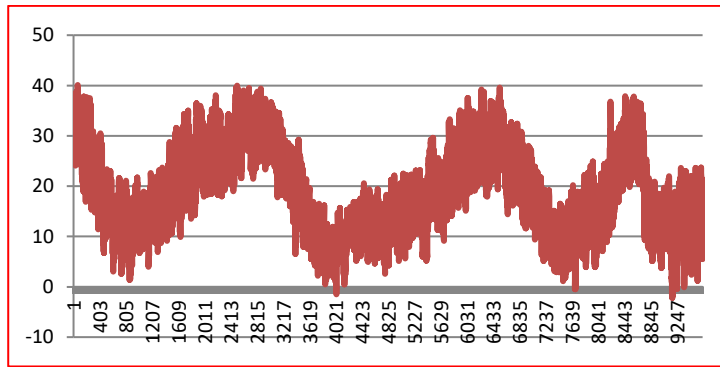


Figure 6. Temperature chart by data

In Figure 6, within the scope of the data, fluctuations between 0-40 °C are striking in general. The highest temperature occurs in the 40-45°C, while the lowest temperature occurs between -5–0 °C. It can be said that the average value is a temperature in the range of 10-30 °C.

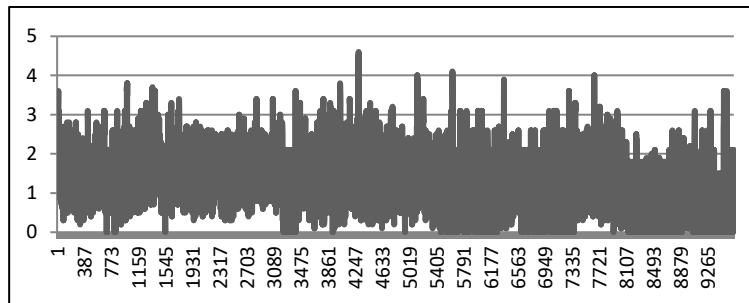


Figure 7. Wind chart by data

In Figure 7, the wind speed is shown as m/s, and within the scope of the available data, it is understood that the maximum speed is 4-5 m/sec, often 0, and generally 1-2 m/sec.

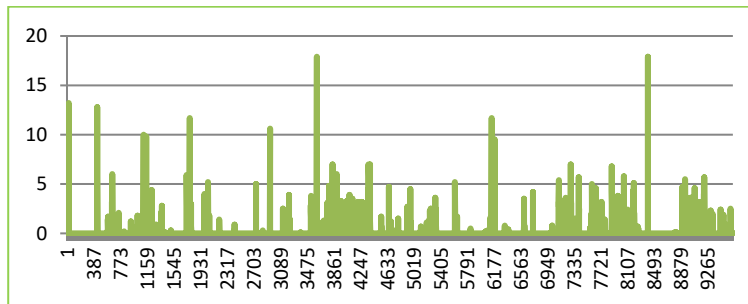


Figure 8. Precipitation chart by data

In Figure 8, the amount of precipitation is given in mm=kg/, and it is understood that it is 4-5 mm at most, 0 most of the time, and 1-2 mm generally.

Different input layers are derived by shifting the data of the parameters to form a model so that they do not lose their meaningful relationships. The correlation between data is given in Table 1.

h in Table 1; relative humidity (%), t; temperature (c°), w; wind speed (m/s) and p; represents precipitation (mm=kg/) data and -1, -2, -3 represents the number of shifted hours. There are linear, inverse correlations in the table, with the highest correlation being linear with a value Models created with highly correlated parameters are given in Table 3. of 0.956 and between $y-1$ and y (correlation of precipitation between the amount of precipitation one hour ago). On the other hand, the lowest correlation is between $r-1$ and s , with a value of -0.021.

Table 1. Correlation of data

	h	h-1	t	t-1	w	w-1	p	p-1	p-2	p-3
h	1									
h-1	0.762	1								
t	-0.695	-0.568	1							
t-1	-0.557	-0.695	0.898	1						
w	0.040	0.043	-0.023	-0.025	1					
w-1	0.040	0.040	-0.021	-0.022	0.667	1				
P	0.194	0.189	-0.101	-0.099	0.081	0.083	1			
p-1	0.199	0.194	-0.104	-0.101	0.085	0.080	0.956	1		
p-2	0.204	0.199	-0.108	-0.104	0.087	0.084	0.909	0.955	1	
p-3	0.207	0.203	-0.107	-0.108	0.089	0.086	0.877	0.908	0.955	1

Table 2. t-test on datas

Variables	Parameter	Values
X=h, Y=p	t Stat	285,4
	P(T<=t)	0
X=h-1, Y=p	t Stat	285,3
	P(T<=t)	0
X=t, Y=p	t Stat	217,0
	P(T<=t)	0
X=t-1, Y=p	t Stat	217,0
	P(T<=t)	0
X=w, Y=p	t Stat	135,2
	P(T<=t)	0
X=w-1, Y=p	t Stat	133,3
	P(T<=t)	0
X=p-1, Y=p	t Stat	0,85
	P(T<=t)	0,20
X=p-2, Y=p	t Stat	0,62
	P(T<=t)	0,27
X=p-3, Y=p	t Stat	0,38
	P(T<=t)	0,35

* X is independent and Y is dependent variable

As can be seen in Table 1, there are 10 different parameters belonging to the data set. 9 of these parameters are independent variables and 1 (precipitation) is dependent variable. The t and P values obtained as a result of the t test are given in Table 2.

Accordingly, a high tStat value and a low P value (the acceptable level is usually 0.05) means that the difference between the tested parameters is large and statistically significant. According to the t test of precipitation data shifted with precipitation data, it is seen that the results are outside the acceptable level.

When Table 3 is examined, it is seen that the average precipitation between the years 2016-2021 is between 1.3 and 1.7 mm. On the other hand, it is seen that the highest precipitation occurred in 2017, and the lowest precipitation occurred in 2016.

$$\sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}} \tag{10}$$

The formula for the standard deviation is shown in Equation (10). x represents each data in the data set, the mean, and n the sample size. When Table 3 is evaluated according to years, it is understood that the distribution of precipitation in 2017 was higher than in other years, and it showed a closer spread to the average in 2019 and 2020.

Table 3. Descriptive statistical parameters of datas

Years	2016	2017	2018	2019	2020	2021
Average precipitation*	1,689	1,537	1,469	1,234	1,367	1,315
Maximum precipitation *	12,100	44,400	17,900	20,700	17,900	19,000
Standart deviation	2,491	3,039	2,382	1,793	1,793	2,151
Skewness	2,660	7,789	3,638	4,354	3,873	3,922
Kurtosis	7,623	94,277	16,593	32,761	25,524	20,808
Coefficient of variation	147,483	197,722	162,151	145,299	131,163	163,574
Total number of data (hourly)	282	1921	1939	2174	1555	1768

* mm=kg/m²

$$\frac{n}{(n-1)(n-2)} \sum \left(\frac{x_j - \bar{x}}{s} \right)^3 \tag{11}$$

Skewness indicates the degree of asymmetry around the mean of a distribution. Positive skewness indicates a skewness whose asymmetric end expands towards higher positive values, while negative skewness indicates a distribution whose asymmetric end expands towards lower negative values. It can be said that the skewness decreases when it approaches zero. Its formula is given in Equation (11). s is the standard deviation, x_j represents each data in the data set, \bar{x} the mean, and n is the sample size. In Table 3, it can be seen that 2016 was the year with the least skewness and the closest to normality in the data set, while 2017 was the year with the highest skewness, and there was a positive skewness in all the data.

$$\left\{ \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum \left(\frac{x_j - \bar{x}}{s} \right)^4 \right\} - \frac{3(n-1)^2}{(n-2)(n-3)} \tag{12}$$

Kurtosis gives the relative steepness or flatness of a distribution compared to the normal distribution. Positive kurtosis indicates a comparatively steep distribution, while negative kurtosis indicates a comparatively flat distribution. Its formula is shown in Equation (12). s is the standard deviation, x_j represents each data in the data set, \bar{x} the mean, and n is the sample size. , it is seen that there is a steep distribution due to positive kurtosis, and the steepest distribution was in 2017.

$$\frac{\sqrt{\frac{\sum(x - \bar{x})^2}{n-1}}}{Average\ value} * 100 \tag{13}$$

The coefficient of variation is a statistical measure in which the variation in a data set is expressed as a percentage. The coefficient of variation gives the ratio of the variability of a measurement to the mean. A high coefficient of variation indicates that the values in the data set deviate significantly from the mean, while a low coefficient of variation indicates that the values are closer to the mean. The coefficient of variation is calculated as the ratio of the standard deviation to the mean and is usually expressed as a percentage (%). It is calculated by Equation (13).

When the data in Table 3 are examined, it is seen that there are large deviations from the mean. The reason for this is that all data belonging to the hour when at least one of the parameters is empty among the collected 45384 data were removed, and the number of data decreased to approximately 1 in 5 for this reason.

3. STUDY AREA

3.1. Precipitation Station Data

Station; Cumhuriyet, 1999. Sk. The data were obtained from the precipitation observation station in Aydın province, numbered 17,234, which has the "Automatic Meteorological Observation Station AMOS - Synoptic - Daily Climate" observation type. No:3, 09020 Efeler Aydın, located next to the Aydın Meteorology Directorate building. The station is located at latitude 37° 50` 26.32`` and longitude 27° 50` 16.19`` with an altitude of 53m and observation type mm [28]. Satellite image is shown in Figure 9.



Figure 9. Weather station location

3.2. Information About the Region

Aydın province is located in the Aegean region and has a Mediterranean climate with warm and rainy winters and hot and dry summers. It covers the provinces of Uşak, Aydın and Denizli in the Büyük Menderes Basin and is located between Aydın Mountains and Menteşe Mountains. In the basin, which has an area of 24976 m², Aydın province has a surface area of 1582 m² [29].

4. RESULTS

In Table 4, using Table 1, models were created from parameters with high correlation to create an input layer to work in a flow, as seen in Figure 1. In Table 4, the coefficients obtained with the MLR are given as parameters. Table 5 shows the variable coefficients and related equations obtained as a result of applying the data to the MLR process according to the input/output parameters created in Table 4.

Table 4. Models prepared for multiple linear regression and artificial neural networks.

Model	Input Layer	Output Layer
1	h, t, w, p-1, p-2, p-3	P
2	h, t, w, p-1, p-2	P
3	h, h-1, t, w, y-1	P
4	h, t, t-1, w, p-1, p-2	P
5	h, t, w, w-1, p-1	P
6	h, t, w	P

Table 5. Equations obtained as a result of multiple linear regression.

Model	Equation
1	$0.0006x_1 + 0.0006x_2 + 0.0045x_3 + 0.1502x_4 - 0.195x_5 + 0.9943x_6 - 0.0475$
2	$0.0005x_1 + 0.0001x_2 + 0.0056x_3 - 0.0463x_4 + 0.9856x_5 - 0.0316$
3	$0.0004x_1 + 0.0002x_2 + 0.0004x_3 + 0.0061x_4 + 0.941x_5 - 0.0472$
4	$0.0006x_1 + 0.0012x_2 - 0.0009x_3 + 0.0061x_4 + 0.9411x_5 - 0.0451$
5	$0.0005x_1 + 0.0004x_2 + 0.0102x_3 - 0.0061x_4 + 0.9415x_5 - 0.0399$
6	$0.0006x_1 + 0.0005x_2 + 0.6665x_3 + 0.3998$

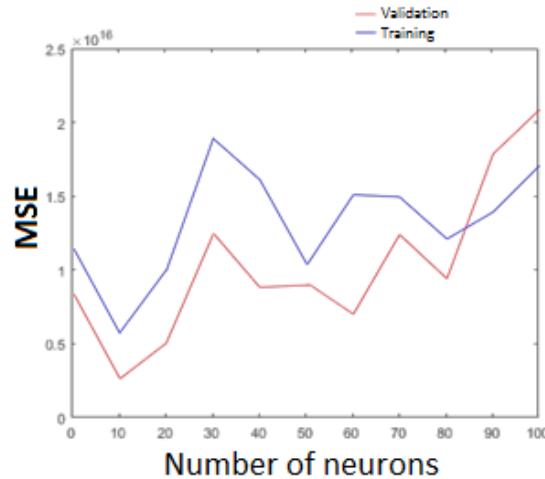


Figure 10. MSE values according to the number of neurons in neural network training.

In the ANN model created with the Neural Fitting application of the MATLAB program, the number of hidden layer neurons containing the sigmoid function was tried to be determined according to the lowest MSE value between 0-100 at the validation and education level with the MATLAB program, as shown in Figure 10. The optimal neuron value of the data set is 10, and 70% (6747) of the 9639 data were used for training, 15% (1446) for validation, and 15% for testing (1446). Additionally, MAPE and MAE are included in the calculations.

Levenberg-Marquard training algorithm was used for training. ANN's working style is shown in Figure 11. Levenberg-Marquard training algorithm was used for training. ANN working style is shown in Figure 11.



Figure 11. Artificial neural networks working steps for models.

Figure 11, x value in the input layer; is the number of coefficients of each model, that is, the number of parameters in the Input Layer column in Table 4, Introduction section; from the input of the data to be trained, the Hidden Layer; From training the data using the sigmoid function, the Output Layer; It is responsible for verifying the data and transferring the trained data to the output section. MSE, MAPE and MAE values are given in Table 6. As these values approach zero, the error decreases. The R value represents correlation; Approaching +1 or -1 means that the relationship is increasing (the coefficient of determination), the square of the correlation value between the model result and the actual result (included in Table 6) and measures the correlation between outputs and targets. The closer the value is to 1, the higher the correlation and reliability.

Table 6. R^2 , MSE, MAPE and MAE values of the data obtained with multiple linear regression and artificial neural networks.

Model	MLR				ANN			
	R^2	MSE	MAPE	MAE	R^2	MSE	MAPE	MAE
1	0.91	0.1838	0.2966	0.0186	0.98	0.0438	0.0766	0.0036
2	0.91	0.1870	0.2945	0.0271	0.88	0.0433	0.0745	0.0031
3	0.91	0.1872	0.2960	0.0278	0.90	0.0384	0.0650	0.0038
4	0.91	0.1872	0.2915	0.0274	0.90	0.0375	0.0635	0.0034
5	0.91	0.1872	0.3213	0.0325	0.90	0.0382	0.0643	0.0035
6	0.44	0.5153	0.6824	0.0925	0.45	0.2552	0.3724	0.0185

When these data in Table 6 are examined, it is seen that the 6th model has a bad value compared to other models in terms of error and regression values. On the other hand, the regression values of the first five models are above 90% and have a good deal. When we include the errors in the evaluation, it is seen that the model with both the highest regression value and the lowest errors is the 1st model.

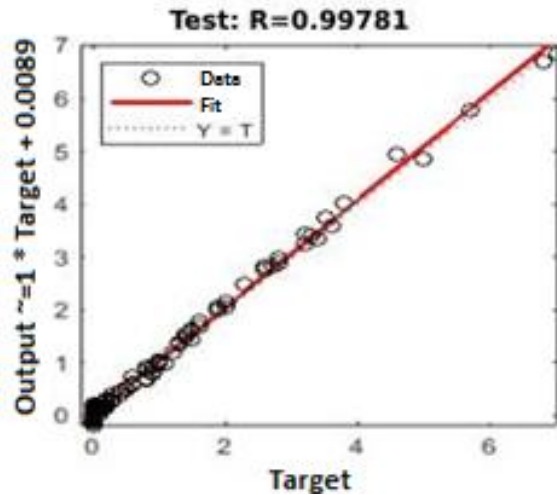


Figure 12. Neural networks regression graph.

As seen in Figure 12, if the R value is very close to 1, then the model is the most successful. This represents the success rate in training the data, so when the graph is interpreted, it can be stated that the data has undergone successful training.

In error evaluation, as shown in Figure 13, the error value in the training, validation, and testing areas is very close to the orange line representing zero error. It can be stated that it is in the range of -1 to 1 for training, validation, and testing, and a situation far from high error occurs.

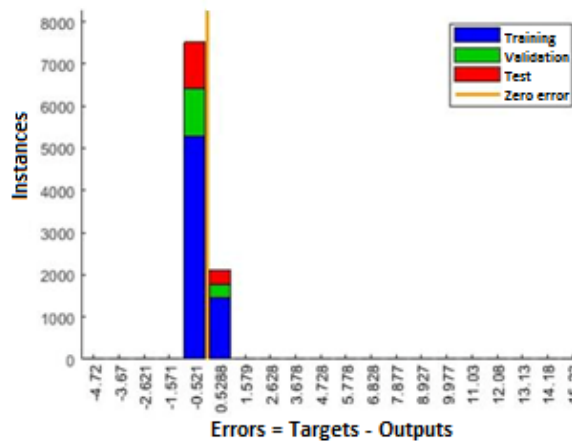


Figure 13. Neural networks error histogram.

7. CONCLUSION

Multiple Linear Regression and Artificial Neural Networks methods were used to forecast precipitation with temperature, humidity, wind speed, and precipitation data. To get meaningful results, six different models were created by shifting the data up to 3 hours, paying attention to the correlation coefficient between them. Models were calculated with MLR and ANN methods, performance criterias (R^2), MSE, MAPE and MAE) were obtained as a result of the processes, and the 1st model, the most efficient model, was selected according to these criteria. The first model consists of humidity (h), temperature (t), wind (w), and precipitation (p-1, p-2, p-3) parameters shifted up to 3 hours. It is understood that the more precipitation



parameters in the input parameters compared to the other models contribute to better results in terms of performance criteria.

The results of artificial neural networks working with a feedforward backpropagation algorithm gave more successful results than multiple linear regression analyzes in all models.

With the application of the obtained model, it is seen that benefits can be obtained in many areas that require precipitation forecasting.

There are some limitations in the study in terms of Multiple Linear Regression and Artificial Neural Networks.

- ANNs often require large amounts of data. There was no problem with this limitation with 9639 pieces of data.
- High-capacity ANNs can overfit the training dataset. This can negatively impact generalizer performance and may fail with new data. In the study, which reached a rate of 99%, no action was taken to prevent this situation in education. To prevent this, data splitting, data generalization, dropout, early stopping methods can be tried.
- Training large and complex ANNs can be time consuming. Such a situation was not encountered in this study.
- ANNs are generally less interpretable models due to their complex nature. Since the obtained data were interpreted on the basis of the performance evaluation criteria, this limitation did not constitute an obstacle to a large extent.
- MLR is based on the assumption of a linear relationship between dependent and independent variables. If the relationship is not linear, the MLR model may be inadequate. To reduce this limitation, highly correlated data sets were studied.
- MLR is based on the assumption of complete independence between independent variables. If there are multiple correlations or other relationships between the independent variables, this assumption is violated and the results may be misleading. In order to obtain a high correlation in the study, new parameters were derived by clock shifting the parameters. For this reason, there is a possibility that the models obtained with MLR may be misleading.

THANKS

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AUTHOR CONTRIBUTION STATEMENT

In the work carried out, Serkan ANSAY contributed to data collection, design, technical implementation, literature review and analysis; Bayram KÖSE consisted of creating the idea, checking the spelling, controlling the content and evaluating the results

CONFLICT OF INTEREST

There is no conflict of interest in this study.



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The Metaverse: A Brave New “World”

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Abstract

As we stand on the precipice of the next significant socio-technological revolution, the Metaverse promises to transform our lives as profoundly as the internet did, if not more. The Metaverse is evolving as an immersive, collaborative, and interactive digital space, offering early glimpses of its vast potential. The scope of this digital universe extends far beyond just entertainment and gaming—it provides innovative ways to revolutionize education, business, healthcare, and finance, including burgeoning areas like cryptocurrencies. However, without establishing appropriate safeguards, the Metaverse also poses considerable challenges. The pervasive risks to privacy, security, and safety of individuals in an environment where redress mechanisms are yet undefined, are areas of concern that need urgent attention. This article defines the Metaverse, its evolution, potential benefits, and potentially harmful impact due to data privacy. Subsequently, it shares the results of a bibliographic study demonstrating that the Metaverse is becoming popular along with ethics and AI. Next, it presents the results from a global survey which suggests that the Metaverse implies cautiously optimistic tones. Moreover, the article introduces an AI-based new technology as an example between today's and tomorrow's worlds. Based on the results, it concludes why it is important to establish educational programs and guidelines for applying the technologies in the Metaverse. Finally, it makes recommendations for new research and other actions for the entire Metaverse ecosystem.

Keywords: Metaverse, Ethics, Digital anthropology, AI, Artificial intelligence, AR, VR

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1. INTRODUCTION

The Internet has transformed our world, reaching into sectors such as business, education, government, healthcare, and communication, effecting changes unlike any other technology in history. As an essential part of daily life, the Internet's influence has blended online and offline activities to indistinguishability. The advent of the World Wide Web democratized internet access, and now millions worldwide use it for various purposes such as gathering information, accessing services, communicating, and entertainment.

The Internet's evolution has been characterized by the shift from Web 1.0, a platform for accessing and reading information, to Web 2.0, which fostered user interaction and collaboration. Today, we're witnessing the dawn of Web 3.0, marked by a transition from a network structure to a database model, incorporating elements of artificial intelligence (AI), 3D web design, and more. A key concept within the framework of Web 3.0 is the Metaverse. This idea seeks to blend physical and digital realities using cutting-edge technologies like augmented reality (AR), virtual reality (VR), 5G, edge and cloud computing, blockchain, AI, and non-fungible tokens (NFT).

The Metaverse, still an evolving concept, has found applications like Geppetto, with over 200 million subscribers, and Animal Crossing, which has even hosted virtual election campaigns. Along with others like Roblox, these platforms highlight the shift in social values of the younger generations, who treat their online personas as tangible as their offline identities. As such, the Metaverse requires a contemporary definition that accounts for this evolution.

This paper explores in detail the extensive implications of this shift towards the Metaverse. While recognizing the potential benefits, our focus leans more towards the unexpected challenges, particularly those related to privacy and data protection that could lead to user profiling and a permanent erosion of privacy. We will delve into the dichotomy of innovations and potential pitfalls within the Metaverse, contrasting the present state and future potentials of the technology within this sphere.

The exploration entails a comprehensive analysis of the current scientific research and public awareness regarding the Metaverse and its ethical dimensions using bibliographic analysis and a global survey. To highlight the necessity for additional research and more effective governance mechanisms in the Metaverse, we will also feature AI-based technology that illustrates how insights can be derived beyond the traditional boundaries of private data. In conclusion, we aim to propose future research and development directions within the Metaverse ecosystem, stressing the need for effective privacy measures and ethical standards.

2. THE METAVERSE

The term "Metaverse" originated from Neal Stephenson's 1992 science fiction novel, *Snow Crash*. This word blends the prefix "meta" with "universe," representing a digitally constructed universe consisting of persistent, interactive, shared, 3D virtual spaces. In *Snow Crash*, Stephenson envisions the Metaverse as a vast virtual realm mirroring the physical world, where humans, embodied as avatars, engage with each other and software agents in a space reminiscent of the real world. The Metaverse, a virtual reality-focused internet, is touted as the future successor of the internet. This concept has gained significant traction since *Snow Crash*, inspiring the development of online virtual worlds such as *Second Life* and *Active Worlds*. Initially, the Metaverse concept primarily influenced internet-based video games and the creation of social media (Babu & Mohan, 2022).

The Metaverse can be seen as an interconnected network of advanced virtual worlds linked with the physical world through specific hardware and biological interfaces and complemented by software technologies, services, and data. The Metaverse is a form of Extended Reality (XR), a continuum bridging the XR and real worlds. While XR is a current reality, the Metaverse remains an aspirational idea. Contemporary XR includes



technologies like Augmented Reality (AR) and Virtual Reality (VR), which gather human data through various channels and methods. The real world is the physical realm we experience without technology (Stephens, 2022).

VR places an avatar in a digitally crafted three-dimensional world, like Zeppetto, creating the illusion of being in a different location, unrestricted by physical limitations. AR, with its relatively simple hardware, such as glasses, offers a more tangible solution, though it's suitable for shorter content. Mixed Reality (MR) combines VR and AR, enabling user interaction with virtual objects within a 3D environment. It merges the immersive virtual environment of VR and the overlay of virtual content in AR (Park & Kim, 2022).

The modern Metaverse differs from its earlier version in three main aspects (Park & Kim, 2022). First, rapid advancements in deep learning have substantially enhanced the accuracy of vision and language recognition. The development of generative models has facilitated more immersive environments and natural movement. The processing time and complexity have been minimized using multimodal models as end-to-end solutions with a pre-trained multimodal model (Park & Kim, 2022).

Second, the current Metaverse, unlike its predecessor, which was predominantly PC-based and lacked consistency due to spatial and temporal limitations, is now readily accessible anytime, anywhere through mobile devices with constant internet connectivity. Platforms like Roblox host 50 million games, with users logging 3 billion hours monthly, surpassing social network platforms like TikTok and YouTube. As user engagement and usage times increase, content creators earn higher revenues, which boosts digital advertising sales (Park & Kim, 2022).

Lastly, the Metaverse continues to evolve, differentiating from its predecessors in that coding can now be executed within the Metaverse itself. It is also more tightly integrated with real life through virtual currency. The Metaverse expands with various social implications such as fashion, events, gaming, education, and work, all rooted in immersive interaction (Park & Kim, 2022).

Cryptocurrencies like Dime are an economic link between the Metaverse and the physical world. In Roblox, Robux acts as a virtual currency, and Fortnite has V-Bucks. Decentralized Finance (DeFi) also permeates the Metaverse. Non-Fungible Tokens (NFT) add another layer of uniqueness and security to digital assets. Users can own unique virtual assets, such as virtual real estate, digital art, or even digital pets, secured by blockchain technology (Stephens, 2022).

The Metaverse is expanding with digital twins and digital me, revolutionizing human identity. A digital twin refers to a virtual counterpart of a physical asset or a process, representing it in the Metaverse, providing real-time monitoring, simulation, and optimization. A digital me is a self-aware avatar in the Metaverse that represents its owner's values, experiences, and characteristics in an online setting (Babu & Mohan, 2022).

The Metaverse is expanding with digital twins and digital me, revolutionizing human identity. A digital twin refers to a virtual counterpart of a physical asset or a process, representing it in the Metaverse, providing real-time monitoring, simulation, and optimization. A digital me is a self-aware avatar in the Metaverse that represents its owner's values, experiences, and characteristics in an online setting (Babu & Mohan, 2022).

From this discussion, it's clear the Metaverse while stemming from early conceptions in science fiction and online gaming, has expanded its horizons to encompass various aspects of daily life. As technology continues to evolve, so too will the applications of the Metaverse, paving the way for new possibilities. However, it's also important to consider the potential ethical and governance challenges such developments might bring.

In a study (Damar, 2021), the data of all documents from 1990-2021 from the Web of Science database was extracted. The study observed a few studies whose popularity has peaked in recent months. It was pointed out that the metaverse was heavily associated with virtual reality and augmented reality technologies.



Furthermore, its applications were highest in the sectors of education and digital marketing. The study concluded that the Metaverse will be shaping our lives in the next few decades by taking advantage of the opportunities of developing technology.

The metaverse is poised to revolutionize how we interact with digital environments through augmented and virtual reality technologies. In this light, popular virtual environments like Second Life, Fortnite, Roblox, and VRChat provide insight into the metaverse's potential socio-economic impact (Dwivedi, 2022). Although the complete technology and infrastructure are yet to exist for a fully functional cross-platform metaverse, the transformative potential of the metaverse is being actively studied. Impact areas include marketing, education, healthcare, and societal aspects, among others.

Expert perspectives from various disciplines combine to scrutinize topics related to the metaverse, concluding with a proposed research agenda that could be beneficial for researchers, professionals, and policymakers (Yemenici, 2022). The exploration delves into entrepreneurship opportunities, challenges, and potential effects on the business world and social life standards.

Entrepreneurship in the metaverse is seen as a ripe opportunity. However, the initial costs for participation might be high, suggesting that entrepreneurs solidify their ideas and assess their feasibility in the virtual world. This exploration represents one of the few that examine entrepreneurship in the metaverse, aiming to shed light on the associated problems and opportunities (Yemenici, 2022).

The rapid development of the metaverse is expected to have widespread effects on humanity, both positive and negative. Amid concerns about digital manipulation, it is argued that understanding imminent risks is crucial before diving headlong into the metaverse (Serpil & Karaca, 2023). Philosophical perspectives on human creation could provide valuable insights in raising awareness about these risks. The focus is on analyzing cognitive processes underlying mainstream attitudes and perspectives towards the metaverse, offering a roadmap for understanding this digital transformation (Serpil & Karaca, 2023).

2.1. The Metaverse Applications

Listed below are some Metaverse use cases and applications in different sectors of the world;

2.1.1. Gaming

The gaming sector is considered a significant early adopter and investor in the Metaverse technology. It enables players to interact within a single, interoperable environment. Games like The Sandbox, Sorare, and Axie Infinity are successful examples of the Metaverse in the online gaming industry. The Metaverse games, with attributes such as a full-fledged social environment, cryptocurrency earning potential, compatibility with in-game NFT assets, and a mixed reality experience, offer unique gaming experiences.

2.1.2. Travel and Tourism

Virtual tourism, a progressive application of the Metaverse, facilitates virtual exploration, ideal for those unable to travel long distances. Creating immersive digital experiences using AR and VR is a breakthrough in the travel industry. Thomas Cook's Virtual Reality Holiday "Try before you Fly" is a perfect example.

2.1.3. Education and Learning

The Metaverse's potential in education and learning is substantial. It allows students to watch live experiments, enhancing the learning experience. An example includes New York school students learning astronomy in a virtual spaceship. It also removes language barriers, allowing students worldwide to learn in a shared digital space. Microsoft's Mesh, a mixed-reality platform, is another instance where learners can interact using 3D avatars.



2.1.4. Remote Working

The Metaverse radically transforms traditional business models. Companies like Nike, Intel, YouTube, McDonalds, and emerging startups like Gravity Sketch and Upland have embraced the Metaverse's virtual business architecture. It enables VR training for employees, virtual communication and collaboration, and conducting meetings with 3D avatars.

2.1.5. Real Estate

The Metaverse has also found a place in the real estate sector by offering clients immersive virtual reality experiences. Clients can explore properties in real-time via virtual tours, saving them the time and effort of physical visits. Moreover, these virtual tours can be customized to suit clients' preferences and needs.

2.1.6. Healthcare (Intelligent)

The Metaverse technology provides innovative ways of delivering treatments, resulting in improved outcomes at lower costs. The Metaverse technology powers concepts like Telemedicine and Telehealth, digital therapies, and digital workouts. Digital Twin technology is another noteworthy application, creating a patient's digital representation for testing treatments. On top of this, the metaverse, a convergence of technological and sociological advancements, has potential applications beyond entertainment and social networking. It can be used in fields like professional training, education, supply chains, real estate marketing, and even healthcare, as demonstrated by the concept of MeTAI (Wang, 2022). The substantial growth of telemedicine during the COVID-19 pandemic indicates the potential speed of metaverse adoption. Initiatives are needed to develop the healthcare metaverse, or MeTAI, to ensure it is cost-effective, user-friendly, high-performing, safe, equitable, and ethical while balancing hype with realistic expectations.

2.1.7. Banking and Finance

The Metaverse application in banking offers a complete overview of physical banks from any location. This technology, along with blockchain, NFT marketplace development, and other DeFi cryptocurrency assets, brings substantial advantages to banking, enhancing customer experiences with personalized services and data visualization.

2.1.8. Social Media and Entertainment

The Metaverse technology has significantly transformed online entertainment in social media. Users now communicate using digital avatars and virtual clones. Facebook's name change to Meta signifies abundant opportunities in the digital media space. The Metaverse applications are also emerging in industries like fashion, eCommerce, sports, and potentially in the manufacturing IoT and supply chain industry.

2.1.9. Digital Anti-Aging

The metaverse harbors potential benefits in digital anti-aging by providing virtual healthcare, fitness programs, and opportunities for socialization. It delves into integrating these services into the metaverse while acknowledging the potential challenges that might emerge (Mozumder, 2023). Additionally, it highlights the metaverse's potential for managing chronic diseases by transitioning existing digital solutions into the virtual environment, employing holographic construction and simulation, fusion of the virtual and real, and virtual-real linkage. There is a suggestion for integrating AI, IoT, and brain-computer interfaces to develop medical equipment and methods for the simulation process. However, it's recognized that these technologies are still in their developmental stages, necessitating further research.

2.2. Innovation Dilemma

Immersive technology is just like atom splitting. It can be used to help mankind, lifting mankind, or it can be



used for destroying mankind. That's where we are with virtual reality. We're on the cusp of having powerful tools like fire. What are we going to do with it? How are we going to use it? How are we going to put in safeguards so that we don't get burned? (Heller, 2021).

Since our inception, our natural propensity towards discovery and invention has shaped our existence. We perpetually strive to invent new tools and modify our surroundings, a process we commonly term as innovation.

However, innovation carries its own burdens, often manifesting as unforeseen consequences. Consider the case of DDT (Dichlorodiphenyltrichloroethane), a widely used pesticide of the past. The adverse environmental effects of DDT are well-documented, notably its near eradication of the bald eagle, America's emblematic bird. However, post the 1972 agricultural ban of DDT in the US, the bald eagle population has made a remarkable recovery. Paradoxically, DDT has saved countless lives by assisting in eradicating malaria in the US and Europe. Presently, malaria cases in these areas are restricted to individuals returning from tropical regions, where malaria continues to be a significant issue.

While DDT symbolizes well-intentioned innovation gone awry, sometimes innovation can be intentionally misused. Social media platforms exemplify this. They have positively transformed lives by helping people reconnect with old friends and stay connected with family. However, they also facilitate the spread of misinformation, affecting public opinion and electoral choices. The anonymity provided by these platforms has unfortunately empowered cyberbullying, causing distress and harm. Furthermore, as exposed by the Facebook Cambridge Analytica scandal, these platforms can misuse user data.

Given our problem-solving nature, innovation will persist. But we must comprehend the potential repercussions of our creations. The Metaverse is one such recent innovation that requires caution. In the subsequent section, we'll discuss why robust technology is crucial for the Metaverse while emphasizing the importance of governance, data privacy, and ethical considerations. (Kellenberger & Davidson, 2019).

Privacy is like oxygen; we really appreciate it only when it is gone. —Charles Sykes (1999)

2.3. User-Privacy Concern

The Metaverse is not simply an evolution of our digital experience but a revolution, offering an unprecedented level of integration between the digital and physical realms. With applications like Geppetto, Animal Crossing, and Roblox boasting hundreds of millions of users, the Metaverse captures the social values of Generation Z, where online personas are as substantial as their real-world counterparts (Park & Kim, 2022).

However, this growing influx of users entering the Metaverse also means an increase in personal information being willingly surrendered, often without a comprehensive understanding of the consequences. Individuals will unwittingly create permanent profiles surpassing the data footprints left on social media platforms. Why does this differ from our current digital context? And what could be the tangible impact of this shift?

The Metaverse, as a blend of numerous cutting-edge technologies, offers a much more immersive experience compared to conventional platforms, such as AR, VR, and AI. Such technologies enable hyper-personalized and contextual interactions, leading to more sophisticated data capture and profiling (Babu & Mohan, 2022; Vladimirov, Nenova, Nikolova, & Terneva, 2022). Furthermore, the lack of consensus on data governance and ethical norms in this new domain amplifies the potential risks to privacy and security.

While these concerns might seem speculative to consensus-based thinkers who require collective agreement before accepting such statements, those open to personal logic may resonate with the assertion that the Metaverse could potentially result in digital incarceration—an outcome arguably worse than real-world imprisonment due to its widespread and irreversible nature. However, it is crucial that these arguments are effectively communicated to suit both groups of thinkers.



This paper addresses this challenge by presenting empirical evidence and reasoned arguments. It offers a thorough analysis of the technologies shaping the Metaverse, the potential benefits and drawbacks, and highlights the current challenges and the need for further research. Notably, it examines the use of cutting-edge AI technology, such as Spiky.ai, which exemplifies how information can be extrapolated beyond the traditional boundaries of private data. The objective is to provide clear, compelling arguments that appeal to both consensus-based thinkers and those open to personally logical reasoning, promoting an inclusive discussion on the Metaverse and its societal implications.

2.4. Current and Future Technologies

The evolution of the Metaverse is shaping a new era of technological breakthroughs, led by innovations like brain-computer interfaces (BCIs) and augmented reality (AR). BCIs, by converting brain-generated electrical signals into external device commands, are pioneering an unmatched level of human-machine interaction (Vladimirov et al., 2022). Similarly, AR technology enhances our engagement with the Metaverse, integrating real-world elements into the digital landscape to enrich user experiences (Di Pietro & Cresci, 2021).

Nevertheless, this exploration of the Metaverse comes with a slew of risks, particularly in personal data, behavioral analysis, and communication privacy. Social platform-derived data, with its burgeoning growth, is vulnerable to misuse, leading to issues like doxing that compromise privacy (Vladimirov et al., 2022). The amplification of interactions within the Metaverse further heightens the possibility of data misuse and cybercrime.

Security concerns, including content integrity and user authentication, are also prominent (Vladimirov et al., 2022). The impending prominence of quantum computing, known for its complex computations and potential to crack traditional encryption methods, poses an immense challenge to maintaining a secure Metaverse environment.

Furthermore, the Metaverse will evolve the multimedia-centric internet experience to a multi-sensory content delivery platform (Di Pietro & Cresci, 2021). This transformative change would bridge the gap between physical and virtual realities, providing force-return effects that imitate real-world interactions. However, this heightened immersion also intensifies the associated risks, necessitating the creation of robust protective measures as we delve deeper into this digitized reality.

2.5. A Special Metaverse Application: Spiky.Ai

There is a novel application by Spiky.ai (2022). It is a new startup utilizing AI to build a better meeting experience. Spiky provides a digital sentiment dashboard that aims to unleash everybody's best potential by utilizing statistical theory to fuel conversational intelligence and to maximize success rates based on experience. Spiky's mission is to empower organizations, communities, and corporations via online meetings, video games, and any interactions by making them more insightful, engaging, and thus efficient. These benefits, in turn, help them to create an inclusive online workplace using artificial intelligence (AI). The AI tool respects data privacy by not copying any data to its servers – instead uses the storage of their users. The ultimate objective of Spiky is to offer a personalized experience by which the users have empowered engagement and enhanced communication among themselves. Finally, this leads to a brighter future for hybrid and online workplaces and unleashes the best potential in everyone.

Spiky incorporates 20 AI models that evaluate three verticals of metrics. They have verbal cues, such as objectivity and positivity, vocal cues such as energy level and emotional vocal tone, and non-verbal cues from eye movement, nodding, and facial expressions. This technology provides 50+ metrics in the backend to create a comprehensive picture of what happened each second of the video. They can then correlate these metrics with how well a meeting went, based on any success metric one might have. In their current focus, they evaluate sales meetings and customer calls to give salespeople more average success per meeting.

Furthermore, their technology has been incorporating aspects of generative AI to analyze context feedback to create a personalized coaching engine.

Their technology appears to have the most in-depth perspective on conversation compared to anything on the market. Technologies such as Spiky.AI are proof of the innovation of technology surrounding the Metaverse. Implementing such technologies would allow the Metaverse to gather user behavioral data.

3. METHODS

3.1. Bibliographic search

Bibliometric analysis of the Metaverse-related publications was performed to understand the interesting trend in the Metaverse as a concept in Google Ngram and in scientific publications using Google Scholar.

3.2. Survey

Furthermore, a survey was conducted globally to qualitatively and quantitatively understand people's perceptions of the Metaverse. To better understand the public's perception of the Metaverse and to validate the information presented in this paper, the survey was conducted with 22 questions using an online Google Form. Six questions were demographic, and the rest (16) were explorative ones about the public's knowledge.

3.3. Spiky.ai

Finally, an AI-based analysis of video recordings (meetings, video game sessions, and YouTube) was performed using the text and voice data to demonstrate what kind of behavior quantification can be obtained. There are different tools available in the market depending on the applications. For example, for sales training, gong.io for conversation sentiment analysis, and one for video analytics. For the analysis, Spiky.AI was used as it is the only one that covered conversation, video, and text, making it most relevant to the scope of the Metaverse.

Spiky.ai examines meetings from Zoom, Webex, and Microsoft Teams, and any video uploads, and analyzes the attentiveness, emotion, language used, etc. to give a score of engagement to a meeting. This acts as a metric for a company as it analyzes what goes on in the meetings.

4. RESULTS

4.1. Bibliographic search

Based on the Google Ngram search, we found that the number of the Metaverse relevant terms, e.g. virtual reality, increased steadily between the years 1990 and 2019 (the latest year available) (Fig. 1).

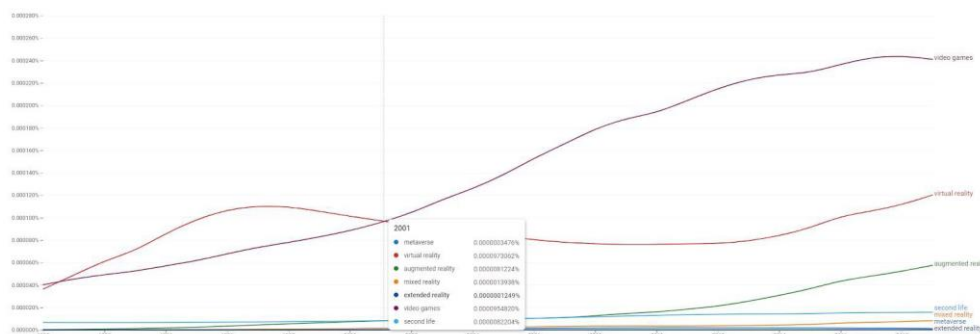


Figure 1. Google Ngram showing the increase in the number of occurrences of the Metaverse relevant terms, e.g., virtual reality.

Popularity of Metaverse and Metaverse & Ethics

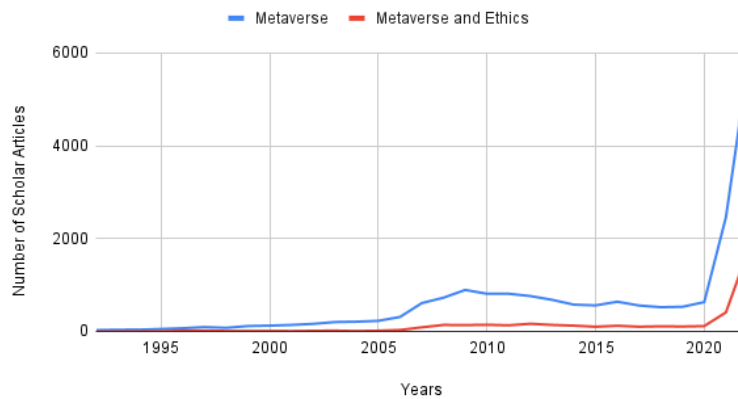


Figure 2. Google Scholar results for Metaverse and Metaverse & Ethics

Google Scholar results showing an exponential increase in the number of publications with the keywords “Metaverse” and “Metaverse & ethics” in the recent years, using the date between the years 1992 and 2022

Popularity of AI

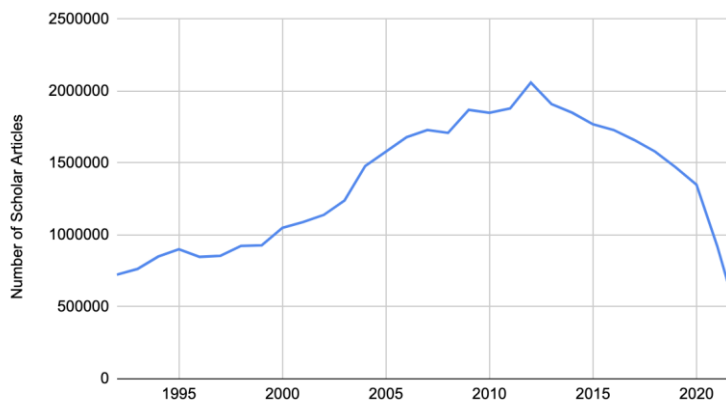


Figure 3 Google Scholar results for AI

Google Scholar results showing an increase until 2012, and then a decline in the number of publications with the keyword “AI” in recent years, using the date between the years 1992 and 2022.

Popularity of Metaverse and AI

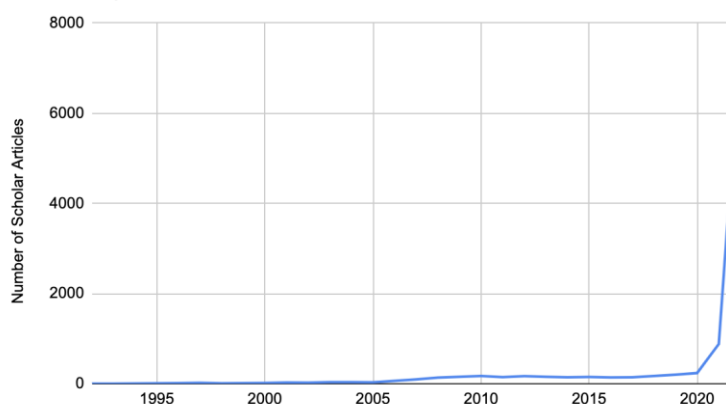


Figure 4 Google Scholar results for Metaverse and AI

Google Scholar results showing an exponential increase in the number of publications with the keywords “Metaverse and AI” in recent years, using the date between the years 1992 and 2022.

4.2. Survey

Following is the summary of responses from a cohort of 97 participants to these 16 questions.

Q1: Have you ever heard of the Metaverse? (Multiple Choice)

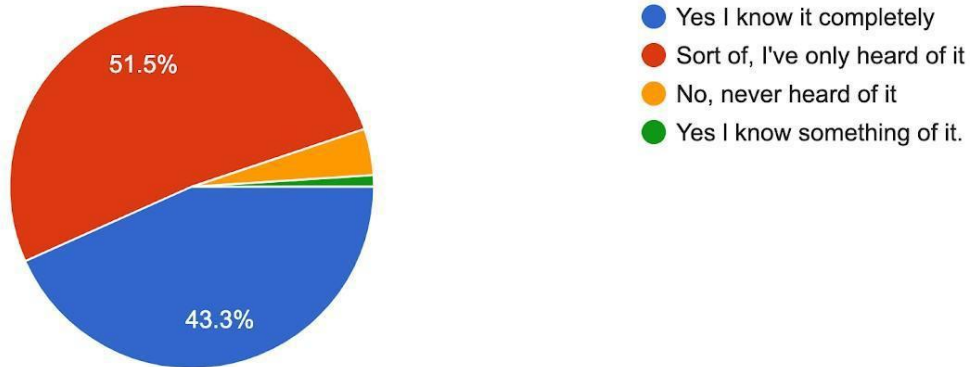


Figure 5. Answers for Q1

Q2: Do you think the Metaverse will be beneficial to society? (Multiple Choice)



Figure 6. Answers for Q2

Q3: How often would you use the Metaverse if it was affordable and easy? (Multiple Choice)

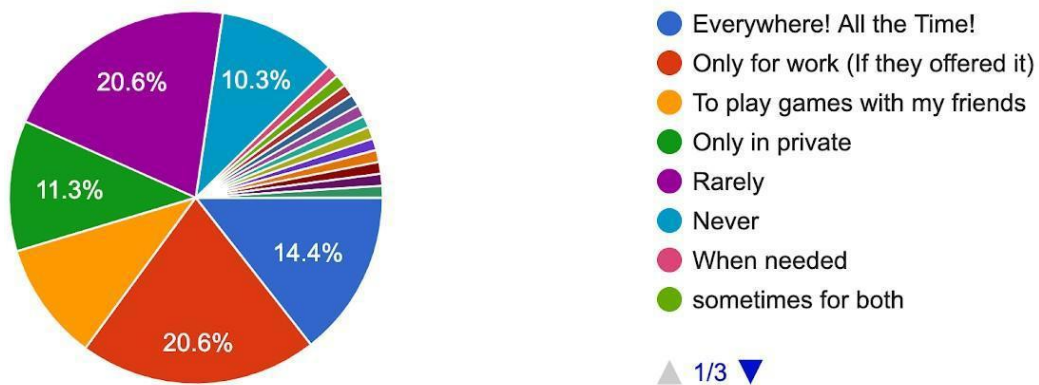


Figure 7. Answers for Q3

Q4: Do you think that if the promises of the Metaverse were to be true, it would be the most innovative technology to develop in the 21 st Century? (Multiple Choice)



Figure 8. Answers for Q4

Q5: Would you use the Metaverse if it were free while collecting your behavior data? (Multiple Choice)



Figure 9. Answers for Q5

Q6: Would you use it in your workspace if it were required? (Multiple Choice)

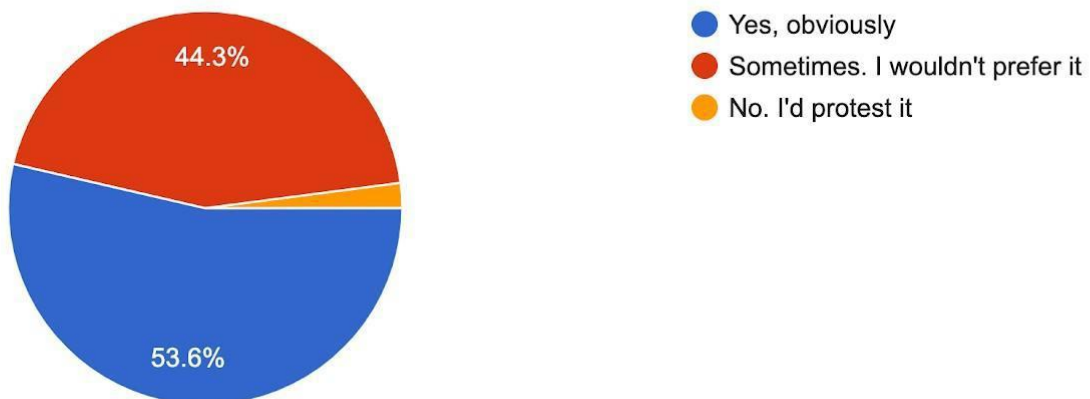


Figure 10. Answers for Q6

Q7: Did you ever have a bad experience on the Internet? (Multiple Choice)

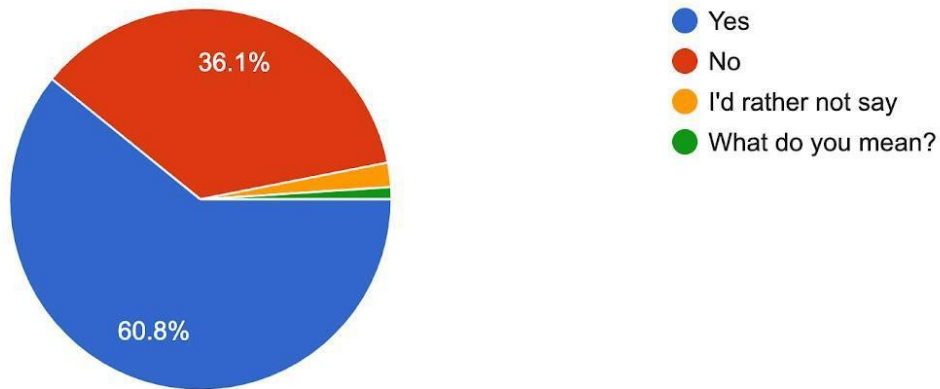


Figure 11. Answers for Q7

Q8: Which area(s) was your bad internet experience in? (Checkboxes)

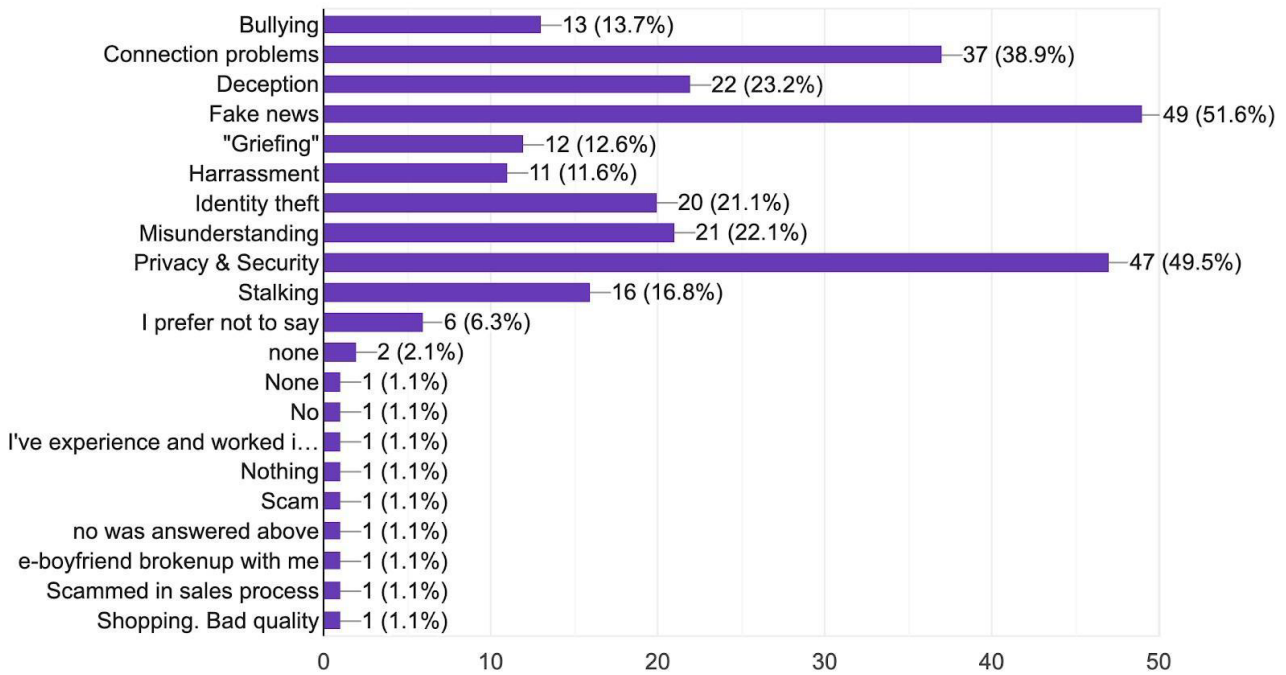


Figure 12. Answers for Q8

Q9: Do you think that same bad experience could be possible on the Metaverse? (Multiple Choice)



Figure 13. Answers for Q9

Q10: Which Industry(-ies), if any, do you think the Metaverse would have an impact on? (Checkboxes)

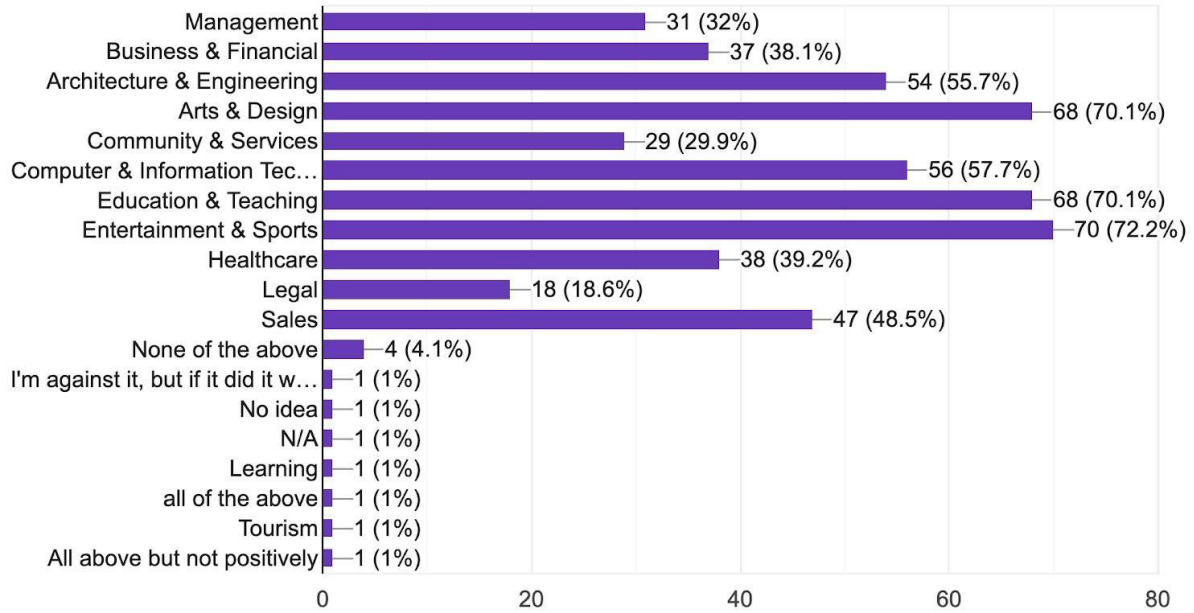


Figure 14. Answers for Q10

Q11: Do you think the Metaverse will be a convincing duplicate of our world? (Multiple Choice)

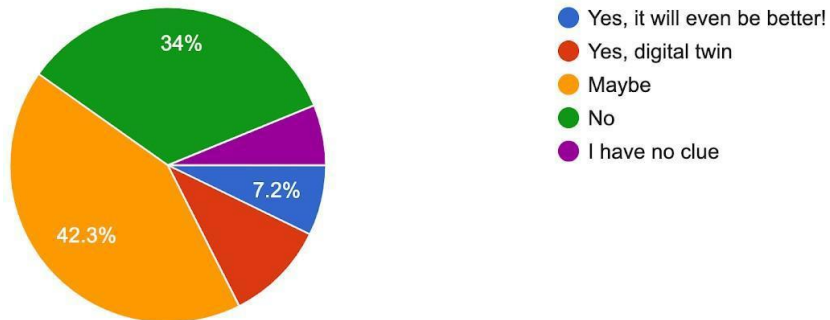


Figure 15. Answers for Q11

Q12: In your opinion, is the Metaverse even possible? (Multiple Choice)

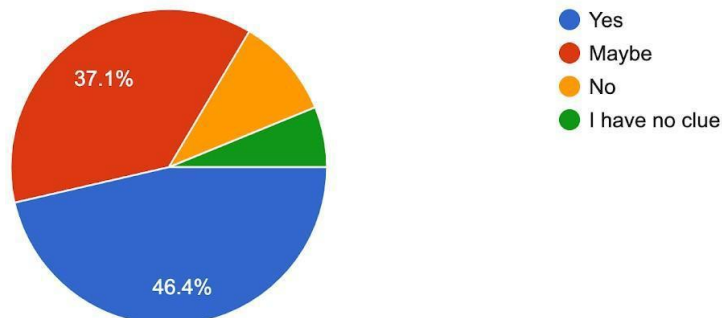


Figure 16. Answers for Q12

Q13: If the Metaverse becomes possible, in how many years do you think it will reach wide-spread use?

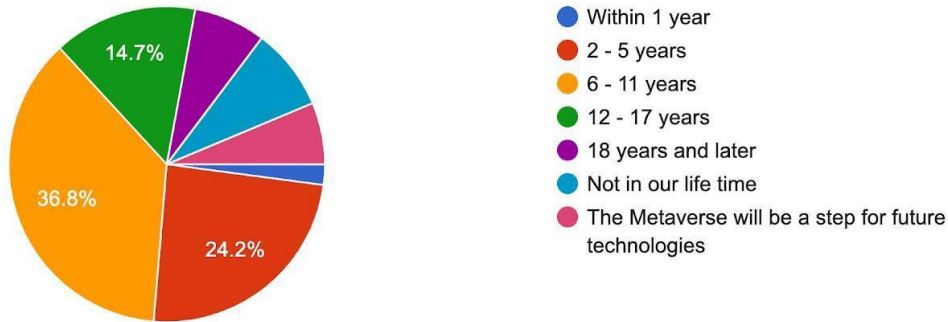


Figure 17. Answers for Q13

4.3. Spiky.ai

Spiky.ai was used to do analysis of 16 videos composed of three categories: 1) meetings, 2) video game sessions and 3) YouTube videos. The analyses of the best example from each category are shown in Figures 18, 19 and 20.

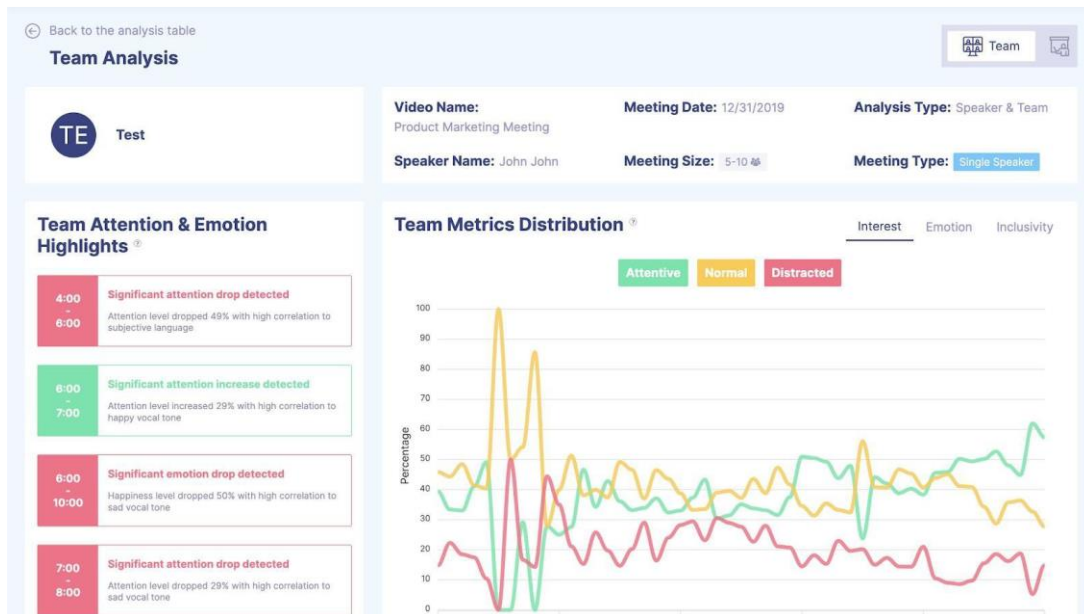


Figure 18a. Analysis of a corporate team meeting

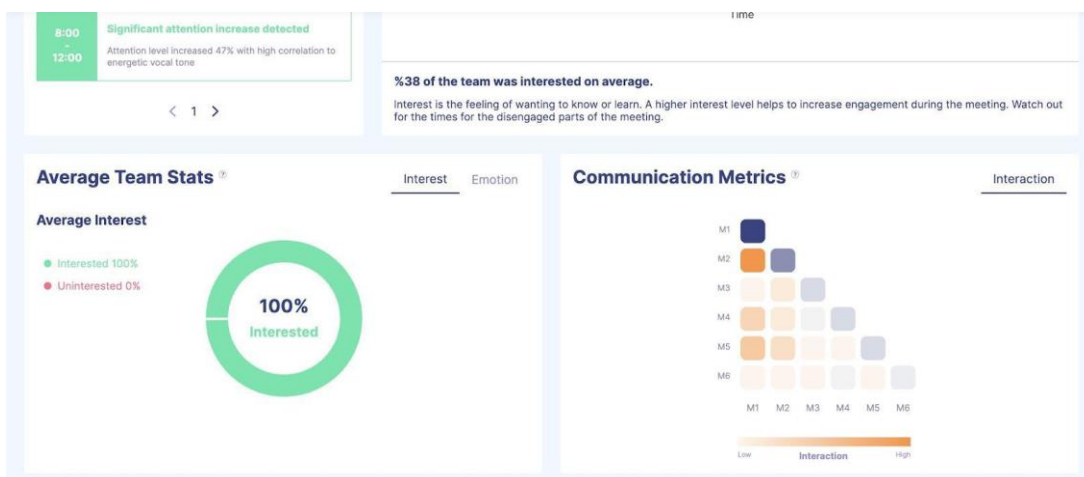


Figure 18b. Analysis of a corporate team meeting

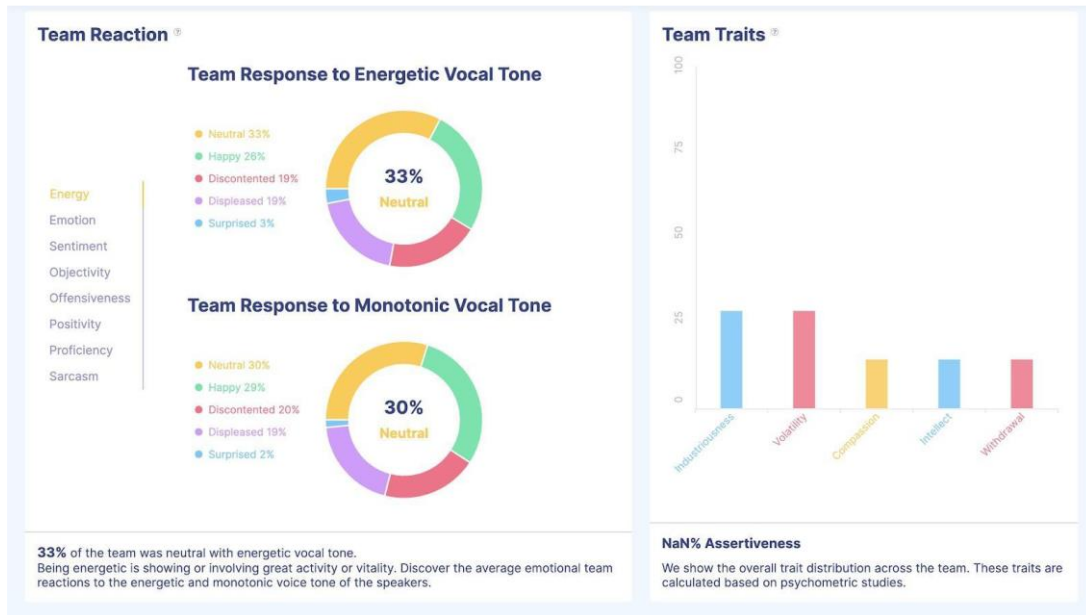


Figure 18c. Analysis of a corporate team meeting



Figure 19a. Analysis of a video game session

Figure 19b. Analysis of a video game session

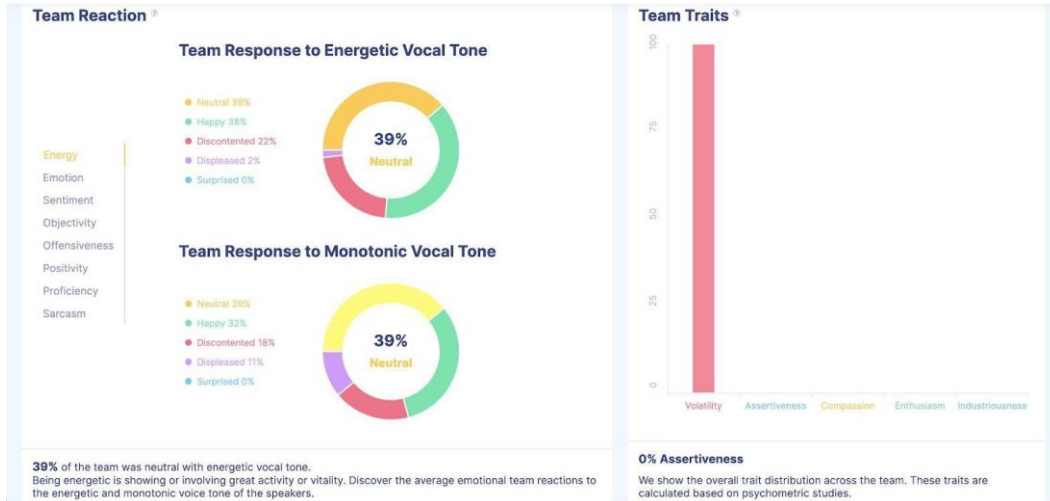


Figure 19c. Analysis of a video game session

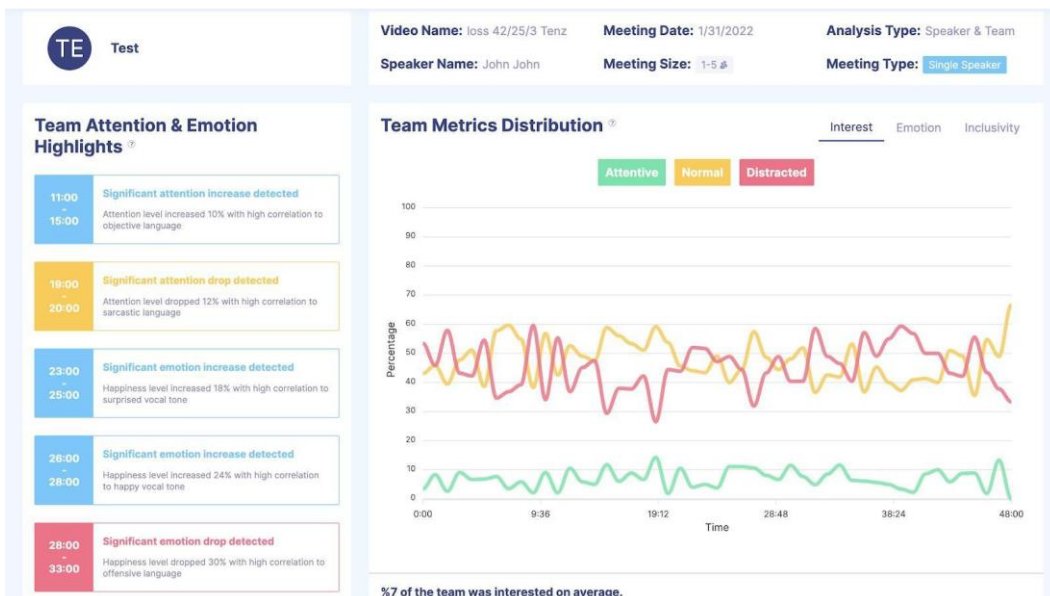


Figure 20a. Analysis of a YouTube video

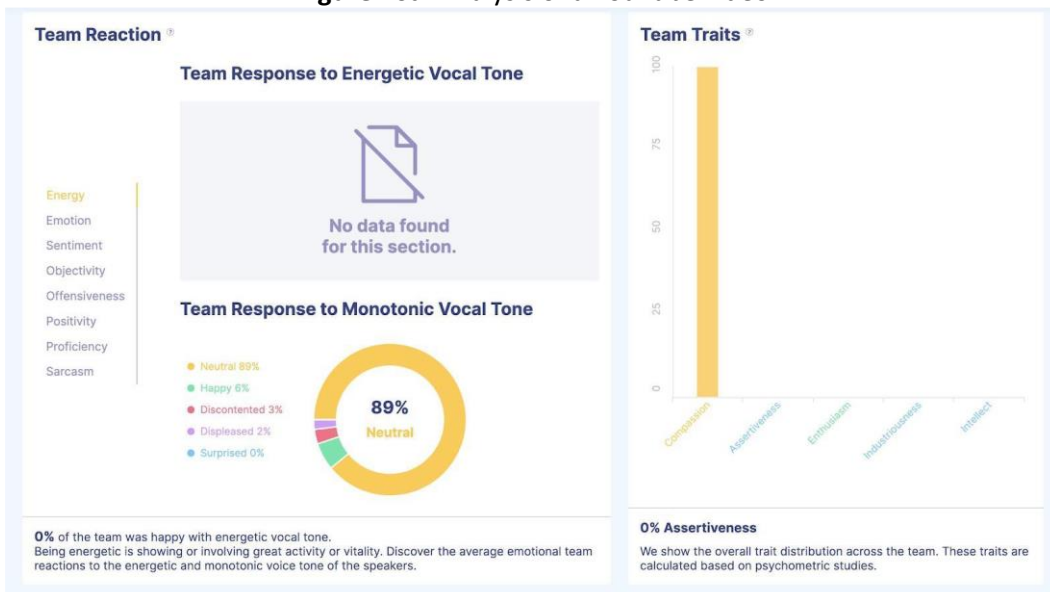


Figure 20b. Analysis of a YouTube video

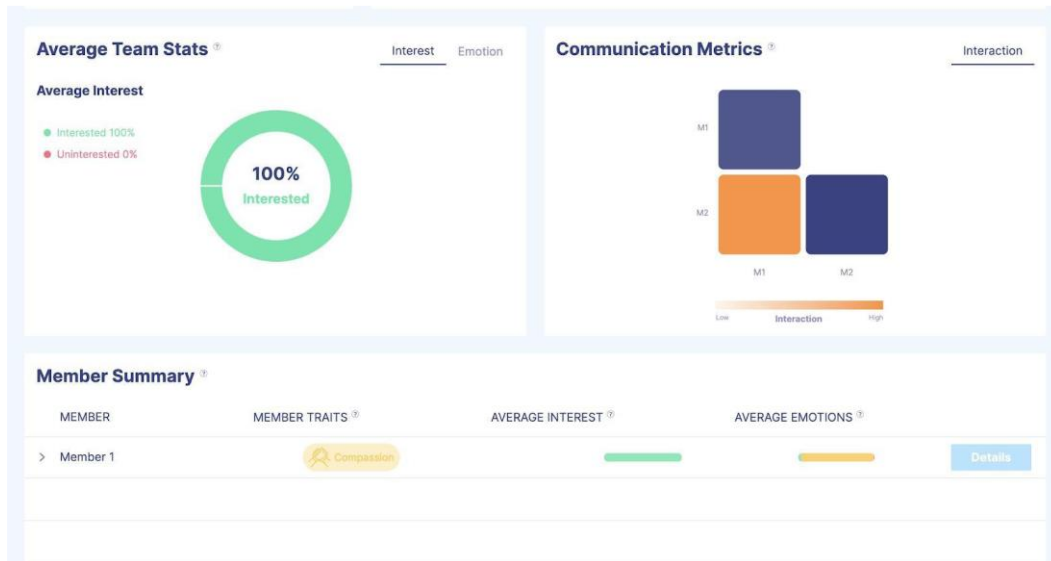


Figure 20c. Analysis of a YouTube video

5. DISCUSSION

5.1. Bibliographic search

According to the Google Ngram search, concepts relevant to the Metaverse have had a steady increase suggesting that the public's interest is on the rise. It is anticipated that the public's awareness will continue to increase.

Similarly, and probably more sharply, scientific publications are expected to increase. A more detailed subset of keywords can be used to see the trends. Those about technology are likely to increase while those about governance and ethics may not have a strong trend unless these topics are encouraged – a purpose of this publication.

5.2. Survey

In addition to the results, there is more information to be extracted from this survey. For example, certain populations followed different trends.

Based on the survey results, other interesting observations can be made:

- Out of the responses,
 - a) 47.3% believe that the Metaverse will bring new opportunities to society
 - b) Out of the 47.3% that believe the Metaverse will bring new opportunities to society;
 - c) 26.2% believe that the Metaverse will reach wide-spread use in 2 to 5 years.
 - d) 50% believe that it will reach widespread use in 6 to 11 years.
 - e) 14.2% believe that it will reach use in 12 to 17 years.
 - f) 4.8% believe that it will reach use later than 18 years.
 - g) 0% said it won't be used in our lifetime
 - h) 4.8% believe that the Metaverse will be a step for future technologies.
- 19.1% has a Doctorate Degree:
 - a) 17.6% believe that the Metaverse will revolutionize our world.

- b) 45% believe that it will be the best technology of the 2020s
- c) 17.6% believe it will just be another Facebook (Meta)
- d) 9.8% believe that it will have no effect e. 10.0% have no clue
- 51.1% of the respondents have experienced privacy and security issues. 92% of these people agree that it can happen on the Metaverse.
- Out of the 34% females:
 - a) 49% said yes to allowing the Metaverse to collect data.
 - b) 51% said no.
- Out of the 61.7% males:
 - a) 42% said no to allowing the Metaverse to collect data.
 - b) 58% said yes.

5.3. Spiky.ai

Utilizing verbal, vocal and non-verbal cues along with emotional vocal tone, Spiky.ai provided several metrics by analyzing every second of the sample videos. As a result, the psychographic reports inform the leadership about the effectiveness of the meetings.

- For example, in the corporate meeting (Fig. 18) the monotonic tone made the team happier (29%) vs. the energetic tone did (%26%).
- In the case of gaming (Fig. 19), however, the energetic tone resulted in 38% vs 32% happiness with the team, compared to the monotonic tone.
- In the last example of a YouTube video, compassion did not bring much happiness (6%) but the interest was high (100%) with the team.

Our results are not comprehensive to draw definite conclusions. However, they are directionally consistent with the results of similar studies. Additional insights were also obtained with the survey and innovative AI-based analysis with the example of spiky.ai results.

In the future studies, the sample size and diversity used in the survey and AI should be increased. For the bibliographic analysis, only those publications with English were included; publications in other languages, e.g., French, Spanish, and China, should be included for a better representation to draw conclusions worldwide.

6. CONCLUSION

This paper focused on the Metaverse and the potential challenges that would make people feel incarcerated rather than letting them enjoy freedom.

Accordingly, three different types of analysis were performed. The bibliographic analysis showed the privacy and security aspects of the Metaverse. The survey demonstrated that the insight and awareness of the public about the Metaverse is still immature. Finally, Spiky.ai based analysis illustrated that new tools are available to obtain the virtual mind-prints of the users/their avatars. If the latter is not protected along with the standard personal information, the Metaverse – which is otherwise full of potential to offer value to the society, to the economy, and to many other areas, may end up being harmful to humankind. This outcome would be even worse than being incarcerated in the real-world.



Looking at social media, gaming, online harassment, and other challenges with user safety and speech-related harms in online spaces may offer a cautionary example for anticipating and addressing emerging problems with immersive experiences (Heller, 2021).

Combining the results from this study and those from the others (Stephens, 2022), the recommendations include:

- We must build a general awareness of the problem: we must understand what the Metaverse is, its governance challenges and feasible opportunities are.
- While we need governance at a universal level, it must adapt to the characteristics of industry and markets, suggesting that the importance of this topic spans across geographies, industries, and disciplines.
- There must be data sharing and auditing across different entities including governing bodies, and this requires standards, educators, auditors, and enforcers.
- Because the speed of technological innovation is so fast, there must be an agile framework that responds to changes and observations from deploying these technologies.
- The issue of long-term research needs committed funding, and it should be spread across multiple disciplines—sciences, social sciences, and politics—to do justice to the emerging phenomena.
- We should start involving all age groups in the studies and regulations as the topic is relevant to all but also especially the vulnerable groups like children and elderly.
- We should not only cover technology and governance elements of the protection of privacy but enhance the Metaverse with ethics. This would not only make the Metaverse a safer place, it would also provide a “mirror” effect on the real-world, as we iterate between the two “universes”.

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Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning

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Abstract

Since its maiden release into the public domain on November 30, 2022, ChatGPT garnered more than one million subscribers within a week. The generative AI tool –ChatGPT took the world by surprise with its sophisticated capacity to carry out remarkably complex tasks. The extraordinary abilities of ChatGPT to perform complex tasks within the field of education has caused mixed feelings among educators, as this advancement in AI seems to revolutionize existing educational praxis. This is an exploratory study that synthesizes recent extant literature to offer some potential benefits and drawbacks of ChatGPT in promoting teaching and learning. Benefits of ChatGPT include but are not limited to promotion of personalized and interactive learning, generating prompts for formative assessment activities that provide ongoing feedback to inform teaching and learning etc. The paper also highlights some inherent limitations in the ChatGPT such as generating wrong information, biases in data training, which may augment existing biases, privacy issues etc. The study offers recommendations on how ChatGPT could be leveraged to maximize teaching and learning. Policy makers, researchers, educators and technology experts could work together and start conversations on how these evolving generative AI tools could be used safely and constructively to improve education and support students' learning.

Keywords: ChatGPT, Education, Generative AI, Teaching and Learning

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1. INTRODUCTION

The 21st century has experienced a rapidly changing landscape in educational practices largely due to advancement in technology (such as artificial intelligence) (Petersen, 2021). Recent progress and expansion in machine learning has led to a more sophisticated innovative technology digital content generation like generative artificial intelligence (AI) (Hu, 2022). Generative modeling artificial intelligence (GAI) is an unsupervised or partially supervised machine learning framework, which generates manmade relics via the use of statistics, probabilities etc (Hu, 2022; Jovanović, 2022). Through advances in deep learning (DL), generative AI creates artificial relics using existing digital content such as but not limited to video, images/graphics, text, audio, video by examining training examples; learning their patterns and distribution (Abukmeil, et al., 2021; Hu, 2022; Jovanović, 2022; Gui, et al., 2021). Extant literature has identified two major generative AI – Generative Adversarial Network (GAN) and Generative Pre-trained Transformer (GPT) (Abukmeil, et al., 2021; Brown et al., 2020; Hu, 2022; Jovanović, 2022; Gui, et al., 2021). Currently, GAN is the common GAI technique used. GAN uses two neural networks (i.e., generator and discriminator networks). The generator network generates synthetic data (e.g., image of someone’s face), while the discriminator network examines the genuineness of the content to determine whether the content is authentic or not (e.g., whether the image of the human is real or not). This verification process continues until the discriminator network is not able to decipher between the synthetic and real content, and synthetic is recognized as real (Hu, 2022; Jovanović, 2022). GAN is predominantly used for voice generation, graphics and video (Hu, 2022).

On the other hand, Generative Pre-trained Transformer (GPT) models use large amount of publicly available digital content data (natural language processing [NLP]) to read and produce human-like text in several languages and can exhibit creativity in writing from a paragraph to a full research article convincingly (or near convincing) on almost any topics (Aydin & Karaarslan, 2023). These models are even able to engage customers in human-like conversation such as customer-service chatbots or fictional characters in video games (Aydin & Karaarslan, 2022; Jovanović, 2022; Korngiebel et al., 2021; Pavlik, 2023). A more sophisticated Generative Pre-trained Transformer (GPT) -3 has recently been developed (Brown, et al., 2020). Using 175 billion parameters, GPT-3 has been developed to enhance task-agnostic and even become competitive with prior state-of-the-art fine-tuning approaches (Brown, et al., 2020). Brown et al., (2020) stated that GPT-3 is ten times more than any previous non-sparse language model. GPT-3 has become the basic NLP engine that runs the recently developed language model ChatGPT, which has attracted attention in various fields, including but not limited to education (Williams, 2023; Tate, 2023), engineering (Qadir, 2022), Journalism (Pavlik, 2023), medical (Nisar, & Aslam, 2023; O’Connor, & ChatGPT, 2023) and economic and finance (Alshater, 2022; Terwiesch, 2023). In the next sections we provided an explanation of what ChatGPT is, and the potential to improve education and students’ learning. We also discussed some limitations and how educators can use ChatGPT to support and improve students’ learning. An earlier version of this work has previously been published in a preprint (see Baidoo-Anu & Owusu-Ansah, 2023).

2. METHODOLOGY

We employed an exploratory methodology to understand the potential benefit of ChatGPT in Education. The purpose of this methodology is to systematically review and explore (a) how interactive ChatGPT is, (b) the benefits of ChatGPT and related generative AI in advancing teaching and learning, (c) the possible drawbacks of using ChatGPT and related generative AI in education, reflections and implications for practice. The study was guided by these research questions –(a) How interactive is ChatGPT? (b) What are the potential benefits of ChatGPT and related generative AI in advancing teaching and learning? (c) what are the possible drawbacks of using ChatGPT and related generative ai in education? The study focused on publicly available resources on ChatGPT from November 2022-March 2023. Specifically, we focused on articles published in a peer reviewed journals or preprints as well as newsletter articles and social media. We were also interested in



articles which have been published in English Language.

3. WHAT IS CHATGPT?

To begin, we asked ChatGPT to explain itself. The prompt we started with was “*What is ChatGPT?*”. ChatGPT generated this response.

“ChatGPT is a large language model trained by OpenAI. It is designed to generate human-like text based on a given prompt or context. It can be used for a variety of natural language processing tasks, such as text completion, conversation generation, and language translation”. (By ChatGPT January 23, 2023).

As a follow up, we used another prompt “*How does it work?*” To know how conversational it is, we intentionally wrote “*How does it work?*” instead of “*How does ChatGPT work?*”. It returned with the response below.

“ChatGPT is based on a transformer architecture, a type of neural network that has been shown to be very effective for natural language processing tasks. It is trained on a large dataset of text, such as books and articles, and learns to generate text that is similar to the text it was trained on. When given a prompt or context, the model processes the input and generates a response. The response is generated one word at a time, with the model predicting the next word based on the input and the words it has generated so far. The model uses attention mechanisms to focus on the most relevant parts of the input and generate a response that is coherent and appropriate for the given context. After the training, the model can be fine-tuned on a specific task such as question answering or dialogue generation by providing it with task-specific examples and fine-tuning the model on this data. It can also generate text in multiple languages by fine-tuning the model on the multilingual dataset or by providing the model with the language code” (By ChatGPT January 23, 2023).

Then the topic of conversation was changed to discuss COVID-19 and impacts on educational deliveries using the prompt “*Now discuss how COVID-19 has changed educational pedagogies.*” Within seconds it wrote the passage below.

The COVID-19 pandemic has had a significant impact on the way education is delivered, with many schools and universities shifting to online or remote learning in order to comply with social distancing guidelines. This has resulted in a rapid shift to digital and online pedagogy, as educators have had to quickly adapt to this new mode of instruction.

One of the major changes that has occurred is the increased use of technology for teaching and learning. This has included the use of online learning platforms, such as Zoom, Google Classroom and other video conferencing tools, as well as the use of digital materials, such as e-books, videos, and interactive activities. This has allowed for increased flexibility and accessibility in the delivery of education, as students can now access materials and participate in classes from anywhere with internet access.

Additionally, there has been a shift towards more self-directed and asynchronous learning, where students are given more autonomy in their learning and are able to complete coursework at their own pace. This approach allows students to work at a time that is convenient for them, and it can be beneficial for students who may have other responsibilities or who may have difficulty attending live classes. However, the shift to online learning has also highlighted the digital divide, where students in low-income or rural areas may not have access to the technology or internet connectivity needed to fully participate in remote learning. And it also brought challenges such as lack of interaction, lack of motivation and lack of accountability.

Overall, COVID-19 has accelerated the adoption of technology and digital pedagogy in education, but it has also highlighted the need for equity and accessibility in the delivery of education. The education system will have to continue to adapt and evolve to meet the needs of students, teachers and parents during these



challenging times (By ChatGPT January 23, 2023).

Obviously, the outcome clearly shows that ChatGPT is very interactional and capable of not only holding a realistic human-like conversation on a wide range of topics, but also it produces a convincing creative content.

Since its maiden release into the public domain on November 30, 2022, ChatGPT garnered more than one million subscribers within a week (Altman, 2022; Mollman, 2022). The ChatGPT took the world by surprise with its sophisticated capacity and became the hottest topic on social media and news outlets including Nature (Stokel-Walker, 2022) and The New York Times (Metz, 2022), among others. The ChatGPT has unprecedented ability to carry out remarkably complex tasks like writing an article (GTP-3 et al., 2021), story, poem, an essay (Lucy & Bamman 2021), ability to provide a summary or expansion of a text, adjusting texts to reflect a different perspective, and even write and debug original computer code (Williams, 2023; Tate et. al, 2023). The extraordinary abilities of ChatGPT to perform complex tasks within the field of education has caused mixed feelings among educators, as this advancement in AI seems to revolutionize existing educational practices. It has become a contentious topic among educators, while some perceive ChatGPT and related generative AI as the future of teaching and learning, as well as educational research. Others are skeptical and view it as a threat and a potential end to most educational activities, which makes teachers and students lazy with no or little analytical abilities. So, the question that begs for an answer is whether ChatGPT and related generative AI are the future for teaching and learning or a threat to the education field? We co-authored with ChatGPT to unpack some benefits of ChatGPT and related generative AI in advancing teaching and learning. We also co-authored to discuss the possible drawback of using ChatGPT and related generative AI in education. Implication for practice was discussed.

4. BENEFITS OF CHATGPT AND RELATED GENERATIVE AI IN ADVANCING TEACHING AND LEARNING

We queried ChatGPT to generate the benefit of ChatGPT and related generative AI in advancing teaching and learning. The initial prompt was *“What are the benefits of ChatGPT and related generative AI in advancing teaching and learning”*. ChatGPT generated very brief (a paragraph) response which was not detailed. Then when we altered the prompt, ChatGPT also altered the response by providing a detailed explanation. The altered prompt was *“I want you to discuss with possible reference the benefits of ChatGPT and related generative AI in advancing teaching and learning”*. The following detailed responses were generated.

ChatGPT, a large language model developed by OpenAI, has the potential to be a powerful tool in the field of education. Here are some specific ways in which ChatGPT can be used to enhance learning and the references that support it:

Personalized Tutoring: ChatGPT can be used to provide personalized tutoring and feedback to students based on their individual learning needs and progress. A study by Chen and colleagues (2020) demonstrated that a conversational agent based on a generative model (ChatGPT) could provide personalized math tutoring to students, resulting in improved learning outcomes. The study showed that the conversational agent was able to provide explanations that were tailored to students' misconceptions and was able to adapt to their level of understanding.

Automated Essay Grading: ChatGPT can be trained to grade student essays, providing teachers with more time to focus on other aspects of teaching. A study by Kim and colleagues (2019) showed that a generative model (ChatGPT) trained on a dataset of human-graded essays could accurately grade essays written by high school students, with a correlation of 0.86 with human grades. The study showed that the model was able to identify key features of well-written essays and was able to provide feedback that was similar to that provided by human graders.

Language Translation: ChatGPT can be used to translate educational materials into different languages, making them more accessible to a wider audience. A study by Johnson and colleagues (2016) demonstrated that a generative model (ChatGPT) trained on a dataset of bilingual sentence pairs could accurately translate between languages, achieving state-of-the-art results on several translation benchmarks. The study showed that the model was able to understand the meaning of sentences in one language and to generate accurate translations in another language.

Interactive Learning: ChatGPT can be used to create interactive learning experiences where students can interact with a virtual tutor in a conversational manner. A study by Peng and colleagues (2019) demonstrated that a generative model-based conversational agent could provide effective support for students learning English as a second language, resulting in improved language proficiency. The study showed that the agent was able to understand students' questions and to provide appropriate and relevant responses.

Adaptive Learning: ChatGPT can be used to create adaptive learning systems that adjust their teaching methods based on a student's progress and performance. A study by Chiang and colleagues (2021) showed that an adaptive learning system based on a generative model (ChatGPT) could provide more effective support for students learning programming, resulting in improved performance on programming assessments. The study showed that the model was able to understand students' knowledge and to adjust the difficulty of the problems it generated accordingly.

Overall, ChatGPT has the potential to be a powerful tool for enhancing teaching and learning by providing personalized tutoring, automated essay grading, language translation, interactive learning and adaptive learning (By ChatGPT January 24, 2023).

5. POSSIBLE DRAWBACK OF USING CHATGPT AND RELATED GENERATIVE AI IN EDUCATION

To have an overview of the possible drawback incorporating ChatGPT and related generative AI in education, ChatGPT was asked to discuss with references the possible drawback of using ChatGPT and related generative AI in education. Below is the outcome of my query.

While there are many potential benefits of using ChatGPT and other generative AI models in education, there are also some drawbacks to consider. These drawbacks are supported by research studies:

Lack of Human Interaction: ChatGPT and other generative models are not capable of providing the same level of human interaction as a real teacher or tutor. This lack of human interaction can be a disadvantage for students who may benefit more from a personal connection with a teacher. A study by D'Mello and colleagues (2014) found that students who interacted with a virtual tutor that mimicked human-like affective behavior had a better learning outcome than those who interacted with a virtual tutor that lacked this behavior.

Limited Understanding: Generative models are based on statistical patterns in the data they are trained on, and they do not have a true understanding of the concepts they are helping students learn. This can be a disadvantage when it comes to providing explanations or feedback that are tailored to a student's individual needs and misconceptions. A study by Wang and colleagues (2020) showed that a generative model-based tutoring system lacked the ability to provide explanations that were tailored to students' misconceptions.

Bias in Training Data: Generative models are only as good as the data they are trained on, and if the training data contains biases, the model will also be biased. For example, if a model is trained on a dataset of essays that are primarily written by students from a certain demographic, it may not be able to accurately grade essays written by students from other demographics. A study by Bolukbasi and



colleagues (2016) showed that a generative model trained on a large corpus of text from the internet exhibited gender bias in its language generation.

Lack of Creativity: Generative models can only generate responses based on the patterns in the data they have seen during training, which can limit the creativity and originality of the responses. A study by Ziegler and colleagues (2019) found that a generative model-based music composition system had a limited ability to generate original and diverse melodies.

Dependency on Data: Generative models are trained on a large amount of data, and the quality of the model is highly dependent on the quality and quantity of the data. If the data is not sufficient or not relevant, the model will not be able to perform as well. A study by Kocaguneli and colleagues (2019) showed that a generative model-based question answering system performed poorly when the training data was not relevant to the task at hand.

Lack of Contextual Understanding: Generative models lack the ability to understand context and situation, which can lead to inappropriate or irrelevant responses. A study by Gao and colleagues (2019) showed that a generative model-based dialogue system had a limited ability to understand and generate contextually appropriate responses in a conversation.

Limited ability to personalize instruction: ChatGPT and other generative AI models can provide general information and assistance, but they may not be able to personalize instruction to meet the individual needs of a particular student. (Ribeiro & Vala, 2020)

Privacy: There are also concerns about privacy and data security when using ChatGPT and other generative AI models in education. (Ribeiro & Vala, 2020).

It is important to keep in mind that ChatGPT and other generative AI models are powerful tools, but they are not a replacement for human teachers and tutors. It is important to use these tools responsibly and in conjunction with human instruction and support (Ribeiro & Vala, 2020).

Overall, while generative AI models such as ChatGPT can be powerful tools for enhancing teaching and learning, it is important to be aware of their limitations and to use them in conjunction with other teaching methods that emphasize human interaction and understanding (By ChatGPT January 23, 2023).

6. REFLECTIONS AND IMPLICATIONS FOR PRACTICE

Undoubtedly, ChatGPT and other generative AI is already pushing educational boundaries and initiating a significant paradigm shift in existing educational praxis. Since its introduction to the public in 2022, educators have written extensively about potential implications for teachers, students, and policy. Some educators have already started testing the efficiency of ChatGPT by integrating it in their educational activities (e.g., research, teaching, assessment) and found that through automation of certain tasks and processes, ChatGPT is able to save time for other important activities like spending more time with students (Alshater, 2022; Terwiesch, 2023). For example, Terwiesch who is a Professor at the Wharton School of the University of Pennsylvania indicated that it usually takes 20 hours of work to create an exam and another 10 hours for TAs to test the exam and write solutions to it. However, ChatGPT was able to create the exams within 10 hours and reduced TAs time to 5 hours. This shows 100% productivity increase in the “exam writing operation” (Terwiesch, 2023, p. 23). Similarly, Zhai (2022) stated that it took him 2-3 hours to conduct a study on ChatGPT. He said “...the entire process, including generating and trying queries, adding subtitles, and reviewing and organizing the content, took 2-3 hours” (p.9). Researchers were able to ask OpenAI’s GPT-3 to write an academic paper about itself and how it works (Thunstrom, 2022; preprint, GPT et al., 2022). The paper was submitted to an academic journal.

Herft (2023) has also identified several ways teachers could use ChatGPT to support and improve their



pedagogical and assessment practices. For example, teachers can leverage the capabilities of ChatGPT to create prompts for open-ended questions that align with the learning goals and success criteria of the unit of instruction. Additionally, ChatGPT can be used to also generate quality rubrics that clearly and concisely explain exactly what students need to accomplish to be successful in the various required levels of proficiency. Again, teachers can use ChatGPT to create “prompts for formative assessment activities that provide ongoing feedback to inform teaching and learning” (Herft, 2023, p. 3). Thus, generative AI-powered assessment systems may support the integration of continuous feedback into learning processes by utilising distinctive and atypical artefacts. Students can also use ChatGPT and other chatbots to support their learning. For instance, students could leverage the capacity of these advanced generative AI to provide systematic explanations of certain complex concepts. ChatGPT can serve as a virtual tutor, which can answer students' questions and provide explanations to a wide range of subjects. This can be particularly useful for students who are struggling with a particular topic or who need extra help outside of the classroom. Also, studies have found that non-native speakers of national languages and students with learning and language disabilities (i.e., struggles to write well) will benefit most from these natural language models. There are a wide range of student-centred learning approaches that can be constructed to be played in groups. The ChatGPT and related generative AI have the capacity to create distinct scenarios for students to collaborate to solve problems and achieve goals. In this way, students can learn from each other, which promote a sense of community among learners. Arguably, ChatGPT has a great potential to support and advance the work of educators, students and researchers.

Despite the myriad of potential educational benefits, in its current state ChatGPT has been found to have several serious inherent limitations, such as generating wrong answers and making-up articles that do not exist. For example, an author asked ChatGPT to generate books and articles in a paper he is working on, ChatGPT included a make-up article which does not exist and even provided full bibliographic details of the article with a non-functional URL (Qadir, 2022). These limitations and other glitches have been reported in other studies. Similarly, when we asked ChatGPT to discuss with references the possible drawback of using ChatGPT and related generative AI in education, it fabricated a reference “Ribeiro and Vala, 2020” to support it discussion. When we asked for ChatGPT to reference the citation it stated "A Survey on Generative Artificial Intelligence" by Ribeiro and Vala, which was published in the Proceedings of the 1st International Conference on Emerging Trends in Intelligent Computing and Informatics (ETICI 2020). Deep search for ‘Ribeiro and Vala, 2020’ work revealed that there is no conference presentation by Ribeiro and Vala, 2020 on generative artificial AI. Therefore, we have reasons to believe that this was fabricated article. This confirms a tweet from the CEO of OpenAI, Sam Altman, who described ChatGPT as “incredibly limited, but good enough at some things to create a misleading impression of greatness. It’s a mistake to be relying on it for anything important right now. It’s a preview of progress; we have lots of work to do on robustness and truthfulness.” (Tweet on December 11, 2022). Again, a cursory look at the ChatGPT- generated responses in this study reveals that it has no idea of the world after 2021. Hence it could not add any references or information after 2021. This is because ChatGPT was trained with information only up to 2021 (OpenAI, 2022). Given these inherent limitations, educators, researchers, students and other professionals who use ChatGPT and other chatbot should be cautious.

7. CONCLUSION AND THE WAY FORWARD

Despite its inherent limitations, it is a nearly undeniable fact that ChatGPT and other generative AI have come to stay and will continue revolutionizing the current educational system. Many have called for ChatGPT to be banned in the schools while others have started developing software to detect AI generated-texts (see, <https://writer.com/ai-content-detector/> and <https://huggingface.co/roberta-base-openai-detector>). Others have also provided tips that teachers can use to prevent students from using ChatGPT in writing their essays and other school assignments. For example, Elsen-Rooney (2023) reported that the New York City



Education Department (NYC) has blocked ChatGPT on school devices and networks so that students and teachers can no longer access ChatGPT. While these various strategies may work for a while, it may not stand the test of time with even more sophisticated generative AI like GTP-5, which is anticipated to come in the not-too-distant future.

Currently, extant literature has shown that AI generated-text detectors are not effective with current sophisticated natural processing language models (e.g., Williams, 2023; Tate, 2023). We should not lose sight of the fact that students also have access to these detectors and can alter the text generated to ensure that it becomes undetectable. In lieu of this, it is high time we began to accept the rapidly changing landscape in educational practices and incorporate these changes in our current educational praxis. Moreover, with Microsoft trying to incorporate ChatGPT holistically into its products (Rudolph et al., 2023; Warren, 2023), in no time ChatGPT will be conventional, and it may possibly be too late for educational institutions to rethink their policies and practices to guide and support their students in using ChatGPT safely and constructively. One area that has garnered more attention and become topical is students' assessment. It is too soon to conclude but very soon educators may need to rethink how students are assessed. They may have to change how assessment is currently done to more innovative assessments. Extant literature has demonstrated that teachers have limited capacity and skills to engage in high quality assessment practices that move learning forward. In lieu of this, educators have consistently called on teachers to develop capacity to engage students in high-quality assessment practices (Earl, 2012; Wiliam, 2011; Willis, Adie, & Klenowski, 2013). Through professional capacity building, teachers could develop the skills needed to harness the power of ChatGPT, and other generative AI to engage in high-quality assessment practices that improve students' learning.

Given the increase in AI even in workspaces, integrating generative AI tools in the classroom and teaching students how to use it constructively and safely could also prepare them to thrive in an AI-dominated work environment after school. Therefore, educators could harness generative AI models like the ChatGPT to support students' learning. Some questions need urgent answers, for example, how can we leverage ChatGPT to support students' learning? Do we need to train teachers and students on how they can use current generative AI tools to improve teaching and learning? How can we integrate generative AI tools into teacher education programs to prepare teacher candidates or pre-service teachers to effectively use AI tools in their classrooms? Will these generative AI tools close or augment existing digital divide and what is the way forward? Policy makers, researchers, educators and technology experts should work together and start conversations on how these evolving generative AI tools could be used safely and constructively to improve education and support students' learning.

CONFLICT OF INTEREST

We have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

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Integrated Risk Management and Artificial Intelligence in Hospital

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Review Article

Abstract

The topic revolves around the integration of Artificial Intelligence (AI) in Hospital Integrated Risk Management (IRM). AI offers significant advantages in enhancing risk identification, assessment, and mitigation across various areas of hospital operations. It can contribute to patient safety by enabling early detection of critical conditions, improving clinical risk management, and enhancing decisionmaking processes. AI also plays a vital role in information security and privacy, operational risk management, regulatory compliance, and human resources in hospitals. However, the use of AI in Hospital IRM comes with certain disadvantages and risks that need to be mitigated. These include data quality and bias, interpretability and transparency challenges, privacy and security concerns, reduced human oversight, ethical considerations, and implementation challenges. Mitigating these risks requires robust data governance, addressing bias in AI algorithms, ensuring transparency and accountability, implementing strong cybersecurity measures, and upholding ethical guidelines. To achieve successful implementation, hospitals should prioritize employee competencies, such as domain knowledge, data literacy, AI and data science skills, critical thinking, collaboration, adaptability, and ethical awareness. By developing these competencies and adhering to best practices, hospitals can optimize the use of AI in IRM, improve patient outcomes, enhance operational efficiency, and mitigate risks effectively.

Keywords: *Artificial Intelligence, Hospital, Integrated Risk Management, Patient*

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1. INTRODUCTION

The integration of Artificial Intelligence (AI) in Hospital Integrated Risk Management (IRM) (Mun et al., 2020), (Rodrigues et al., 2022) has emerged as a transformative approach to enhance patient safety, optimize operations, and mitigate risks in healthcare settings. AI offers powerful capabilities in analyzing vast amounts of data, identifying patterns, and making data-driven predictions to support proactive risk management practices. By harnessing AI technologies, hospitals can identify potential risks, improve decision making processes, and enhance overall risk mitigation strategies.

In this context, AI serves as a valuable tool for various areas of Hospital IRM, including patient safety, clinical risk management, information security and privacy, operational risk, regulatory compliance, and human resources. It assists in early detection of critical conditions, improves diagnostic accuracy, identifies fraudulent activities, optimizes resource allocation, and ensures compliance with regulations. AI-driven systems can continuously monitor patient data, detect anomalies, and provide real-time alerts, enabling healthcare professionals to intervene promptly and prevent adverse events.

However, the use of AI in Hospital IRM also poses challenges and risks. Data quality and biases, interpretability of AI algorithms, privacy and security concerns, reduced human oversight, ethical considerations, and implementation complexities need to be carefully addressed. Hospitals must establish robust data governance practices, validate AI outputs, ensure transparency, and adhere to ethical guidelines to mitigate these risks effectively.

To fully leverage AI in Hospital IRM, employees involved in its implementation and usage must possess specific competencies. These include domain knowledge, data literacy, AI and data science skills, critical thinking, collaboration, adaptability, and ethical awareness. By equipping employees with these competencies, hospitals can optimize the use of AI technologies, drive innovation, improve patient care, and strengthen their overall risk management strategies.

In summary, the integration of AI in Hospital IRM offers tremendous potential to revolutionize healthcare by enhancing patient safety, improving operational efficiency, and mitigating risks. While challenges and risks exist, the effective utilization of AI, along with the development of necessary competencies, can enable hospitals to navigate these complexities and achieve successful outcomes in risk management and patient care.

2. APPLIED AI IN IRM

Integrated risk management (IRM) refers to the coordinated and strategic approach to identifying, assessing, and mitigating various risks across an organization. It involves combining different risk management disciplines, such as operational risk, financial risk, compliance risk, and strategic risk, into a unified framework. Artificial Intelligence (AI) can play a significant role in enhancing integrated risk management practices. Here are a few ways in which AI can be applied (Oboni et al., 2007; Sun et al., 2020):

Risk Identification and Assessment. AI can analyze vast amounts of data from various sources, both internal and external, to identify potential risks and assess their impact. By applying machine learning algorithms, AI can detect patterns, anomalies, and correlations that may not be apparent to human analysts, helping organizations proactively manage risks.

Predictive Analytics. AI can leverage historical data, combined with real-time information, to generate predictive models. These models can forecast potential risks and their likelihood of occurrence, enabling organizations to take preventive measures and allocate resources effectively. For example, AI-powered algorithms can analyze market trends, customer behavior, and economic indicators to predict financial risks or identify emerging cybersecurity threats.



Fraud Detection. AI can be employed to identify fraudulent activities and anomalies in financial transactions, insurance claims, or procurement processes. By analyzing large volumes of data and employing pattern recognition techniques, AI algorithms can flag suspicious activities, reducing the risk of financial losses and reputational damage.

Compliance Monitoring. AI can help organizations stay compliant with regulations and policies by automating the monitoring of vast amounts of data. It can analyze transactions, communications, and documents to identify potential violations, such as insider trading, money laundering, or data privacy breaches. AI can also assist in assessing the effectiveness of internal controls and implementing regulatory changes.

Cybersecurity. AI plays a crucial role in enhancing cybersecurity defenses. It can continuously monitor network traffic, user behavior, and system logs to detect and respond to potential security threats. AI-powered systems can identify patterns indicative of malicious activities, such as malware infections or unauthorized access attempts, and trigger immediate alerts or automatic response mechanisms.

Decision Support. AI can provide valuable insights and recommendations to support risk management decision-making processes. By analyzing complex data sets, AI algorithms can offer risk scenarios, assess their potential impact, and suggest optimal risk mitigation strategies. This can help organizations make more informed decisions, improve risk allocation, and enhance overall risk management effectiveness.

It is important to note that the application of AI in risk management also comes with challenges, such as data quality and bias, interpretability of AI-driven decisions, and potential ethical considerations. Organizations need to carefully design and implement AI systems, ensuring transparency, accountability, and human oversight throughout the process.

3. SPECIFICS OF THE IRM IN HOSPITAL

Integrated risk management (IRM) in hospitals involves the systematic identification, assessment, and mitigation of risks across various aspects of healthcare delivery. Here are some specific areas where IRM is applied in hospitals (Johns, 1990; Miniati et al., 2016):

Patient Safety. Ensuring patient safety is a primary concern for hospitals. IRM focuses on identifying and mitigating risks that can harm patients. This includes developing protocols and procedures to prevent medication errors, infections, falls, surgical complications, and other adverse events. Risk assessments are conducted to identify potential vulnerabilities in patient care processes, and measures are implemented to address those risks.

Clinical Risk Management. IRM in hospitals involves managing clinical risks associated with medical procedures and treatments. This includes implementing evidence-based protocols, standardizing clinical pathways, and conducting regular audits to ensure compliance with best practices. IRM also includes proactive identification of potential risks related to medical equipment, medication management, diagnostic errors, and clinical documentation.

Information Security and Privacy. Hospitals handle sensitive patient information and rely on electronic health records (EHRs) for storing and managing data. IRM encompasses measures to protect patient data from unauthorized access, breaches, or cyberattacks. This involves implementing robust IT security infrastructure, conducting regular vulnerability assessments, staff training on data privacy, and ensuring compliance with regulations like HIPAA (Health Insurance Portability and Accountability Act).

Operational Risk. Hospitals face various operational risks, including supply chain disruptions, equipment failures, utility outages, and natural disasters. IRM includes contingency planning, business continuity management, and disaster recovery strategies to minimize the impact of such events on patient care. Risk assessments are conducted to identify vulnerabilities in critical operations, and appropriate measures are



implemented to ensure uninterrupted healthcare services.

Regulatory Compliance. Hospitals must comply with numerous regulations and standards, such as those related to patient care, documentation, billing, and accreditation. IRM involves ensuring compliance with these requirements through audits, staff training, policy development, and continuous monitoring. Non-compliance with regulations can result in financial penalties, reputational damage, and legal consequences, making effective IRM essential.

Human Resources. IRM in hospitals also addresses risks associated with human resources, such as ensuring appropriate staffing levels, minimizing employee turnover, and managing employee safety and well-being. This includes implementing employee training programs, performance evaluations, and employee engagement initiatives. Managing risks related to workplace safety, occupational health, and staff burnout are also crucial aspects of IRM.

By adopting an integrated approach to risk management, hospitals can proactively identify and address potential risks, enhance patient safety, improve operational efficiency, and ensure compliance with regulations. Effective IRM contributes to providing high-quality healthcare services while minimizing adverse events and disruptions in hospital operations.

4. ROLES OF AI IN IRM OF HOSPITAL

Here, it will be shown the roles of AI in IRM of hospital (Somayajula, 2021; Ferdosi et al., 2020).

Patient Safety

- AI can analyze patient data in real-time to identify patterns and detect early signs of deterioration, allowing healthcare providers to intervene promptly.
- Machine learning algorithms can analyze large datasets to identify risk factors associated with adverse events, enabling hospitals to implement targeted interventions and preventive measures.
- AI-powered image recognition can assist in the early detection of anomalies in medical images, such as X-rays or MRIs, improving diagnostic accuracy and reducing errors.

Clinical Risk Management

- AI can help hospitals standardize clinical pathways by providing evidence-based guidelines and recommendations for diagnosis and treatment.
- Natural language processing (NLP) techniques can analyze clinical documentation, identify potential errors or missing information, and improve the accuracy and completeness of patient records.
- Machine learning algorithms can analyze historical data to identify patterns of medication errors, enabling hospitals to implement targeted interventions and prevent similar incidents in the future.

Information Security and Privacy

- AI algorithms can continuously monitor network traffic and identify potential cybersecurity threats, such as malware or unauthorized access attempts, allowing hospitals to take immediate action to mitigate risks.
- Natural language processing can assist in analyzing and classifying sensitive patient data, ensuring compliance with regulations of privacy and preventing data breaches.
- AI can detect anomalous user behavior patterns, such as unauthorized access attempts or unusual data access patterns, helping to identify and prevent insider threats.



Operational Risk

- AI-powered predictive analytics can analyze historical data and external factors, such as weather patterns or disease outbreaks, to forecast and mitigate operational risks, such as supply chain disruptions or staff shortages.
- Machine learning algorithms can optimize hospital resource allocation by predicting patient admissions, emergency department utilization, and demand for specific medical services.
- AI can automate and optimize scheduling and logistics processes, improving operational efficiency and minimizing the risk of errors or delays.

Regulatory Compliance

- AI can assist in monitoring and analyzing vast amounts of data to ensure compliance with regulations and standards, such as detecting billing errors or anomalies in documentation.
- Natural language processing can help hospitals stay updated with regulatory changes by analyzing and summarizing relevant guidelines and policies.
- AI-powered systems can automate compliance audits by comparing actual practices against regulatory requirements, identifying areas of non-compliance, and generating reports.

Human Resources

- AI can assist in the recruitment and selection process by analyzing candidate profiles and identifying individuals with the desired skills and qualifications.
- Machine learning algorithms can analyze employee data and identify patterns related to burnout or turnover risks, enabling hospitals to implement interventions to improve employee well-being and retention.
- AI-powered chatbots or virtual assistants can provide employees with access to relevant HR information, policies, and support, improving communication and engagement.

It's important to note that while AI can provide valuable support in these areas, human expertise, judgment, and oversight remain crucial to ensure ethical and responsible use of AI systems and to address the limitations and potential biases of AI algorithms.

5. COMPETENCES OF EMPLOYEES' WHICH ARE NEEDED FOR USING AI IN HOSPITAL IRM

Employees involved in using AI in Hospital IRM should possess certain competencies to effectively utilize AI technologies. Here are some key competencies (European Parliamentary Research Service, 2022):

Domain Knowledge. Employees should have a strong understanding of the healthcare industry, including clinical workflows, patient safety protocols, regulatory requirements, and risk management practices. This domain knowledge helps in effectively integrating AI into existing processes and ensuring alignment with healthcare standards.

Data Literacy. Competence in handling and analyzing data is crucial. Employees should have knowledge of data collection, data quality assessment, data preprocessing, and statistical analysis techniques. They should also understand the ethical and legal considerations related to handling patient data.

AI and Data Science Skills. Familiarity with AI concepts and techniques is important. Employees should have a basic understanding of machine learning algorithms, natural language processing, predictive analytics, and



data visualization. This allows them to collaborate with data scientists and AI experts, interpret AI outputs, and provide domain expertise for model development.

Critical Thinking and Problem-Solving. Employees should possess strong critical thinking skills to evaluate AI-driven insights, question assumptions, and validate AI outputs. This helps in assessing the relevance and reliability of AI recommendations in complex healthcare scenarios and ensures appropriate decision-making.

Collaboration and Communication. Effective communication and collaboration skills are essential for interdisciplinary teamwork. Employees should be able to communicate effectively with data scientists, clinicians, IT professionals, and other stakeholders to foster collaboration, share insights, and bridge the gap between technical and clinical perspectives.

Adaptability and Continuous Learning. Given the rapid advancements in AI, employees need to be adaptable and open to learning new technologies and approaches. They should be willing to continuously update their knowledge and skills to keep up with evolving AI trends and practices in Hospital IRM.

Ethical and Legal Awareness. Employees should have a strong understanding of ethical considerations related to AI, including privacy, fairness, accountability, and bias. They should be aware of legal regulations such as HIPAA and other relevant healthcare regulations to ensure responsible and compliant use of AI technologies.

Training programs, workshops, and ongoing professional development opportunities can help employees develop and enhance these competencies. Additionally, fostering a culture of learning and collaboration within the organization can promote the acquisition of these skills among employees involved in using AI in Hospital IRM.

6. ...AND THE COMPETENCES NEEDED FOR USERS OF AI IN HOSPITAL IRM

Users, such as healthcare professionals and administrators, who interact with AI systems in Hospital IRM, should possess certain competencies to optimally utilize AI technologies. Here are some key competencies for users (Mousavi Baigi et al., 2023):

Familiarity with AI Applications. Users should have a basic understanding of AI concepts, its potential applications in healthcare, and the specific use cases relevant to Hospital IRM. This knowledge enables users to appreciate the benefits and limitations of AI and effectively collaborate with AI experts and data scientists.

Data Literacy. Users need to have a basic understanding of data collection, management, and quality assessment. This allows them to provide feedback on data relevance, identify potential biases, and ensure the accuracy and integrity of data used in AI algorithms.

Interpretation of AI Outputs. Users should possess the ability to interpret and understand the outputs generated by AI systems. They should be able to discern between actual insights and noise in AI-driven recommendations and critically evaluate their relevance and reliability in the context of patient safety and risk management.

Clinical Expertise. Users with clinical expertise, such as physicians, nurses, or risk managers, should bring their domain knowledge and experience to the table. They understand the intricacies of patient care, clinical workflows, and associated risks, enabling them to effectively validate AI outputs, assess clinical relevance, and make informed decisions based on AI-driven insights.

Communication and Collaboration. Effective communication skills are crucial for users to articulate their requirements, concerns, and feedback to AI developers, data scientists, and other stakeholders. Users should be able to collaborate and communicate effectively with technical experts, translating their domain-specific knowledge and needs into AI system requirements.



Continuous Learning and Adaptability. Users should embrace a mindset of continuous learning and be open to acquiring new skills and knowledge as AI technologies evolve. This includes staying updated on the latest AI advancements, attending relevant training programs, and adapting their practices based on new insights and recommendations.

Ethical Considerations. Users should be aware of the ethical implications associated with AI technologies, including issues of privacy, bias, and fairness. They should be able to navigate ethical dilemmas and make informed decisions while ensuring the responsible and ethical use of AI in Hospital IRM.

Training programs, workshops, and educational resources can help users develop and enhance these competencies. Ongoing support and collaboration between technical experts and users can also facilitate optimal utilization of AI technologies in Hospital IRM.

7. PRECONDITIONS FOR EFFICIENT USE OF AI IN EACH OF THE AREAS IN HOSPITAL IRM

To efficiently use AI in each area of Hospital IRM, several preconditions should be considered (Wilkins, 2014):

Patient Safety

- Availability of high-quality and comprehensive patient data that is properly structured and standardized.
- Integration of various data sources and systems to provide a complete view of patient information.
- Clear protocols and processes for data collection, ensuring data accuracy and reliability.
- Collaboration and buy-in from healthcare professionals to embrace AI technologies and incorporate them into their workflows.

Clinical Risk Management

- Access to reliable and comprehensive clinical data, including electronic health records (EHRs), medical imaging, and laboratory results.
- Robust data governance and management practices to ensure data quality, integrity, and privacy.
- Collaboration between clinical experts, data scientists, and AI developers to develop and validate AI models based on domain expertise.
- Integration of AI solutions into existing clinical workflows and systems, ensuring seamless adoption and usability.

Information Security and Privacy

- Strong cybersecurity infrastructure and practices to protect sensitive patient data from breaches, unauthorized access, and cyber threats.
- Well-defined data governance policies and procedures that address privacy regulations and ensure compliance.
- Regular risk assessments and vulnerability testing to identify and address potential weaknesses in the IT infrastructure.
- Ongoing staff training on cybersecurity best practices and awareness of potential risks and threats.

Operational Risk



- Availability of reliable and comprehensive operational data, including patient flow, resource utilization, and supply chain information.
- Integration of data from various hospital departments and systems to provide a holistic view of operations.
- Collaborative approach involving operational stakeholders, data analysts, and AI experts to develop accurate predictive models and optimize resource allocation.
- Infrastructure and processes to facilitate the real-time collection and analysis of operational data for timely decision-making.

Regulatory Compliance

- In-depth understanding of regulatory requirements and standards applicable to the healthcare industry.
- Well-documented and up-to-date policies and procedures to ensure compliance with relevant regulations.
- Clear data governance and management practices to ensure accurate documentation and data integrity for regulatory purposes.
- Collaboration with legal and compliance teams to validate AI solutions and ensure they meet regulatory requirements.

Human Resources

- Availability of reliable and comprehensive human resources data, including employee records, performance evaluations, and staff satisfaction surveys.
- Well-defined data privacy and confidentiality policies to protect employee information.
- Collaboration between HR professionals, data analysts, and AI experts to develop AI models that address specific HR challenges.
- Effective change management strategies to ensure employee acceptance and engagement with AI technologies.

The efficient use of AI in Hospital IRM requires a strong foundation of accurate and comprehensive data, collaboration between domain experts and AI specialists, robust data governance and privacy practices, and a focus on integrating AI solutions into existing workflows and processes.

8. ENSURING PRECONDITIONS

Ensuring the preconditions for efficient use of AI in each area of Hospital IRM requires careful attention and implementation of specific measures. Here are some steps to consider for each area (Wilkins, 2014):

Patient Safety

- Implement data capture and integration mechanisms to ensure high-quality and standardized patient data.
- Invest in interoperable systems and technologies that facilitate seamless data exchange across departments and healthcare providers.
- Train healthcare professionals on data collection protocols and the importance of accurate and complete data.



- Establish cross-functional teams that include clinicians, data scientists, and IT experts to collaborate on AI implementation and workflow integration.

Clinical Risk Management

- Implement robust EHR systems and ensure data integrity and completeness.
- Establish data governance practices that address data quality, documentation, and privacy concerns.
- Encourage clinicians to actively participate in AI model development by providing domain expertise and validating AI-driven insights.
- Conduct thorough user acceptance testing and provide adequate training to clinicians to ensure smooth adoption of AI tools.

Information Security and Privacy

- Implement robust cybersecurity measures, including firewalls, encryption, and intrusion detection systems.
- Conduct regular vulnerability assessments and penetration testing to identify and address potential security weaknesses.
- Develop and enforce data governance policies that address privacy regulations and ensure compliance.
- Conduct regular staff training on cybersecurity best practices and the importance of safeguarding patient data.

Operational Risk

- Implement systems and technologies that capture real-time operational data, such as patient flow and resource utilization.
- Ensure interoperability between different operational systems to facilitate data integration.
- Foster collaboration between operational stakeholders and AI experts to develop accurate predictive models and optimization strategies.
- Establish processes for real-time data monitoring and reporting to enable proactive risk mitigation.

Regulatory Compliance

- Maintain a thorough understanding of healthcare regulations and standards, and regularly update policies and procedures accordingly.
- Develop data governance frameworks that address regulatory requirements for data management and privacy.
- Collaborate with legal and compliance teams to validate AI solutions and ensure they align with regulatory guidelines.
- Implement auditing mechanisms to regularly assess and monitor compliance with relevant regulations.

Human Resources

- Implement robust HR information systems to capture and manage employee data effectively.
- Establish policies and procedures to ensure data privacy and confidentiality.

- Foster collaboration between HR professionals, data analysts, and AI experts to develop AI models that address specific HR challenges.
- Provide training and change management support to employees to ensure understanding and acceptance of AI technologies in HR processes.

Regular monitoring and evaluation of AI implementations, feedback collection from endusers, and continuous improvement efforts are also essential to ensure the preconditions for efficient AI use in Hospital IRM are met and maintained over time.

9. ADVANTAGES AND DISADVANTAGES OF USING AI IN IRM OF HOSPITAL

Advantages of using AI in hospital IRM (Bhbosale et al., 2020):

1. *Enhanced Risk Identification:* AI can analyze vast amounts of data from various sources to identify potential risks and patterns that may not be apparent to human analysts. This enables proactive risk management and early detection of potential issues.
2. *Improved Decision Making:* AI can provide valuable insights and recommendations to support risk management decision-making processes. By analyzing complex data sets, AI algorithms can offer risk scenarios, assess their potential impact, and suggest optimal risk mitigation strategies.
3. *Increased Efficiency and Accuracy:* AI can automate manual and time-consuming tasks, such as data analysis and risk assessments, leading to increased efficiency and accuracy in risk management processes. This allows healthcare professionals to focus on higher-value activities.
4. *Real-time Monitoring and Alerting:* AI-powered systems can continuously monitor and analyze data in real-time, allowing for early identification of risks and prompt response. This is particularly beneficial in areas such as patient safety, where timely interventions can prevent adverse events.
5. *Predictive Analytics:* AI algorithms can analyze historical data combined with real-time information to generate predictive models. This helps hospitals forecast potential risks and allocate resources effectively, leading to improved planning and resource utilization.

Disadvantages of using AI in Hospital IRM (12):

1. *Data Quality and Bias:* The accuracy and quality of AI models heavily depend on the quality and representativeness of the data they are trained on. Biases present in the data can be inadvertently incorporated into AI algorithms, leading to biased decisions and outcomes.
2. *Interpretability and Transparency:* Some AI models, such as deep learning neural networks, can be challenging to interpret and understand. The lack of transparency in AI decision making processes can raise concerns regarding accountability and trust.
3. *Ethical Considerations:* AI raises ethical considerations, such as privacy concerns related to patient data, algorithmic fairness, and the potential impact on healthcare professionals' roles. Ensuring ethical and responsible use of AI in healthcare is a critical challenge.
4. *Dependency on Technology:* Over-reliance on AI systems may lead to a reduced ability to critically assess and validate outputs. There is a need for human oversight and expertise to ensure that AI outputs align with clinical judgment and best practices.
5. *Implementation Challenges:* Implementing AI in a healthcare setting requires significant investments in technology infrastructure, data management, staff training, and change management. The successful integration of AI into existing workflows and processes can be complex and time-consuming.

It is crucial to carefully address these disadvantages by implementing robust data governance practices, validating and auditing AI algorithms, promoting interpretability and transparency, and ensuring ongoing human oversight and expertise in the decision-making process. By doing so, the advantages of AI in Hospital IRM can be maximized while mitigating potential risks and challenges.

10. RISKS

The disadvantages associated with using AI in Hospital IRM can give rise to various risks, including (Sidorenko et al., 2021; Sunarti et al., 2021):

Data Bias and Discrimination. If AI algorithms are trained on biased or incomplete data, they may perpetuate and amplify existing biases and discrimination. This can result in unfair treatment or disparities in patient care, resource allocation, or risk assessment.

Misinterpretation of Results. Lack of interpretability in AI models can make it difficult to understand how and why certain decisions or predictions are made. This can lead to misinterpretation of results and potentially incorrect actions or interventions based on flawed AI outputs.

Privacy and Security Breaches. AI systems rely on access to large amounts of sensitive patient data. If not properly secured, AI algorithms and the underlying infrastructure can be vulnerable to data breaches, unauthorized access, or misuse, compromising patient privacy and confidentiality.

Reduced Human Oversight and Accountability. Over-reliance on AI systems without sufficient human oversight can lead to a reduction in critical thinking and accountability. If decisions are solely driven by AI algorithms, healthcare professionals may rely on them without adequately questioning or validating the outputs.

Ethical Concerns. The use of AI in healthcare raises ethical considerations such as patient consent, transparency, and the responsibility for AI-driven decisions. Lack of ethical guidelines and frameworks can result in unintended consequences or violations of ethical principles.

Implementation Challenges and Disruption. Integrating AI into existing workflows and processes can be complex and disruptive. If not managed effectively, implementation challenges can result in workflow inefficiencies, resistance from healthcare professionals, or unintended consequences that negatively impact patient care and risk management practices.

Addressing these risks requires careful attention to data quality and bias, ensuring transparency and interpretability of AI models, robust security measures, ethical guidelines, and ongoing monitoring and evaluation of AI implementations. It is essential to have multidisciplinary teams involving healthcare professionals, data scientists, ethicists, and legal experts to address these risks proactively and develop appropriate safeguards.

11. METHODS FOR MITIGATING THE RISKS

To mitigate the risks associated with using AI in Hospital IRM, several methods and best practices can be implemented (Argaw et al, 2020; McClean et al., 2021):

1. Data Quality and Bias Mitigation:

- Implement robust data governance practices to ensure data quality, accuracy, and representativeness.
- Regularly assess and address biases in training data to minimize the risk of biased AI outputs.
- Implement diverse and inclusive data collection strategies to reduce disparities and

discrimination in AI algorithms.

2. Interpretability and Transparency:

- Use AI models and techniques that offer interpretability, such as rule-based systems or explainable AI approaches.
- Develop clear documentation and reporting mechanisms that explain the reasoning behind AI-driven decisions.
- Foster collaboration between AI experts and healthcare professionals to promote transparency and trust in AI systems.

3. Privacy and Security Measures:

- Implement robust cybersecurity measures to protect patient data from breaches, unauthorized access, and cyber threats.
- Adhere to privacy regulations and guidelines, such as HIPAA, by implementing strict access controls and encryption techniques.
- Regularly audit and monitor AI systems and infrastructure to identify and address potential vulnerabilities or data privacy risks.

4. Human Oversight and Accountability:

- Ensure that AI systems are designed to augment human decision-making, with clear roles and responsibilities defined for healthcare professionals.
- Establish mechanisms for human oversight, validation, and critical review of AI outputs to prevent undue reliance on AI decisions.
- Foster a culture of accountability and continuous learning, encouraging healthcare professionals to question and validate AI recommendations.

5. Ethical Considerations:

- Develop and adhere to ethical guidelines and frameworks that address the responsible use of AI in healthcare.
- Conduct ethics reviews and assessments to identify and address potential ethical risks and implications of AI systems.
- Involve ethicists, legal experts, and stakeholders in the development and deployment of AI systems to ensure ethical decision-making.

6. Effective Implementation Strategies:

- Develop robust implementation plans that include comprehensive training programs, change management strategies, and stakeholder engagement.
- Conduct pilot testing and evaluation of AI systems in real-world scenarios to identify and address implementation challenges early on.
- Continuously monitor and evaluate AI systems to assess their performance, impact, and adherence to established risk management practices.

By implementing these methods, hospitals can mitigate risks associated with AI in IRM, promote responsible and ethical use of AI, and enhance the benefits AI can bring to patient safety, risk management, and



healthcare delivery.

12. EXAMPLES OF SUCCESSFUL USE OF AI IN HOSPITAL IRM

There are several examples of successful use of AI in Hospital Integrated Risk Management (IRM). Here are a few notable examples (Intellipat, 2023):

Early Detection of Sepsis. Sepsis is a life-threatening condition that requires timely intervention. AI algorithms have been employed to analyze vital signs, laboratory results, and other patient data in real-time to identify early signs of sepsis. This enables healthcare providers to intervene promptly, improving patient outcomes and reducing mortality rates.

Predictive Analytics for Hospital Readmissions. AI-powered predictive models have been used to identify patients at high risk of readmission. By analyzing patient data and risk factors, such as medical history, demographics, and social determinants of health, these models can help hospitals allocate resources and develop targeted interventions to prevent readmissions, improving patient care and reducing healthcare costs.

Radiology and Imaging Analysis. AI algorithms have demonstrated success in analyzing medical images, such as X-rays, CT scans, and MRIs. These algorithms can assist radiologists in detecting abnormalities, improving diagnostic accuracy, and reducing the chances of missed diagnoses. AI-powered imaging analysis can aid in early detection of conditions like tumors, fractures, or pulmonary diseases.

Fraud Detection and Prevention. AI has been utilized in hospitals to detect and prevent healthcare fraud and abuse. Machine learning algorithms can analyze vast amounts of claims data, billing patterns, and historical fraud cases to identify suspicious activities and patterns indicative of fraudulent behavior. This helps in reducing financial losses and ensuring compliance with healthcare regulations.

Patient Monitoring and Predictive Analytics. AI systems equipped with wearable devices and remote sensors can continuously monitor patient health parameters and vital signs. By analyzing real-time data, AI algorithms can detect deviations from normal patterns and alert healthcare providers of potential risks. This enables early intervention and proactive management of patient health, reducing adverse events and hospital stays.

Cybersecurity and Threat Detection. AI has been used to enhance hospital cybersecurity measures by continuously monitoring network traffic, user behavior, and system logs. AI algorithms can detect and respond to potential cybersecurity threats, such as malware infections or unauthorized access attempts, in real-time. This helps in mitigating the risk of data breaches and protecting sensitive patient information.

These examples demonstrate the successful application of AI in various aspects of Hospital IRM, including early detection of critical conditions, predictive analytics for better resource allocation, improved diagnostic accuracy, fraud prevention, patient monitoring, and enhanced cybersecurity. These applications highlight the potential of AI to enhance patient safety, optimize healthcare operations, and improve overall risk management in hospitals.

13. A FEW NOTABLE EXAMPLES OF HOSPITALS WHICH HAVE AI IN IRM

While there are several hospitals around the world implementing AI in their Integrated Risk Management practices, here are a few notable examples:

Massachusetts General Hospital (MGH) - Boston, United States (Massachusetts General Hospital, 2023). MGH has been at the forefront of AI implementation in healthcare. They have developed AI models for early detection of sepsis, prediction of patient deterioration, and optimization of patient flow. MGH's AI initiatives have shown promising results in improving patient outcomes and resource utilization.



Johns Hopkins Hospital - Baltimore, United States (The Johns Hopkins Hospital, 2023). Johns Hopkins Hospital has implemented AI powered predictive analytics models to identify patients at high risk of readmission. By leveraging patient data and risk factors, they have achieved significant reductions in readmission rates, leading to better patient care and cost savings.

Moorfields Eye Hospital - London, United Kingdom (Moorfields Private Eye Hospital, 2023). Moorfields Eye Hospital has utilized AI in their ophthalmology practice to assist in diagnosing eye diseases and conditions. They have developed AI algorithms that can analyze retinal images and detect signs of diabetic retinopathy, age-related macular degeneration, and other eye disorders with high accuracy.

Chang Gung Memorial Hospital - Taipei, Taiwan (Chang Gung Memorial Hospital, 2023). Chang Gung Memorial Hospital has implemented AI-based systems for real-time patient monitoring and prediction of patient deterioration. By continuously analyzing vital signs and patient data, the system alerts healthcare providers of potential risks, enabling timely interventions and improved patient outcomes.

Seoul National University Hospital - Seoul, South Korea (SNUH, 2023). Seoul National University Hospital has integrated AI in their radiology department to assist radiologists in analyzing medical images. AI algorithms are used for the detection and diagnosis of lung cancer, brain tumors, and other conditions, enhancing diagnostic accuracy and efficiency.

University of California, San Francisco Medical Center (UCSF) - San Francisco, United States (UCSF Health, 2023). UCSF has implemented AI-powered systems for fraud detection and prevention. By leveraging machine learning algorithms, they analyze claims data, billing patterns, and historical fraud cases to identify and prevent healthcare fraud, ensuring financial integrity and compliance. These hospitals serve as examples of institutions that have successfully embraced AI in their Integrated Risk Management practices, showcasing the potential of AI in improving patient care, diagnostic accuracy, resource allocation, and risk mitigation. It is important to note that advancements in AI technology and practices continue to evolve, and there may be other hospitals worldwide implementing AI in innovative ways for effective risk management in healthcare.

14. CONCLUSION

The integration of Artificial Intelligence (AI) in Hospital Integrated Risk Management (IRM) holds immense potential for transforming healthcare practices and improving patient outcomes. AI offers valuable capabilities in risk identification, assessment, and mitigation across various areas of hospital operations. By leveraging AI technologies, hospitals can enhance patient safety, optimize resource allocation, and ensure compliance with regulations.

However, the use of AI in Hospital IRM is not without challenges. Data quality, biases, interpretability of AI algorithms, privacy and security concerns, ethical considerations, and implementation complexities pose risks that must be carefully addressed. Mitigating these risks requires robust data governance practices, transparency in AI decision-making, and adherence to ethical guidelines. To maximize the benefits of AI in Hospital IRM, employees involved in its implementation and usage must possess specific competencies. These include domain knowledge, data literacy, AI and data science skills, critical thinking, collaboration, adaptability, and ethical awareness. Equipping employees with these competencies enables effective utilization of AI technologies and fosters collaboration between technical experts and healthcare professionals.

In conclusion, the integration of AI in Hospital IRM offers promising opportunities for improving patient safety, operational efficiency, and risk management practices. By navigating the challenges and addressing the associated risks, hospitals can harness the power of AI to optimize decision making, enhance patient care, and mitigate potential risks. By prioritizing employee competencies and fostering a culture of responsible



and ethical AI use, hospitals can leverage AI as a transformative tool in driving positive change in healthcare. Reviewing the area of using AI in Hospital Integrated Risk Management (IRM) reveals significant potential and benefits, along with notable challenges and considerations. Here is a review of the key aspects:

Advantages and Benefits:

- **Improved Patient Safety:** AI enables early detection of critical conditions, prediction of patient deterioration, and proactive risk management, leading to enhanced patient safety and reduced adverse events.
- **Enhanced Decision-Making:** AI provides valuable insights and recommendations to support risk management decision-making processes, helping healthcare professionals make more informed and data-driven decisions.
- **Operational Efficiency:** AI automation and optimization can improve resource allocation, streamline workflows, and reduce errors, leading to increased operational efficiency and cost savings.
- **Predictive Analytics:** AI-powered predictive models can forecast risks, identify high-risk patients, and support proactive interventions, improving resource planning and patient outcomes.
- **Fraud Detection and Compliance:** AI algorithms can analyze large datasets to detect fraudulent activities, ensure regulatory compliance, and mitigate financial risks.
- **Diagnostic Accuracy:** AI-powered image analysis can assist in the early detection and accurate diagnosis of various medical conditions, improving diagnostic accuracy and reducing errors.

Challenges and Considerations:

- **Data Quality and Bias:** AI performance heavily relies on the quality, representativeness, and bias-free nature of the training data. Ensuring accurate and diverse data is essential to avoid biased outcomes.
- **Interpretability and Transparency:** Some AI models, such as deep learning neural networks, lack interpretability, making it challenging to understand the reasoning behind their decisions. Transparency is vital for trust, accountability, and ethical considerations.
- **Privacy and Security:** The use of AI requires handling large amounts of sensitive patient data, raising concerns about privacy and security. Robust cybersecurity measures and compliance with privacy regulations are crucial.
- **Ethical and Societal Implications:** AI raises ethical concerns, such as the responsible use of patient data, algorithmic fairness, and potential impacts on employment and healthcare equity. Addressing these concerns is vital for ethical AI adoption.
- **Implementation Challenges:** Integrating AI into existing workflows and processes can be complex, requiring adequate infrastructure, data governance, stakeholder engagement, and change management strategies.

Future Directions:

- **Interoperability and Data Sharing:** Enhancing interoperability between systems and facilitating secure data sharing can improve data quality, access, and enable more comprehensive AI applications.
- **Explainable AI:** Advancing techniques for explainable AI can enhance transparency, interpretability, and enable better understanding and trust in AI-driven decisions.



- Ethical Guidelines and Regulations: Continued development of ethical guidelines and regulatory frameworks can ensure responsible AI use, addressing privacy, fairness, transparency, and accountability concerns.
- Collaboration and Education: Encouraging collaboration between healthcare professionals, AI experts, and regulatory bodies, and promoting education and training programs on AI ethics and usage will be crucial for optimal AI adoption.

Sources of information:

Here are some potential sources of information about the topic of AI in Hospital Integrated Risk Management:

Research Papers and Academic Journals. Academic publications often provide in-depth research and analysis on the application of AI in healthcare risk management. Journals such as the Journal of Healthcare Risk Management, Journal of Medical Systems, or the Journal of Biomedical Informatics can be valuable sources of information.

Industry Reports and White Papers. Various organizations, research institutions, and consulting firms publish reports and white papers on the use of AI in healthcare and risk management. Examples include reports from Deloitte, McKinsey, Gartner, or Frost & Sullivan, which provide insights into the trends, challenges, and best practices in AI implementation in healthcare.

Healthcare Associations and Organizations. Professional associations and organizations related to healthcare and risk management often publish resources and guidelines on AI adoption in the healthcare sector. Examples include the American Society for Healthcare Risk Management (ASHRM), Healthcare Information and Management Systems Society (HIMSS), or the World Health Organization (WHO).

Healthcare Technology Conferences and Events. Attending conferences and events focused on healthcare technology, AI, and risk management can provide valuable insights from experts, practitioners, and industry leaders. Examples include HIMSS conferences, AI in Healthcare Summit, or Risk Management Society (RIMS) events.

Case Studies and Success Stories. Exploring case studies and success stories of hospitals and healthcare organizations that have successfully implemented AI in risk management can provide practical insights and lessons learned. Hospital publications, industry news articles, and healthcare technology websites often highlight such examples.

Academic Institutions and Research Centers. Universities and research centers specializing in healthcare informatics, AI, and risk management conduct research and publish studies in this field. Exploring their websites and accessing their research publications can provide valuable information.

Government Agencies and Regulatory Bodies. Government agencies and regulatory bodies focused on healthcare and risk management, such as the U.S. Food and Drug Administration (FDA) or the European Medicines Agency (EMA), may publish guidelines, regulations, or reports related to AI use in healthcare.

It is important to critically evaluate and verify the information obtained from these sources, ensuring that they are from reputable and reliable sources.

CONFLICT OF INTEREST

I have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.



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