



INTERNATIONAL JOURNAL OF **METAVVERSE (IJM)**

ISSN: 2837-2417 (ONLINE)

VOLUME 2 ISSUE 1 (2024)



PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

New Metaverse Games Based on Artificial Intelligence: A Review

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Article Information

Received: July 09, 2024

Accepted: August 04, 2024

Published: August 07, 2024

Keywords

Metaverse, Gaming, Artificial Intelligence (AI), Virtual Reality (AR), Augmented Reality (AR), Extended Realities (XR)

ABSTRACT

The current review conveys Metaverse integration with AI-based gaming exploring the advancements in Metaverse games and its potential in growing self-learning AI in the latest years for the readers. Using state-of-the-art deep learning techniques, it aimed to pinpoint its advancements, issues, and suggested solutions. For the current review, 18 papers were used that appeared in peer-reviewed publications and were searchable on Google Scholar within the last five years (2020–2024). To analyse the collected data, thematic analysis was employed. The article delves into the various ways the Meta-Metaverse might be used in the gaming industry. It highlights how it can enhance character creation, game design, level design, and visual effects, among other areas. The entertainment industry's usage of AI in game production encompasses a wide range of methods, such as CVEs, deep learning, and intrinsic curiosity-driven variation autoencoders. The Metaverse, a dynamic platform, uses ML/DL algorithms for classification, clustering, and regression, while pre-trained AI models can achieve great responses quickly. These technologies streamline the gaming world and create interactive platforms for various applications. Deep Reinforcement Learning (DRL) is proposed as a dynamic solution to balance the stability of the game world, the intelligence of non-player characters, and the sustainability of the Metaverse environment.

INTRODUCTION

Artificial Intelligence (AI) and Machine learning (ML) techniques are used for text recognition, and emotion recognition is crucial for personalizing material in Metaverse gaming. Real-time conversations are created using neural networks and natural language processing (NLP) algorithms present the potential applications of AI and immersive technology in advancing the Metaverse gamifying (Dyulichева & Glazieva, 2021). Together AI and Augmented Reality (AR) can create a more interactive and immersive experience for the advancement of Metaverse gaming engaging virtual and real worlds with more realistic gaming experiences. For instance, the use of AI-based non-player characters which enhance the collaboration of gamers for better collaboration and realistic Metaverse gaming. The high visuals and natural experience with NLP and speech recognition advance the human interaction in gaming (Chenna, 2023; Y. Li *et al.*, 2023).

As observed from existing research, the growth of technology has been widely discussed across different sectors. This discussion has often revolved around integrating technology into the business environment and leveraging various opportunities for profitability. While focusing on adopting technology, it is critical to acknowledge the varying interests of different parties and the growth of the so-called tech giants in different markets. The rationale of the research was to explore how the technological growth has been seen through their recent investment into AR and AI under the umbrella of Metaverse gaming. This investment was initiated after the initial change of company name to Meta and the announcement of their strategic growth

and future investment strategies. Therefore, the current review highlighted Meta's investment in AI-based gaming exploring the advancements in Metaverse games and its potential in growing self-learning AI presented in the existing studies in the latest years identifying its developments and proposed methods.

LITERATURE REVIEW

Virtual environments like the Metaverse, with numerous users and multiple data sources, are highly productive for ML due to their ability to automate learning processes through repetitive learning and continuous data discovery. AI-based games can learn human behaviour and the game environment, with human interaction playing a crucial role in setting up the system and asking the right questions. This approach requires fluid decision-making and progressive development, with a feedback mechanism in place to reward intelligent agents' actions and success (Hadjar *et al.*, 2022).

Al-Azawi *et al.* (2012) highlight the diverse requirements of various games, with AI-based games often being used to address issues and challenges associated with classic games. AI has been adopted to improve design behaviour and decision-making processes in electronic arts games and other game developer companies. As AI adoption in the gaming industry increases, it is crucial to recognise the variation in application due to the numerous game categories and system requirements. These variations can be attributed to different levels of immersion and entertainment forms. AI-based games should focus on individuals' availability to amplify the game's underlying characteristics. For instance, adventure games should

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attract individuals who love exploration, information gathering, and problem-solving, while sports game engines should focus on virtual representations to attract sports enthusiasts. AI-based games should account for the learning process and provide optimal solutions based on the type of game and platform users (Al-Azawi *et al.*, 2012).

According to Jeon *et al.* (2021), this technology leverages artificial intelligence and deep learning (DL) architectures to improve the frame rate and visuals expected within the virtual environment. Similarly, efforts have been made to balance different elements of multiplayer games via supervised learning. Amidst these applications, it is critical to acknowledge that the learning process can be significantly time-consuming. However, this challenge has been tackled by introducing metaheuristic optimisation algorithms like dwarf mongoose optimisation and Ebola optimisation. Therefore, the overall experience and the learning process have been improved significantly (Jeon *et al.*, 2022). Notably, the integration of AI in video games such as Street Fighter, Tekken, and Mortal Kombat has focused on interactive dialogue and content creation. This has limited the realisation of AI potential due to the focus on local optimality (Nimpattanavong *et al.*, 2023). Moreover, past research examined that intelligent systems in gaming provide learning to reason in the multi-player multi-tasking game through sequential reasoning. AI assists in round-based decision-making in a single continuous game, such as leveraging counter-strike, which is a round-based shooter game for the first person. The use of AI-based Natural Language Processing (NLP) provides a coordinated representation leveraging learning with three modalities, including visual signals shown by images, written natural language and social medial interaction graphs (Zeng, 2021). Additionally, AI-based gaming enhances the design when playing games

for the cognitive load classification for mundane tasks. Cognitive load increases the complexity of games when young individuals are playing games involving simple to complex activities of the brain (Das *et al.*, 2020). Also, Du *et al.* (2021) demonstrated that with quick developments in ML, the impact of deep reinforcement learning (DRL) is also significant in E-sports, such that ML allows easy and effective coaching for training. Flappy Bird is one such example in which training AI is developed on the basis of Q-learning, assisting players to improve their skills and experience escaping from potential accidents and errors (Du *et al.*, 2021).

METHODOLOGY

Search Strategy

In this review, the focus of the author was to use the latest 5-year articles published in peer-reviewed journals. Therefore, the author gathered the data by opting for specific search strategies shown in Table 1 below. These strategies were used for data search on renowned databases like Web of Science and Google Scholar to get the most recent articles, applying filters of time frame to improve the search.

This review was conducted based on gathering literature published between 2020 and 2024 to the latest month identifying the Metaverse games based on AI. The search strategies were made based on the targeted keywords including; “Meta”, “Metaverse Potential”, “Deep Learning”, “Machine Learning”, “Deep Learning Network”, “AI-based Gaming”, “Intelligence Gaming”, “AI Algorithms”, “AI-based Models”, “Game Development”, “AI-based Models”, “Metaverse Gaming”, “Human Interaction”, “Humanisation” and “Human-Computer Interaction”. Furthermore, table 2 denotes the inclusion and exclusion criteria applied to these review’s search strategies.

Table 1: Search Strategies

S. No.	Search Strategy
1.	(“Meta”) AND (“Metaverse Potential”) AND (“Gaming”)
2.	(“Deep Learning” OR “Machine Learning” OR “Deep Learning Network”) AND (“AI-based Gaming” OR “Intelligence Gaming”)
3.	(“AI Algorithms” OR “AI-based Models”) AND (“Game Development” OR “Gaming”)
4.	(“AI Algorithms” OR “AI-based Models”) AND (“Metaverse Gaming”) AND (“Human Interaction” OR “Humanisation” OR “Human-Computer Interaction”)

Source: Author

Inclusion and Exclusion Criteria

Table 2 presents all the points which were set as criteria

for selecting research articles for this review paper.

Table 2: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Studies published in journals where publishers offer peer-reviewing policies were included.	Studies published in journals where publishers do not offer a peer-reviewing policy were excluded.

Studies included in the review were selected based on having Metaverse OR/AND AI OR/AND gaming as the most keywords.	Studies not containing any of the three specific keywords Metaverse OR/AND AI OR/AND gaming were excluded.
In this review, studies published in the last 5 years, from 2020 and 2024, were included.	The studies conducted or published earlier than 2020 were excluded.
Studies only available in full-text format for the public view on Google Scholar were included only.	Studies not available in open access format in any acknowledged database were excluded.

Source: Author

Data Extraction and Analysis

In this review, a total of 18 studies were finalised based on their title, publishers, and main purpose or aim of the research aligned with the current study's rationale. The analysis of the gathered data was conducted using thematic analysis as the extracted data from the 18 articles was categorised, coded and placed in relevant themes presented in the discussion. The themes were designed considering the recurrent keywords in the paper. The themes were therefore named Meta and Metaverse

potential, deep learning and AI-based gaming, AI algorithms in game development and AI-based Metaverse gaming and human interaction.

RESULTS

Overview of Studies Included in the Review

Table 3 below presents the overview of all the studies included in the current review. It shows the author details, publisher and main idea of the findings.

Table 3: Overview of Studies Included in the Review

S. No.	Author	Title	Publisher	Summary of Findings	Advantages	Disadvantages	Examples
1.	(Xiong, 2022)	An Acquisition Deal in the Gaming World	Darcy & Roy Press	The study highlighted the greater potential of Metaverse in the gaming world, highlighting Activision Blizzard chosen by Microsoft. It depicted Metaverse in Xbox and its applications, presenting Microsoft's Metaverse strategy.	Acquisition of Microsoft in Activision of Bizzard accelerate the gaming business, improve Microsoft capacity for content creation in Metaverse and provide the ability to combine PC, TV and Mobile devices.	Potential damaging monopolies may result in major tech giant deals in Metaverse, cultural issues, gender scandals and discrimination might	Acquisition of Microsoft Activision Bizzard, as a strategic move to advance Microsoft's Metaverse strategy
2.	(Kraus et al., 2022)	Facebook and the creation of the Metaverse: radical business model innovation or incremental transformation?	Emerald	An in-depth case study followed by qualitative content analysis showed the potential growth of Metaverse in relation to other industries. While focusing on the firm's market value and other investment factors, it is critical to acknowledge the centrality of the gaming industry in enhancing growth; specifically, gaming activities are set to contribute to at least 50% of potential sales by 2024	Meta's rebranding aims to position the company as a leader in Metaverse technology, signify a diversification of services beyond social networking, and signal a bold move towards innovation and exploring new technological frontiers	Facebook's rebranding to Meta faces risks and uncertainties, including negative publicity due to past criticism and a loss of trust from scandals like the Cambridge Analytical incident, which could impact the company's reception and the transition to new territories.	Google's 2015 rebranding to Alphabet Inc. exemplifies a tech giant diversifying its business model. Facebook's acquisitions of Instagram, WhatsApp, and Oculus demonstrate its expansion into various tech domains. The Cambridge Analytical scandal highlights Facebook's challenges in data privacy and trust.

5.	(Taye, 2023)	Understanding of Machine Learning with Deep Learning: Architectures, Workflow, Applications and Future Directions MDPI	This research presented an overview of the deep learning workflow and architectures. It showed that self-organising maps and CNN are critical improvements to conventional techniques, enabling more effective deep neural network design and potential application in AI-based games.	The system can generate new features from limited training data, produce reliable results using unsupervised learning methods, reduce feature engineering time, and adapt to various issues through continuous training.	The training process relies on constant data flow, increasing computational costs, lack of transparency in fault revision, and the need for expensive resources and GPUs.	Medical image analysis aids disease diagnosis and treatment planning, natural language processing aids sentiment analysis, autonomous driving systems ensure vehicle navigation, and anomaly detection techniques detect fraud in financial transactions.
4.	(Mahesh, 2020)	Machine Learning Algorithms - A Review IJSR	The author showed the application of ML algorithms. DL is often focused on building multi-layered neural networks to achieve high accuracy in regression and classification problems. This has seen the development of different DL architectures, including self-organising maps, recurrent neural networks, autoencoders, and CNN.	Machine learning algorithms offer automated decision making, efficiency, adaptability, improved performance through ensemble learning techniques like boosting and bagging, and handling overfitting through bootstrap aggregating, enabling models to adapt to changing inputs and handle overfitting effectively.	Machine learning algorithms rely on data quality and quantity, may lack interpretability, require significant computational resources, and can overfit training data without proper regularization techniques, causing poor generalization on unseen data.	Reinforcement Learning, Multi-Task Learning, Ensemble Learning, Decision Tree, and Naive Bayes are machine learning techniques used for classification tasks.
3.	(Huynh-The <i>et al.</i> , 2023)	Artificial Intelligence for the Metaverse: A survey Elsevier	Survey-based research highlighting the integration of immersive technologies like AI and ML algorithms in the development of Metaverse contributing towards gaming, smart cities and healthcare.	Enhance user experience in virtual worlds, streamline content creation, and offer technical potential for Metaverse platforms. They improve image enhancement, language modelling efficiency, and play a crucial role in smart cities, aiding in environmental monitoring, precision agriculture, and data analytics.	The Metaverse's AI implementation presents technical challenges like data processing and model training, raises ethical concerns like data privacy and algorithm bias, and requires specialized knowledge for developers and users.	Decentral and, Sandbox, Realy, Star Atlas, Bit. Country, and DeHealth image quality and processing efficiency with CNNs and DL..

<p>(Navidi & Landry Jr, 2021)</p> <p>New Approach in Human-AI Interaction by Reinforcement-Imitation Learning</p> <p>MDPI</p> <p>This study provided effective findings highlighting the different approaches in reinforcement learning (RL). RL algorithms are used to improve the decision-making process and allow non-player characters to interact with users and the Metaverse as well as game-based environments.</p> <p>The system enhances training efficiency, policy learning, and expert guidance by incorporating human feedback, teacher experience, and algorithms like DAGGER and GAIL.</p> <p>Training methods like GAIL can be time-consuming, complex for non-expert teachers, and may suffer from model instability due to stochastic policy assumptions.</p> <p>Human-AI interaction by combining Reinforcement Learning and Imitation Learning. Algorithms include DRAGGAR and GAIL.</p>	<p>(Kadyr & Tolganay, 2024)</p> <p>Affective computing methods for simulation of action scenarios in video games</p> <p>Elsevier</p> <p>In this paper, the authors built an emotion reading system using an ANN model presenting a 2D platform game which uses fuzzy logic to monitor emotions. In non-player games, AI algorithms are used for emotion simulation to improve gamification using facial features and fuzzy logic to perceive a player's emotion.</p> <p>It enhances engagement by changing the game space based on player emotions, creating a more unpredictable and immersive experience and also provide new opportunities for success.</p> <p>Implementing affective computing systems in games may require advanced technical knowledge, ethical concerns about privacy and data collection, and technical challenges in ensuring accuracy and reliability.</p> <p>The study had facial expression analysis, action analysis, and emotion-aware systems to enhance gameplay, employing fuzzy logic for input data and artificial neural networks for output.</p>	<p>6.</p> <p>(Bécue <i>et al.</i>, 2021)</p> <p>Artificial intelligence, cyber threats and Industry 4.0: challenges and opportunities</p> <p>Springer</p> <p>This survey paper presents a discussion on threats and opportunities using AI. Some key AI techniques used in game development include fuzzy logic, decision trees, and genetic algorithms. Each algorithm can be applied to yield multiple possibilities for better immersion and interaction.</p> <p>XRreality technologies offer immersive, interactive IoT data experiences, with attractive visualizations and 3D views, enhancing engagement and understanding in smart cities and IoT fields.</p> <p>Some challenges include Hardware limitations, regulatory issues, and content creation to widespread adoption of VR and AR devices in IoT application.</p> <p>AI techniques used in game development include fuzzy logic, decision trees, and genetic algorithms</p>
<p>∞</p>	<p>7.</p>	

9.	(Yin <i>et al.</i> , 2023)	AI in Human-computer Gaming: Techniques, Challenges and Opportunities	Springer	This study highlighted the breakthrough of AlphaGo, which is a human-computer gaming system effective for better interaction and providing real-time strategy development. The intelligence system analyses the state and determines the overall task in relation to game rules, leading to the need for AI-based games in the Metaverse environment.	Human-computer gaming AIs like AlphaGo, Libratus, OpenAI Five, and AlphaStar have significantly advanced decision-making intelligence. Professional-level AI training can overcome game-theoretic challenges, and self-play or population-play with distributed learning offers simple implementation and performance guarantee.	The article discusses the challenges of implementing tree search-based methods in real-time games and highlights the limitations of current AIs, suggesting future directions.	Deep reinforcement learning, self-play, and population-play techniques in AIs like AlphaStar and OpenAI Five.
10.	(Han <i>et al.</i> , 2020)	Curiosity-Driven Variational Autoencoder for Deep Q Network	Springer	This study shed light on the DRL method which is used for achieving high-dimensional success in decision-making tasks. The algorithms are designed to evaluate various Atari 2600 games, showing effective experimental results. In the case of role-playing games, a vibrational encoder bottleneck can be adopted to enhance the ego-motion characteristics of non-player characters.	The CVAE algorithm improves deep reinforcement learning sample efficiency, enhances exploration, and is easily integrated with other DQN variants, outperforming traditional methods in training and testing processes.	The CVAE algorithm, while promising in Atari 2600 games, may require additional computational resources, hyper parameter sensitivity, and further validation for generalization.	“Curiosity-Driven Variational Autoencoder (CAVE)
11.	(Lyu, 2023)	State-of-the-art Human-Computer-Interaction in Metaverse	Taylor and Francis	A literature review-based research was conducted based on intelligent technology processes in the Metaverse. An in-depth database analysis covering articles between 2018-2023, the research presented the humanised somatosensory advancements in gaming reconstructing the relationship between space and people.	AI advancements in real-time HCI, facial recognition, wearable devices, and MUVR remote psychotherapy are transforming the digital shopping experience in the Metaverse.	Gesture Recognition (GR) methods can be time-consuming and tedious, potentially causing distractions or inconveniences for users with limb paralysis during the interaction with virtual settings.	Ultrathin Stretchable Electronics, Deep Learning (DL) Methods based on Surface Electromyography (sEMG), Multi-User Virtual Reality (MUVR) and Cognitive AI Techniques and Algorithms.

14.	(Bibri & Jagatheesaperumal, 2023)	Harnessing the Potential of the Metaverse and Artificial Intelligence for the Internet of City Things: Cost-Effective XR Reality and Synergistic AIoT Technologies	MDPI	Metaverse represents a 3D network designed for the facilitation of collaboration, learning and social interaction. The emerging technologies like AR, VR and XR are integrated with AI-based Metaverse gaming. The main focus is on exploring the emerging AIoT paradigm. The purpose is to facilitate Metaverse infusion encompassing interaction with holographic devices and virtual elements, enabling manipulation of a seamless gaming experience.	3D network design enhances visualization, improves planning, and enables realistic simulations, enabling better analysis of potential bottlenecks and congestion points, thereby enhancing efficiency and effectiveness in network design.	It is complex, require specialized skills, higher costs, and potential compatibility issues with existing systems.	3D network design that visualizes network infrastructure, allowing engineers to represent network components like routers, switches, servers, and cables for a more realistic and intuitive view.
13.	(Henz, 2022)	The psychological impact of the Metaverse	Springer	The study presented an overview of classic gaming using 3D platforms in Metaverse supporting VR and AI. One autonomous act of the AI gaming inside the Metaverse is the algorithm, which connects with the user's attitude, preferences and past behaviours to create an additional human-like control in gaming experiences showing typical movements and judgements.	The Metaverse provides immersive experiences, enhances professional applications, integrates with existing apps, offers learning opportunities, enables remote operations, and provides access to information.	The Metaverse may significantly impact users' psychological understanding, potentially exploiting vulnerabilities, necessitating efficient legal frameworks, continuous study to understand effects, and potential "Zoom Fatigue" due to remote meetings.	Interaction through avatars
12.	(Njoku <i>et al.</i> , 2023)	Prospects and challenges of Metaverse application in data-driven intelligent transportation systems	Wiley	The study highlighted the concept of Metaverse in various sectors. One aspect of the study was explaining how virtual platforms evolved in 3D virtual gaming over time, such as Runescape, Roblox, Zwift Fortnite Battle Royale in 2017 as multiplayer games. Nonetheless, the company of Meta, i.e., Facebook, has also launched Horizon Worlds, which is a Metaversial game infusing digital and physical worlds.	12V by Nissan Corporation Ltd. Is a convenient, and comfortable driving experience. Although it is not yet a reality, 12V offers unique advantages brought about by the introduction of the Metaverse	Credential and identity theft, ransom ware and sustainability limitations	NISSAN - invisible-to-visible (12V) technology car

15.	(Jamshidi <i>et al.</i> , 2023)	The Meta-Metaverse: Ideation and Future Directions	MDPI	In the era of AI and digitalisation, Metaverse has become increasingly vital. Therefore, the research addressed the phenomena of the innovation named as Meta-Metaverse.	Offers enhanced communication, simplified maintenance, potential scientific advancements, and technological innovation and biodiversity patterns.	Challenges in achieving a virtual environment, scale of integration, , single point of failure, inequality, and societal impact, including complexities in transportation and potential disparities in educational opportunities.
16.	(Himangi & Singla, 2022)	Investigating the Role of Deep Learning in Metaverse	Sage	Avatars are the digital representations generated by computers in which Metaverse is used to communicate and interact with the VR elements. With the evolution of DL, Metaverse gaming is categorised into four aspects, including image compression, image processing, picture segmentation and edge detection.	Communication and interaction with one another as well as with digital goods, combining elements of virtual reality, an online performance game, and the World Wide Web.	Data compression and security concerns might the challenges of the study
17.	(P. Li <i>et al.</i> , 2023)	A Robust Adversary Detection-Deactivation Method for Metaverse-oriented Collaborative Deep Learning	IEEE	The study analysed that the Metaverse is transforming real-world interactions into virtual ones, with pre-trained AI models enhancing response speed. Collaborative Deep Learning (CDL) and Generative Adversarial Network (GAN) are used to degrade model performance and address potential malicious activities.	The system enables collaborative training of large AI models, efficiently utilizes distributed computing resources, and promotes knowledge sharing and model improvement across various entities.	The collaborative training process might create issues OF security, vulnerabilities and privacy concerns due to the sharing of sensitive data among malicious participants.
				Collaborative Deep Learning (CDL), Generative Adversarial Networks (GANs), and Trusted Third Party-based protocols		

18.	(Cho <i>et al.</i> , 2022)	DAVE: Deep Learning-Based Asymmetric Virtual Environment for Immersive Experiential Metaverse Content	MDPI	A novel experience of DL provided an immersive experience in digital gaming. The study proposed a novel symmetric virtual environment and analysed the user experience and interface satisfaction using a survey.	User has no spatial restrictions, and AR users have the advantage of being able to freely control and explore virtual scenes	DAVE which can provide an experience and presence that satisfies all users
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DISCUSSION

Meta and Metaverse Potential

Despite the criticism, Metaverse market is getting investment from several investors with the most prominent one through Microsoft Blizzard from Activision for around \$68.7 billion (Xiong, 2022). From the estimate of Kraus *et al.* (2022), it is evident that Metaverse still has to meet its full potential in comparison to the other industries. However, it is appreciated that the AI in Metaverse gaming segment has contributed to the growth while focusing on the market value of the company and other factors that relate to investment. Thus, sales potential by 2024 shows that gaming related activities will contribute not less than 50%. Based on this investigation, it becomes mandatory to understand that, in the current generation, computer and Smartphone games are becoming popular. The markets of large software companies have given them attention due to the increase of such applications and the increase in research in AI technology (Kraus *et al.*, 2022).

Furthermore, it is equally important to identify that Meta puts weight in enhancing corporate aid and communication through external reality (XR) consumers. The capacity of these investments to expand Metaverse's sales and applications have been demonstrated by the results. With time, and as the Metaverse widens becoming a working feasible computing platform, XR is also shaping gaming by maintaining synchronous, holistic, real-time, connected, and persistent virtual-reality/physics. Thus, by applying the applications of blockchain, computer vision, edge cloud, holographic devices, and AI, it aims at being able to touch as well as feel the holographic devices and virtual components of seamless game experience in the aural and visual realms (Bibri & Jagatheesaperumal, 2023).

Another research highlighted the fact that the applications of Meta-Metaverse are diverse in gaming, which offers visually appealing and complex solutions in the aspects of gaming character, game, level, and visual. The strength of Metaverse is in detailed for shed for creating complex effects like fire, water and other elements of the environment like foliage and clouds. As a result, the

potential of the gaming world advances in accordance with the highly realistic and believable various landscapes, with multifunctional uses. It is even possible with the help of different algorithms, for example fractal algorithm, to make height maps, which will all be different in characteristics and properties changing the look of various terrains in the games, such as forests, mountains and deserts for an infinite number of times (Jamshidi *et al.*, 2023).

Deep Learning and AI-Based Gaming

Considering the significance of AI requirement, it is possible to infer that there are numerous topics, which belong to the AI discipline, as well as many areas of the entertainment industry, where AI can be used. This diversity has been attributed to the numerous techniques that is used in the course of game development to progress various interactive features. It is crucial in this case to analyse Metaverse as a highly dynamic and an open platform of integrating and interacting services. With that characteristic, it means that it can implement a number of ML or AI algorithms to a large extent. Many of these algorithms can be classified as basic or as complex and they are mostly applied for classification and clustering with regression. Hence, it is necessary to analyse various aspects of techniques in terms of AI-based games and their integration into Metaverse platform as a whole. (Huynh-The *et al.*, 2023; Mahesh, 2020).

According to Mahesh (2020), considerably in DL, there is often pursuit of constructing deep multi-layered neural networks in order to achieve a high accuracy in the cases of regression and classification tasks. This has defined diverse sorts of DL architectures such as self-organising maps, recurrent neural networks, autoencoder and CNN. Recurrent neural networks are one of the most basic DL architectures together with having better structural complexities than their feed-forward counterparts, feedback connections, and back-propagation. The primary algorithms of the neural networks are long short-term memory and the gated recurrent unit. Autoencoders are centred on input-to-output translation, facilitated very effectively by the compression and decompression

of images, hence lending themselves to self-supervision (Huynh-The *et al.*, 2023; Mahesh, 2020). CNN and self-organising maps are important enhancements to conventional methods, which make it possible to develop efficient DNNs and maybe apply to AI games. CNNs utilise mathematical functions to analyse complex patterns, not distinguishable from raw unstructured data and on the other hand self-organising maps work on the principles of unsupervised learning to generate distinct neural structures (Taye, 2023).

In their study, Han, Zhang, Chen, and Zhang, (2020) noted that the application of intrinsic curiosity-driven variation autoencoders is a method applied to the DRL approach employed in building a given application's state destruction. It represents uniqueness by implementing the intrinsic reward mechanisms, along with curiosity; there is also a generative model integrated into this loop. For the role-playing games, one can use the inverse dynamic mechanism and vibrational encoder bottleneck to improve the characteristics of ego-motion of non-playable characters (Han *et al.*, 2020). In addition, the ML/DL algorithms improve NLP and computer vision, simplifying the game industry and influencing the Metaverse. The aim is to establish a platform for interaction between virtual assistants and people who play video games (Bibri & Jagatheesaperumal, 2023).

Notably, the role of deep learning in Metaverse gaming may be divided into four categories: edge detection, picture segmentation, image processing, and image compression. Enabling avatar interaction is essential for generating immersive experiences in online role-playing games. Utilising DL enhances the software development process for these kinds of games, improving the design and functionality of the game. (Himangi & Singla, 2022). The term "Metaverse" refers to the digital environment that is being formed to bring the actual world into virtual communications. In this matter, pre-trained AI models have a great capability of improving Metaverse's capacity to quickly and effectively assist in generating an excellent response. Collaborative Deep Learning (CDL) is used to train them, offering the ability to combine and train numerous huge models simultaneously. A pre-trained big model is used to degenerate the model performance, and a Generative Adversarial Network (GAN) is built to address any potential malicious activity weaknesses (P. Li *et al.*, 2023). Besides, shared virtual environments, distributed simulation, 3D multiplayer games, and collaborative engineering all leverage collaborative virtual environments, or CVEs, to create an interactive and cooperative platform. In order to provide a fulfilling presence and fresh experiences in a virtual space, asymmetric virtual environments take into account a variety of experience platforms and surroundings (Cho *et al.*, 2022).

AI Algorithms in Game Development

The observed AI-based algorithms have broad applications in game development; however, it is critical

to acknowledge the complexities associated with adopting alights with diverse scopes. Some key AI techniques used in game development include fuzzy logic, decision trees, and genetic algorithms. Each algorithm can be applied to yield multiple possibilities for better immersion and interaction; for instance, the finite state machine can be used to maintain a given game world, thus maintaining the state of the game (Bécue *et al.*, 2021).

Navidi & Laundry Jr (2021) recognise a paradigm shift to the use of reinforcement algorithms to improve the decision-making process and allow non-player characters to interact with users and the Metaverse as well as game-based environments. This has allowed games to balance subjective interaction and objectivity, creating a better experience for different users. While the experience improves, it is critical to acknowledge the potential advertising and the learning process that comes with the deployment of gaming engines in a virtual environment. Specifically, the main question is how AI-based agents will learn amidst relentless human interaction (Navidi & Landry Jr, 2021). As a whole, it is noted that the technical demands in Metaverse for games and entertainment are higher with the use of HCI DL architectures designed heavily for capturing spatial information using CNN designs. Big Data and AI are used to enhance the somatosensory advancements in gaming, reconstructing the relationship between space and people (Lyu, 2023).

In research by Taye (2023), it has highlighted that DRL is an effective AI approach in which the algorithm used is often employed in robotics and games utilising punishment and reward mechanisms. It is used to handle the issues relevant to decision-making. Furthermore, the applications of recurrent neural networks (RNN) and deep feedforward neural networks (FNN) for DRL are significant in the applications of a variety of architectures like deep Q-network used in various games for optimisation. These are employed for the system to become capable of inconsistent player behaviour-modifying games such as Grand Theft Auto with effective ML algorithm integration (Taye, 2023). Similarly, it can be adapted to model unit behaviour in strategy games. Such infinite possibilities have seen the algorithm being used in developing and designing non-player characters in the game. In the case of the fuzzy logic technique, it has been utilised in decision-making elements and simulating non-player characters' behaviour. Nonetheless, in non-player games, AI algorithms are used for emotion simulation to improve gamification using facial features and fuzzy logic to perceive a player's emotion. These algorithms improve the game development for increased engagement, more immersive gameplay, emotional regulation and real-time dynamic gaming potential with personalised gaming experience (Kadyr & Tolganay, 2024).

AI-Based Metaverse Gaming and Human Interaction

AI is being used into game environments more and more to improve task accomplishment. These are online chess games and reinforcement algorithms like Alpha

Go, which concentrate on figuring out the best ways to beat opponents in exchange for prizes. AI-based games are necessary in the Metaverse environment because the intelligence system evaluates the current situation and decides the overall task in accordance with the game rules. With the introduction of 3D architecture, the Metaverse environment holds the potential to enhance traditional games and provide an enhanced user experience. But the emphasis is on live entertainment advertising, which offers a special chance to include intelligent systems. DL super sampling technique has been created by companies such as NVIDIA to improve gaming and visual integration (Yin *et al.*, 2023).

According to Lyu (2023), the idea of the metaverse first appeared in Neal Stephenson's fiction book "Snow Crash" in 1992. The aspect, which addressed the relationship between real people and virtual figures and the quick adoption and advancement of AI in the Metaverse, was portrayed in a futuristic context. For example, Roblox entered the market as a casual game mashup of self-build content and virtual environments, but its Metaverse concept helped it become very popular. AI-integrated metaverse provides a human-interactive game environment where users can interact virtually, enhancing immersion, accessibility, and low latency. Players can alter their experiences in games by taking on different identities and responsibilities thanks to AR and XR in the Metaverse, especially in shooting games. (Lyu, 2023).

Additionally, analysis has shown that the Metaverse's rise goes beyond conceptual understanding to include its use in the virtual game environment. With the launch of virtual platforms like ActiveWorlds, Traveller, and Croquet in 1998, 3D gaming had its start. AI has been improving multiplayer games like Roblox (2006), Zwiift (2014), Runescape (2001), and Fortnite Battle Royale (2017) while also improving human-computer interaction. Furthermore, Nintendo released an extremely human-interactive Animal Crossing game in 2020 that featured villagers, plants, and animals. However, Facebook, the parent company of Meta, has also introduced Horizon Worlds, a Metaversial game that blends the virtual and real worlds (Njoku *et al.*, 2023).

Since 52.2 million Roblox players are apparently active on the gaming platform every day, another study showing the ongoing development of 3D gaming employing AI-based Metaverse revealed that gaming has reportedly been widespread in the age category of 4-18 years. These games' AI humanization is what draws in a lot of players because it has a psychological effect on them when they may change their identities and roles in the virtual world. The algorithm, which links with the user's attitude, preferences, and past behaviours to produce an extra human-like control in gaming experiences demonstrating typical motions and assessments, is one autonomous act of the AI gaming inside the Metaverse. It turns an avatar into a computer-generated entity in a game like "The Sims", where virtual being observes behavioural forms (Henz, 2022).

Challenges and Important Issues in AI-Based Metaverse Gaming

The study highlights the importance of companies constantly reinventing their business models and product offerings to stay competitive in a rapidly changing market. Meta's strategic virtual reality acquisitions demonstrate the importance of forming beneficial alliances within an ecosystem. Public communications, particularly extravagant ones, should be considered critically. The BM transformation is similar to Philip Morris and Facebook's rebranding, which is often used to regain trust lost due to unethical standards and poor management in gaming. The research provides an initial understanding of Meta's shift from Facebook to Meta, emphasizing its strong entrepreneurial conduct in promoting a metaverse vision (Kraus *et al.*, 2022). DL faces challenges in the AI-driven Metaverse, including model novelty and updating training methodologies. Traditional models like the automated encoder and limited Boltzmann machine require large samples for network parameter evaluation, and longer training times are needed for complex problems. Despite these challenges, AI-based Metaverse faces questions about interpretability, timing, and data volume. Medical professionals often view DL models as "black boxes," and developing techniques to handle temporal healthcare data is crucial for improving precision and speed (Taye, 2023).

Moreover, online and streaming data processing is challenging, requiring algorithms close to $O(n \log n)$. Incremental updates are crucial for dynamic environments. Traditional categorization methods fail due to intentional cybersecurity risks. Customized interfaces are needed for rule extraction or detection. Generalisation capacity is crucial for OT security issues. Machine learning-based algorithms can consider industrial processes and hazards, but may not improve industry-wide knowledge base (Bécue *et al.*, 2021). Notwithstanding, human computer gaming has advanced significantly, but it has three drawbacks: AIs are primarily designed for a single game or map, training high-level AIs requires significant computational resources, and claims of AI reaching expert level are based on performance against a limited pool of human players. Despite these challenges, computer versions of large models, particularly pretrained ones, are emerging from NLP, with potential for use in downstream tasks and zero-shot scenarios (Yin *et al.*, 2023).

Proposed Solutions and Directions for Metaverse

In the metaverse, various AI-driven techniques are employed to tackle data-related issues. The optimal algorithm depends on the problem's nature, variables, and model. K-Means Clustering, Ensemble Learning, and Transductive Support Vector Machines (TSVM) are common machine learning methods. K-Means is unsupervised, while TSVM handles partially labelled data. Ensemble learning generates multiple models to improve performance or reduce selection errors. Other uses include allocating confidence, choosing best features, data

fusion, incremental learning, non-stationary learning, and error-correcting (Jamshidi *et al.*, 2023; Mahesh, 2020). In addition, Taye (2023) proposed that unsupervised learning techniques have introduced optimization issues for DL models. The first CNN architecture was created by Kunihiko Fukushima in 1986, and backpropagation was applied in 1986. Yann LeCun trained a CNN in 2006 to recognize handwritten numerals. DBN, a greedy learning technique, maximizes weights with time complexity proportional to network size and depth. Multimodal DL is another popular advancement. DL models require effective pre-processing techniques and large datasets, which can be challenging when processing occurs in real time or with limited datasets (Taye, 2023).

Additionally, in AI-based gaming, a proposed paradigm called fuzzy logic aids in the representation and management of the ambiguity and imprecision that characterise emotions, which are intricate and personal experiences. It takes into account variables like valence, intensity, and other feelings like surprise, joy, sorrow, rage, and neutrality. Every emotion's intensity is computed, and the resulting matrix shows which emotion is dominant. The degrees of resemblance between several emotional states and face features are modelled and quantified using fuzzy logic; the emotions are neutral, happy, surprised, sad, and angry (Kadyr & Tolganay, 2024). Another study has proposed a web-based speech-to-term recognition technique in the Metaverse, enhancing information systems through natural interaction. The technique combines ontology database, Automatic Speech Recognition (ASR), NLP, Text-to-Speech (TTS), and vocal activity detection. Voice interaction, driven by AI, is being studied in various fields like vehicles, games, social media, chatbots, online marketing, and healthcare. More effort is needed to improve intelligence, disambiguation, and linguistic problem handling in the Metaverse (Lyu, 2023).

CONCLUSION

This reviewed explored the most notable opportunity of gaming in the Metaverse. The transition from Facebook to Meta marked a significant technological advancement, paving the way for a new era of creativity and potential. The Metaverse has seen significant investment in gaming, offering unparalleled user engagement and entertainment. Intelligent agents, driven by complex algorithms like fuzzy logic and finite state machines, are transforming the gaming experience, aiming to boost user satisfaction and engagement. This element of the development has the potential to integrate AI-based games for better user immersion and entertainment experience. The intelligent agents show the presence of numerous algorithms designed to improve overall user experience. The key algorithms that have been and can be used in AI-based range from fuzzy logic to finite state machines. The potential for the integration of generic algorithms also presents numerous technological development and integration opportunities. Amidst these opportunities, it was critical to acknowledge the learning process in the

wake of increased human interaction. Evidence shows that intelligent systems are designed to work based on data and progressive feedback mechanisms. In a gaming environment, intelligent systems are designed to focus on maintaining key aspects of the game, improve visual aspects of the experiences and provide new challenges to users. Therefore, it creates a unique, realistic environment and improves inter-person and human-machine interaction. This development of new AI-based games in Metaverse is likely to improve the overall entertainment value offered by the platform.

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