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Role of Artificial Intelligence in Enhancing Metaverse Gaming Experience and Human Interaction

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ABSTRACT

Artificial Intelligence (AI) is a tool that is useful for enabling and sustaining the Metaverse gaming experience by infusing virtual reality (VR), augmented reality (AR), extended realities (XR), and blockchain. The current research focused on identifying the impact of AI in leveraging immersive experiences and improving human interaction, which plays a crucial role in Metaverse gaming. A quantitative analysis carried out surveys from 200 randomly sampled respondents involved in Metaverse gaming. Using SPSS 26.0, correlation analysis showed that association between the values of 'r' of variables Immersive Gaming Experience ($r=0.983^{**}$), Deep Learning Collaboration ($r=0.957^{**}$) and Increased Human Interaction ($r=0.979^{**}$) are greater than 0.7 depicting strong correlation with Metaverse gaming. Regression analysis further confirmed that the role of AI in enhancing the Metaverse gaming experience and human interaction is significant. With the considerable success of AI in Metaverse, the role of DL algorithms is also groundbreaking in leveraging game balance in multiplayer games, satisfying play-testers and designers who own valuable features, real-time rendering, and multi-user design collaboration.

INTRODUCTION

The adoption of Artificial Intelligence (AI) in the development of games can be traced back to the mid-1960s. During this period, there were numerous variations of video games, with the most common being "Pong"; the game was considered the first with a non-player character (the computer) as an opponent. Nonetheless, with technological advancements today, developers and IT experts have focused on adopting microprocessors to enhance AI functionality and performance. AI has been adopted in various games (Zhouxiang, 2023). The inclusion of Virtual Reality (AR), Augmented Reality (AR), or Extended Realities (XR) in gaming is likely to improve the overall growth of the industry and the application of different technologies.

Moreover, due to Facebook's expected substantial growth through different investments, the global Metaverse market will increase to about \$61.8 billion in 2022. Consequently, the firm is expected to have a market value of approximately \$426.9 billion by 2027; this reflects a compound annual growth rate of about 47.2%. The Metaverse market's growth is attributed to the firm's technological capabilities and increased gaming and entertainment demands (Malik *et al.*, 2024). This recognition has seen Metaverse make significant efforts to integrate gaming into their platforms into a fully unique user experience (Marto & Gonçalves, 2022). However, it is critical to acknowledge that the gaming experience is not limited to visual effects and immersion; instead, an analysis of the gaming markets shows an increased focus on integrating AI-based gaming engines for a better user experience (Machado *et al.*, 2021). This approach to game development has seen developers such as EA, Playfish,

Microprose, Fox Interactive, and Sierra Games adopt AI, developing different games for unique user expertise. This raises the need to examine the various aspects of AI-based games within the Metaverse platform (Goodwin, 2016).

Musicians such as Snoop Dog and Fortnite have made crucial investments in testing Metaverse's ability to provide virtual concerns, while game creators perceive the Metaverse as a new technology for further growth (Khan, 2023). In the case of sales, the firm is expected to have approximately \$800 billion in sales by 2024. Where applications are considered, Metaverse is expected to improve internet gaming, likely accounting for more than 50% of its total sales (Inder, 2023). Furthermore, the firm is set to convert the existing game to a 3D live entertainment environment accompanied by media advertising. These unique approaches to AR, VR and XR have significantly increased sales of VR gear through in-game advertising (Bushell, 2022).

The adoption of ML and AI in gaming engines shows the progressive evolution of technology and its applications. One of the most notable successes has been seen through adopting a generic algorithm for advanced interaction and more user immersion (Hadjar *et al.*, 2022). Previous studies have explored the use of multiple AI-based algorithms in Metaverse gaming. However, limited research has analysed the role of AI in enhancing the Metaverse gaming experience and human interaction. The current research is focused on addressing the gap and identifying the effectiveness of AI-based games in learning human behaviour and improving the game environment, with human interaction playing a crucial role in setting up the system. For this analysis, surveys were conducted

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from the population involved in Metaverse gaming to gather first-hand opinions of players on the role of AI in Metaverse gaming enhancing human interaction. The research questions addressed in this research are stated below.

1. What is the role of AI in enhancing the Metaverse gaming experience and human interaction?

LITERATURE REVIEW

Meta and Metaverse Potential

An analysis of the Metaverse market and underlying investment condition shows the presence of several investors despite the initial criticism. The most notable investment has been the \$68.7 billion from Activision through Microsoft Blizzard (Xiong, 2022). The analysis provided by Kraus *et al.* (2022) indicated the potential growth of Metaverse in 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. Based on this observation, it is critical to acknowledge that computer and mobile games are increasingly becoming popular in the modern environment. Their popularity has been accompanied by increased AI research, shaping the interest of big software companies and markets (Kraus *et al.*, 2022).

Additionally, it is critical to acknowledge Meta's focus on enhancing communication and providing corporate support through external reality (XR) users. These investments have set the potential for expanding the Metaverse in terms of sales and applications. Notably, with the advancement of the Metaverse as an operational and feasible computing platform, the XR technologies are also shaping the gaming experience with a synchronous, comprehensive, interactive, interconnected and ever-present virtual-physical realm. The purpose is to facilitate auditory, visual, and tactile dimensions with Metaverse infusion encompassing interaction with holographic devices and virtual elements enabling manipulation of seamless gaming experience using holistic technologies of AI, XR., computer vision, edge cloud, and blockchain (Bibri & Jagatheesaperumal, 2023).

Another research highlighted the versatile applications of the Meta-Metaverse in gaming, which provides visually captivating and intricate designs in multiple gaming aspects such as character design, game design, level design, and visual effects. The potential of Metaverse lies in its intricate design, which generates complex visual effects such as fire, water, and environmental elements like foliage and clouds. Consequently, the advancement of the gaming world is powered by the immersiveness and believability of the various landscapes with versatile applications. With the integration of different algorithms, such as fractal algorithm, height maps can be generated, each providing unique characteristics and properties adjusting various terrain's appearance for infinite diversity in the games like forests, mountains, and deserts (Jamshidi *et al.*, 2023).

AI and Metaverse

The smooth blend of Metaverse with the virtual and actual worlds allows engagement in entertainment, trading, social networking, and others. AI is useful for enabling and sustaining Metaverse by infusing AR, VR, and Blockchains. An effective, free, and safe engagement of economic and social activities offered by AI that extend past the physical realm. One such example is the creation of avatars in the heart of Metaverse, which analyses 3D scans or 2D user photos to create realistic virtual reproduction. Metaverse is a 3D chatbot offering human-like interactions and discussions in a virtual reality setting (Sivasankar, 2022). Notwithstanding, AI has presented a significant effect of "leading goose" in recent years in multiple areas, from chemistry and biology to medicine discovery and chip design. AI has empowered many areas of research with Metaverse being widely observed, such as the imaging technology to look for the real-world giga-pixel imaging system, artificial neural networks (ANNs) in brain-inspired efficient architecture improving computation efficiency of large to low power (Guo *et al.*, 2022).

Facebook's change to Meta in 2021 was considered a part of strategic growth and promoted their future investment (Bolger, 2021). While Mark Zuckerberg believed it was the best approach to future development, academic and business leaders have often criticised this move due to its underlying implications (Kraus *et al.*, 2022). The application of AI in this video game has been used to simulate real-life sports interaction for higher levels of immersion. It has also been used to enhance the multiplayer component of the game. The observed uses of AI in video games have seen improved entertainment value for the users; however, the implementation is not entirely effective. Evidence from different video games shows the increased focus on constraining non-player characters within certain elements, limiting the exploration of infinite game-based capabilities (Frutos-Pascual & Zapirain, 2015; Pirker, 2023). Metaverse will reduce these challenges by incorporating virtual and extended realities in video games for a more immersive experience. It will be accompanied by reducing the need for local optimality and improving the general application of AI within a given game (Dudley *et al.*, 2023).

Conventional AI approaches focus on specific application standards and can be categorised into supervised, reinforced, semi-supervised, or unsupervised learning. Supervised learning maps data and functions to predict outcomes, while unsupervised models analyse unstructured data. Semi-supervised and reinforced learning approaches combine structured and unstructured data, enhancing Machine Learning (ML) methods and predictive analytics (Morales & Escalante, 2022). Reinforced learning focuses on making decisions in uncertain environments to achieve objectives, particularly in games. These approaches are particularly effective in interactive gaming environments like the Metaverse, where AI machines adopt a trial-and-error approach to learning (Du *et al.*, 2024; Mazandarani *et al.*, 2023).

Deep Learning and AI-based Gaming

AI and its application in the entertainment industry is highly diverse. This diversity has been attributed to the many techniques used in game development to advance different interactive features. In this case, it is worth noting that Metaverse is a highly dynamic and interoperable platform. Consequently, it has the potential to adopt various ML or DL algorithms, which are either conventional or advanced and commonly used for classification, clustering, and regression. Therefore, it is vital to examine different elements of techniques concerning AI-based games and their overall implementation within the Metaverse platform (Huynh-The *et al.*, 2023; Mahesh, 2020).

Mahesh (2020) explained that DL is often used to build multi-layered neural networks to achieve high accuracy in regression and classification problems. This has seen the development of numerous DL architectures, including self-organising maps, recurrent neural networks (RNN), autoencoders, and convolutional neural networks (CNNs). RNNs are a fundamental DL architecture with improved structural features, including feed-forward connections, feedback mechanisms, and back-propagation techniques. Autoencoders focus on input-to-output translation through compression and decompression algorithms, allowing high performance in self-supervised tasks (Huynh-The *et al.*, 2023; Mahesh, 2020). Self-organising maps and CNNs are better than conventional techniques, enabling more effective deep neural network (DNN) design and potential application in AI-based Metaverse games (Taye, 2023).

Han *et al.* (2020) highlighted that introducing intrinsic curiosity-driven variation autoencoders is a technique for deep reinforcement learning (DRL) used to develop an application's state destruction. Using a generative model, it represents uniqueness by integrating intrinsic curiosity mechanisms. In the case of role-playing games, the inverse dynamic mechanism and vibrational encoder bottleneck are essential to enhance the ego-motion characteristics of non-player characters (Han *et al.*, 2020). Besides the ML/DL algorithms streamlining the Metaverse gaming world, NLP and computer vision are also shaping the Metaverse. The idea is to create an interactive platform between virtual assistants and human users in the gaming world (Bibri & Jagatheesaperumal, 2023).

Consequently, the function of DL in Metaverse gaming is categorised into four aspects, including image compression, image processing, picture segmentation and edge detection. It is vital for creating immersive experiences in online role-playing games, allowing players to interact using their avatars. The use of DL improves the software development of such games, enhancing the conception and execution of the game (Himangi & Singla, 2022).

Metaverse creates a digital circumstance for transferring the real world into virtual interactions. Here, the pre-trained AI models have the highest potential for increasing Metaverse's capability to achieve a great response without

delay. These are trained using Collaborative Deep Learning (CDL), which provides multiple large models to combine and train in collaboration. The model performance degenerates with a pre-trained large model, and a Generative Adversarial Network (GAN) is constructed to deal with the vulnerabilities of potential malicious activities (Li *et al.*, 2023). Besides, collaborative virtual environments (CVEs) are used to create an interactive and collaborative platform for various applications in shared virtual environments, 3D multiplayer games, distributed simulation, and collaborative engineering. Asymmetric virtual environments consider multiple experience platforms and environments for presenting satisfying presence and new experiences in a virtual space (Cho *et al.*, 2022).

AI-based Metaverse Gaming and Human Interaction

AI is increasingly being integrated into gaming environments, enhancing the success of tasks. Reinforcement algorithms like Alpha Go and online chess games are examples of such games, which focus on finding optimal strategies to defeat opponents for rewards. The intelligence system analyses the state and determines the overall task of game rules, leading to the need for AI-based games in the Metaverse environment. The Metaverse environment can potentially improve conventional games by introducing 3D architecture for a better user experience. However, the focus is on advertising through live entertainment, presenting a unique opportunity to integrate intelligent systems. Companies like NVIDIA have developed DL super sampling technology for better gaming and visual integration (Yin *et al.*, 2023).

As examined by Lyu (2023), in the fiction novel "Snow Crash" by Neal Stephenson, the concept of Metaverse originated in 1992. The story presented a futuristic setting that explained the actual human and virtual figure connection with the rapid implementation and development of AI in Metaverse. For instance, Roblox came to the market as a game blended with self-build content, virtual worlds and casual games, gaining popularity due to its Metaverse concept. Metaverse embedded into AI offers a human interactive gaming platform with virtual identities of players, improving the gaming experience in terms of accessibility, low latency, and immersion. With AR and XR in Metaverse, players can change their experience with various identities and roles in games, specifically shooting games (Lyu, 2023).

Furthermore, it has been analysed that the emergence of Metaverse is beyond the conceptual level to its application in the virtual gaming world. 3D gaming began in 1998 with virtual platforms like ActiveWorlds, Traveler and Croquet. AI has been advancing the gaming world with better human interaction, such as Runescape, launched in 2001, Roblox in 2006, Zworld in 2014, and Fortnite Battle Royale in 2017 as multiplayer games. In addition, in 2020, Nintendo launched an Animal Crossing game, which was highly human interactive with animals, plants and villagers.

Nonetheless, the company of Meta, i.e., Facebook, has also launched Horizon Worlds, a Metaversial game infusing digital and physical worlds (Njoku *et al.*, 2023). Another research highlighting the continuous development of 3D gaming using AI-based Metaverse highlighted that gaming has reportedly been common in the age group of 4-18 years, as 52.2 million Roblox users are reportedly active daily on the gaming platform. The AI humanisation of such games is the basis for attracting several players as they psychologically impact them when they can shift identities and roles in the virtual world. 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. It transforms an Avatar into a virtual being in a game like "The Sims", where a virtual being observes behavioural patterns (Henz, 2022).

Conceptual Framework

Figure 1 below presents the conceptual framework of the current research derived from the literature review. The following are the hypotheses formulated for the research.

H1a: The role of AI in immersive gaming experience is significant in Metaverse gaming.

H1b: The role of AI in immersive gaming experience is not significant in Metaverse gaming.

H2a: The role of AI using deep learning collaboration is significant in Metaverse gaming.

H2b: The role of AI using deep learning collaboration is not significant in Metaverse gaming.

H3a: The role of AI in increasing human interaction is significant in Metaverse gaming.

H3b: The role of AI in increasing human interaction is not significant in Metaverse gaming.

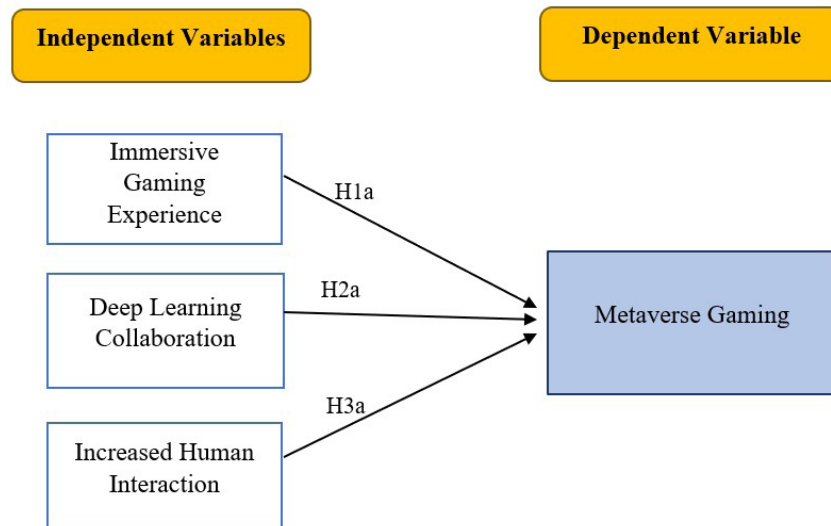


Figure 1: Conceptual Framework
 Source: Author

METHODOLOGY

In the current research, a quantitative research design was adopted to examine the impact of AI on the Metaverse gaming experience and human interaction. The researcher employed a positivist philosophical approach to present objective findings supported by numerical survey data. Data collection in this research was carried out through close-ended questionnaires. These surveys were designed based on the identified independent variables from the literature review to confirm the validity of the variables. The survey questions were constructed using a Likert scale ranging from 0 to 4 (strongly agree to disagree strongly). The target population for the current research were the Metaverse gamers. This population was approached on social media platforms and LinkedIn to participate in the research and fully adhered to ethical guidelines. Using a random sampling technique, 200 Metaverse gamers who completed the survey for this research were sampled.

Data gathered through surveys was analysed using the latest version of SPSS. The responses and demographics profile were evaluated using frequency analysis. Additionally, correlation and regression analysis were used to test the association between AI and Metaverse gaming to test the hypothesis formulated in this research.

RESULTS

Demographics

This section of the research presents the demographics of the research respondents. Table 1 below presents the age, gender, and years of Metaverse gaming experience of the sampled respondents. Notably, most respondents were between the ages of 21 and 20, i.e., 140 (70.0%). Furthermore, 28 (14.0%) respondents were aged between 18 and 20 years, 19 (9.5%) respondents were aged between 31 and 40 years and only 13 (6.5%) were aged 40 and above. Moreover, the majority of the respondents were male,

i.e., 119 (59.5%); however, 75 females (37.5%) also participated in this research. Respondents with some Metaverse gaming experiences were sampled. 63 (31.5%) respondents had gaming experience of less than one

year, 112 (56.0%) respondents had 1 to 3 years of gaming experience, 20 (10.0%) had 3 to 5 years of experience, whereas only 5 (2.5%) respondents had more than 5 years of experience of Metaverse gaming.

Table 1: Demographics

Demographics	Categories	Frequency	Percentage
Age	18-20 Years	28	14.0%
	21-30 Years	140	70.0%
	31-40 Years	19	9.5%
	40 Years and Above	13	6.5%
Gender	Male	119	59.5%
	Female	75	37.5%
	Prefer not to say	6	3.0%
Years of Metaverse Gaming Experience	Less than 1 Year	63	31.5%
	1-3 Years	112	56.0%
	3-5 Years	20	10.0%
	Above 5 Years	5	2.5%
Total		200	100%

Reliability Statistics

The survey scale’s reliability was tested in this research by computing Cronbach’s Alpha (α) to assess the internal consistency of all the research constructs. The accepted value of Cronbach’s Alpha (α) is higher than 0.7, which confirms that each independent variable measures a similar idea to the dependent variable. Table 2 below

confirms that for all three independent variables, including immersive gaming experience ($\alpha=0.920$), deep learning collaboration ($\alpha=0.958$) and increased human interaction ($\alpha=0.959$), the value of ‘ α ’ is higher than 0.9 confirming the internal consistency, proving these constructs measure a similar concept underlying Metaverse gaming.

Table 2: Cronbach’s Reliability Test

Dimension Name	Number of Statements	Cronbach’s Alpha (α) (Standardised) N=200
Immersive Gaming Experience	3	0.920
Deep Learning Collaboration	3	0.958
Increased Human Interaction	3	0.959

Frequency Statistics

Table 3 below presents the survey statements of each independent variable, highlighting the Likert scale responses.

It depicts that for the variable immersive gaming experience, the majority of the respondents (45.0%) agreed that “AI-driven features, such as avatar creation and 3D chatbots, contribute to the immersive experience in Metaverse gaming environments” strongly agreed “The current level of immersion in video games that utilise AI to simulate real-life sports interactions and enhance multiplayer components” and agreed (41.0%) that “AI-based approaches, such as reinforced learning in uncertain gaming environments, are in enhancing the overall immersive experience in interactive gaming environments in Metaverse games.”

Furthermore, for the variable deep learning collaboration, most respondents (32.0%) agreed or were neutral with the fact that “DL-based collaborative virtual environments (CVEs) are used for creating an interactive

and collaborative platform for the various applications in shared virtual environments, 3D multiplayer games, distributed simulation and collaborative engineering”, the majority strongly agreed (36.5%) that “The function of DL in Metaverse gaming is categorised into four aspects, including image compression, image processing, picture segmentation and edge detection” and agreed (45.0%) that “The use of DL improves the software development of games, enhancing the conception and execution of the game vital for creating immersive experiences in online role-playing games, allowing players to interact using their avatars.”

Additionally, for the variable increased human interaction, the majority of the respondents (40.0%) strongly agreed that “Metaverse embedded into AI offers a human interactive gaming platform with virtual identities of players, improving the gaming experience in terms of accessibility, low latency, and immersion”, also strongly agreed (37.0%) that “The AI humanisation of multiplayer games is the basis for attracting many

players as they create a psychological impact on them when they can shift identities and roles in the virtual world” and most of the agreed (45.0%) agreed that “An 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.”

Table 3: Frequency Statistics

1. Immersive Gaming Experience	AI-driven features, such as avatar creation and 3D chatbots, contribute to the immersive experience in Metaverse gaming environments.		The current level of immersion in video games that utilise AI to simulate real-life sports interactions and enhance multiplayer components		AI-based approaches, such as reinforced learning in uncertain gaming environments, enhance the immersive experience in interactive gaming environments in Metaverse games.	
Options	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Strongly Agree	36	18.0	74	37.0	32	16.0
Agree	90	45.0	62	31.0	82	41.0
Neutral	48	24.0	48	24.0	60	30.0
Disagree	26	13.0	16	8.0	26	13.0
Total	200	100	200	100	200	100
2. Deep Learning Collaboration	DL-based collaborative virtual environments (CVEs) create an interactive and collaborative platform for various applications in shared virtual environments, 3D multiplayer games, distributed simulation, and collaborative engineering.		The function of DL in Metaverse gaming is categorised into four aspects, including image compression, image processing, picture segmentation and edge detection.		The use of DL improves the software development of games, enhancing the conception and execution of the game, which is vital for creating immersive experiences in online role-playing games and allowing players to interact using their avatars.	
Options	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Strongly Agree	46	23.0	73	36.5	36	18.0
Agree	64	32.0	65	32.5	90	45.0
Neutral	64	32.0	48	24.0	48	24.0
Disagree	26	13.0	14	7.0	26	13.0
Total	200	100	200	100	200	100
3. Increased Human Interaction	Metaverse embedded into AI offers a human interactive gaming platform with virtual identities of players, improving the gaming experience in terms of accessibility, low latency, and immersion.		The AI humanisation of multiplayer games is the basis for attracting several players as they psychologically impacts them when they can shift identities and roles in the virtual world.		An 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.	
Options	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Strongly Agree	80	40.0	74	37.0	36	18.0
Agree	60	30.0	62	31.0	90	45.0
Neutral	46	23.0	48	24.0	48	24.0
Disagree	14	7.0	16	8.0	26	13.0
Total	200	100	200	100	200	100

Correlation Analysis

The association between the independent and dependent variables of the research is known as correlation analysis. The correlations are tested from

the Pearson Correlation Coefficient ‘r’, values between +1 and -1, where the correlation is strong if ‘r’ is 0.7 or greater (Kafle, 2019). It can be noted from Table 4 below that the association between all four independent

Table 4: Correlations

	Immersive Gaming Experience	Deep Learning Collaboration	Increased Human Interaction	Metaverse Gaming
Immersive Gaming Experience	1			
Deep Learning Collaboration	.964**	1		
Increased Human Interaction	.965**	.980**	1	
Metaverse Gaming	.983**	.957**	.979**	1

** Pearson Correlation is significant at $p < 0.05$ (2-tailed); $N=200$

and dependent variables is positive. The values of ‘r’ of variables Immersive Gaming Experience ($r=0.983^{**}$), Deep Learning Collaboration ($r=0.957^{**}$) and Increased Human Interaction ($r=0.979^{**}$) are greater than 0.7 depicting strong correlation with Metaverse gaming.

Regression Analysis

The association between two or more variables of the study, whether dependent or independent, is computed using regression analysis. The p-value or sig. value is measured to identify the significance of

the impact of one variable on another with a threshold value of less than 0.05 (Kafle, 2019). Table 5 depicts the results for all coefficients using regression for the current study. It shows that the p-value for all three independent variables is less than 0.05; Immersive Gaming Experience ($p=0.000$), Deep Learning Collaboration ($p=0.000$) and Increased Human Interaction ($p=0.000$) have a significant impact on Metaverse gaming proving the essential role of AI in Metaverse gaming. These results also confirm the hypothesis H1a, H2a and H3a.

Table 5: Table of Coefficients using regression

	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.017	.016		-1.081	.281
Immersive Gaming Experience	.660	.038	.652	17.459	.000
Deep Learning Collaboration	-.322	.047	-.334	-6.898	.000

a. Dependent Variable: Metaverse Gaming

DISCUSSION

H1a: The Role of AI in Immersive Gaming Experience is Significant in Metaverse Gaming

The current research accepted the hypothesis that AI offers an immersive gaming experience in Metaverse games ($p < 0.05$). Multiple past studies support this finding. AI in Metaverse brings evolution seen in multiple ways, such as a shift towards mixed, augmented, and 3D reality immersive experiences that offer spatial experiences and shared co-presence where users experience a great multi-user sense. However, challenges like fake identities and transactions might make Metaverse gaming crucial for new gamers (Dubey *et al.*, 2023). Notably, user interactions with immersive AI-based metaverse gaming are improved in shaping the form and function of user interactions, enabling human-like intelligence beneficial with the inclusion of ML and DL algorithms in Metaverse (Huynh-The *et al.*, 2023). Another study examined the role of AI and 6G in enhancing the immersive experience of Metaverse using an in-depth survey. It highlighted that online gaming with all the aspects of cyberspace has advanced with these two technologies delivering smooth experiences with high communication speed and processing power (Zawish *et al.*, 2024).

H2a: The Role of AI Using Deep Learning Collaboration is Significant in Metaverse Gaming

The current research accepted the hypothesis that AI with deep learning collaboration advances the Metaverse gaming experience ($p < 0.05$). This finding is supported by previous studies, such as Huynh-The *et al.* (2023), which reported that the role of AI, including DL and ML algorithms and architectures, is the foundation and advancement of Metaverse. Recently, DL consisting of CNN and RNN architectures have emerged, enhancing the complicated patterns of messy-large-confusing datasets leveraging domains like gaming for human-computer interaction (Huynh-The *et al.*, 2023). Nonetheless, the diversification in Metaverse is offered by DL collaboration along with computer vision technologies enhancing the appearance of virtual worlds. These techniques improve image classification, human pose estimation, object detection, facial recognition, semantic segmentations and scene reconstruction (The *et al.*, 2023).

H3a: The Role of AI in Increasing Human Interaction is Significant in Metaverse Gaming

The current research accepted the hypothesis that AI increases human interaction in Metaverse games

($p < 0.05$). Notably, Wang *et al.* (2023) highlighted that AI-based Metaverse is revolutionising the way humans play, work and socialise. A wave of Metaverse upsurge in gaming is supported by AI vision offering support for massive human-computer interaction to enable the advanced development of the applications of Metaverse gaming (Wang *et al.*, 2022). However, another recent study further contributed to the research. It supported this study's findings that Artificial Intelligence of Things (AIoT) is another advanced version of contributing to improving real-time data processing, enhanced decision-making and improved human-machine interaction (Bibri & Jagatheesaperumal, 2023).

CONCLUSION

Metaverse gaming is merged with advanced technologies like AI to integrate the immersive experience for users in 3D, where they can interact with virtual worlds and others. Collaboration is significant for advancing Metaverse gaming and contributes to the technical application of the games. With the considerable success of AI in Metaverse, the role of DL algorithms is also groundbreaking in leveraging game balance in multiplayer games, satisfying play-testers and designers who own valuable features, real-time rendering, and multi-user design collaboration. When merging with AR or VR, AI technologies further develop a more interactive Metaverse gaming platform that is reliable for advancing the human-like experience.

LIMITATIONS AND FUTURE RESEARCH

The current research employed a quantitative method and limited data collection to surveys. However, these empirical research outcomes can be supported in the future by theoretical research conducted using qualitative methods. In addition, AI-based Metaverse gaming faces some challenges of cybersecurity risks and others that can be discussed to broaden the research area. A review of the use of specific AI-based algorithms in Metaverse gaming is also recommended for future research.

RECOMMENDATIONS

Virtual games are complex and dynamism-driven, influenced by factors like players and the environment. Therefore, the type of game needs and environment variation can create challenges. Consequently, it is recommended that AI be integrated into Metaverse games for their application in creating highly interactive and intelligent non-player characters. It makes the application of these techniques critical for maintaining AI-based games in the virtual environment. 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. This approach focuses on developing and integrating intelligent non-player characters, accommodating generic algorithms for additional functionalities, and enhancing the immersive and multidimensional nature of the Metaverse gaming environment.

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