

Review of Innovative Applications of AI and Web3 in Metaverse Social Platforms

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Abstract

This paper reviews the innovative applications of AI and Web3 in metaverse social platforms. It first analyzes the foundational roles of AI (e.g., virtual avatar generation, intelligent interaction, personalized recommendation) and Web3 (e.g., blockchain, NFTs, decentralized identity) in enabling immersive, secure, and user-centric social interactions. It then examines their synergies, with case studies of Decentraland and The Sandbox illustrating practical integrations. The research identifies key challenges, including technical bottlenecks (e.g., AI realism, blockchain scalability), user-related issues (e.g., awareness, privacy concerns), and industry-level hurdles (e.g., regulatory ambiguities, homogenization). Finally, it proposes future directions: advancing AI/Web3 technologies, expanding application scenarios across education and entertainment, and implementing strategic recommendations to foster inclusive and sustainable metaverse social ecosystems.

Keywords

Metaverse Social Platforms; AI; web3.

1. Introduction

The metaverse, an immersive, persistent, and interconnected 3D virtual environment, is reshaping global social interaction through extended reality (XR), AI, and blockchain technologies [1,2]. Unlike traditional social platforms, metaverse social ecosystems allow real-time, avatar-mediated interaction in shared virtual spaces, transcending geographical and cultural barriers.

However, centralized systems face limitations such as data monopolization, privacy risks, and constrained personalization [3]. AI technologies—spanning generative modeling, natural language processing (NLP), and recommendation algorithms—enable more natural and adaptive social experiences. Meanwhile, Web3 technologies—including blockchain, non-fungible tokens (NFTs), and decentralized identity (DID)—offer transparent, secure, and user-controlled infrastructures.

The convergence of AI and Web3 holds potential for metaverse social platforms to achieve immersive, trust-enhanced, and economically sustainable ecosystems. This paper (i) reviews AI and Web3 foundations, (ii) explores their synergies, (iii) examines innovative applications through a case study, (iv) identifies key challenges, and (v) proposes future development directions.

2. Foundational Technologies for Metaverse Social Platforms

2.1. AI Foundations

AI serves as a cornerstone for metaverse social platforms, enabling immersive and personalized interactions through virtual avatar generation (VAG), intelligent interaction technologies (IIT), and personalized recommendation systems (PRS) three core applications.

Virtual avatar generation relies heavily on deep learning, with models like generative adversarial networks (GANs) and diffusion models driving realistic 3D modeling. These algorithms analyze vast datasets of human features, movements, and expressions to create avatars that mimic real-world gestures and micro-expressions. For instance, custom-trained LLMs such as Meta’s Llama2, combined with computer vision techniques, refine avatar details, ensuring they adapt dynamically to social contexts [2, 4]. This technology allows users to have unique, lifelike digital representations that enhance immersion in virtual social spaces [1, 5].

Intelligent interaction technologies facilitate natural communication between users and avatars. Natural language processing (NLP) enables real-time understanding of text and voice inputs, while speech recognition and synthesis systems ensure seamless verbal exchanges. Emotion recognition, powered by AI, analyzes vocal tones, facial cues, and body language to adjust avatar responses—for example, detecting frustration in a user’s voice and modifying the avatar’s tone to be more empathetic [1,5]. These capabilities, supported by edge AI for low-latency processing, make virtual interactions feel as natural as in-person conversations [6].

Personalized recommendation systems leverage user behavior data to curate relevant content. By analyzing interaction histories, preferences, and social networks, AI models predict user needs, suggesting potential contacts, events, or virtual spaces. Deep reinforcement learning, as used in optimizing resource allocation, helps refine these recommendations over time, ensuring they align with evolving user interests [7]. This not only increases user engagement but also fosters meaningful connections within metaverse communities [2,8]. Together, these AI technologies lay the groundwork for intuitive, immersive, and personalized social experiences in the metaverse, addressing key limitations of traditional platforms.

2.2. Web3 Foundations

Web3 is the next generation of the internet, built on blockchain technology (BT). Its core principle is empowering users to truly own their data, digital assets, and identity, enabling more transparent and open online interactions through decentralized protocols. Web3 technologies provide the decentralized backbone for secure, transparent, and user-centric metaverse social interactions, with BT, digital asset right confirmation and transaction technologies, and decentralized identity authentication (DIA) three core pillars supporting its functionality.

Blockchain technology forms the foundational layer, leveraging distributed ledgers and cryptographic algorithms to ensure data integrity and trust. Distributed ledgers replicate transaction records across multiple nodes, eliminating single points of failure and preventing unauthorized data tampering [1,7]. Encryption algorithms, such as hash functions and public-key cryptography, secure data transmission and storage, ensuring that social interactions, content ownership, and transaction histories remain immutable and verifiable [3]. This infrastructure fosters a trusted environment where users can interact without relying on centralized intermediaries, addressing data security risks inherent in traditional platforms [5]. Digital asset right confirmation and transaction technologies, particularly Non-Fungible Tokens (NFTs), enable secure ownership and trade of virtual assets. NFTs, built on blockchain, use unique cryptographic identifiers to authenticate the scarcity and ownership of digital items—such as virtual land, avatars, or custom content—making them irreplaceable and

traceable [2,9]. Smart contracts automate NFT transactions, facilitating peer-to-peer trades without intermediaries, while ensuring that creators receive royalties from secondary sales [8, 10]. This technology empowers users to monetize their creations and securely exchange assets within metaverse social ecosystems [11].

Decentralized identity authentication ensures user identities are unique, secure, and user-controlled. Unlike centralized systems, decentralized identity (DID) frameworks store identity data on distributed nodes or user-owned wallets, with blockchain verifying identity claims [12, 13]. Users retain full control over their personal information, sharing only necessary details for social interactions, which mitigates privacy risks [14, 15]. Cryptographic keys ensure identity uniqueness, preventing impersonation and enhancing trust in virtual social interactions [16]. This technology enables seamless cross-platform identity verification, allowing users to maintain consistent identities across different metaverse social spaces [17]. Together, these Web3 technologies establish a secure, user-centric infrastructure that underpins trust, ownership, and privacy in metaverse social interactions.

2.3. AI - Web3 Synergies

The integration of AI and Web3 significantly enhances the performance and user experience of metaverse social platforms. AI optimizes resource allocation, such as through edge computing [6], reducing latency in avatar interactions and content rendering. Complementing this, Web3's blockchain ensures data integrity and trust in transactions [1, 7]. For example, AI-driven recommendation systems [2, 8] effectively curate social content, while Web3's decentralized ledgers verify content ownership, boosting user confidence. Furthermore, AI-powered emotion recognition [10] makes interactions more natural, and Web3's NFTs securely manage digital assets like avatar skins [9, 11], fostering a vibrant social economy.

Key technical synergies include: decentralized AI training using federated learning [5] (where models are trained on distributed data protected by Web3's encryption), and smart contracts embedded with AI logic [2] to automate social incentives.

However, challenges remain in fully unlocking this synergistic potential. These include: ensuring compatibility between AI's dynamic models and Web3's immutable frameworks [10], balancing Web3's strong data privacy protections with AI's need for large datasets [12, 13], and managing the significant computational demands of integrating both technologies at scale [14]. Addressing these hurdles requires innovative solutions.

3. Innovative Applications

3.1. AI-driven Applications

AI is driving transformative innovations in metaverse social platforms, significantly enhancing immersion, personalization, and interactivity through three key applications: Virtual Avatars, Intelligent Social Assistants, and Customized Social Scenes.

1. **Virtual Avatars:** AI enables unprecedented realism and intelligence. Advanced deep learning frameworks (e.g., GANs, 3D diffusion models [1, 2]) create avatars with lifelike features and textures. Computer vision-powered motion capture ensures avatars mimic users' expressions, gestures, and micro-expressions with minimal latency [4, 10]. Custom models (e.g., Meta's Llama2 [2,4]) further refine avatars, allowing them to adapt dynamically to social contexts—such as leaning in during conversation—fostering deeper emotional connections that approach real-life interactions [1].

2. **Intelligent Social Assistants:** Acting as virtual companions, these AI-powered assistants leverage NLP and sentiment analysis to interpret user inputs (text, voice, avatar gestures) and anticipate needs [8, 12]. They personalize the experience by suggesting relevant contacts, reminding of events, or proposing topics based on user history to mediate lulls [12, 15]. For

instance, analyzing interaction patterns allows them to recommend activities like virtual concerts to enhance engagement [8, 16].

3. Customized Social Scenes: AI dynamically generates and optimizes virtual environments tailored to user needs. Generative models (e.g., GANs, transformers [3, 10]) create diverse spaces—from cafes to concert venues—based on preferences, activity types, and group sizes. These scenes adapt in real-time: a chat space might expand for a party, or lighting/music can adjust based on group mood detected via conversation sentiment analysis [3, 17]. This flexibility ensures social interactions occur in contexts that maximize comfort and engagement [10].

3.2. Web3-driven Applications

Web3 technologies are revolutionizing metaverse social interactions through three key innovations centered on ownership, autonomy, and incentivization: Digital Assets Integration, Decentralized Social Networks, and Smart Contracts.

1. Digital Assets Integration: NFTs redefine social engagement by enabling the creation, trading, and collection of virtual items. Artists and users can mint unique avatars, accessories, or virtual spaces as NFTs, establishing verifiable blockchain ownership [9, 13]. These assets support peer-to-peer trading on decentralized marketplaces, with smart contracts immutably recording transactions to prevent counterfeiting [13, 18]. Collecting rare items (e.g., limited-edition concert tickets) fosters community identity, as users showcase collections in social hubs, sparking conversations and status-based interactions [4, 9]. Enabled by Web3 standards, cross-platform interoperability allows assets to traverse multiple metaverses, enhancing their utility and social value [18].

2. Decentralized Social Networks: These networks empower users with unprecedented data control. Unlike centralized platforms, Web3 distributes user data (profiles, messages, social graphs) across blockchains or peer-to-peer networks, granting individual ownership [11, 19]. Decentralized identifiers (DIDs) enable self-managed identities without third parties, while encrypted communication preserves privacy [6, 19]. Users can seamlessly port social connections between platforms, reducing lock-in and enabling organic community formation [11]. This autonomy builds trust by eliminating intermediaries that exploit personal data [6].

3. Smart Contracts: Automating social incentives, smart contracts drive participation through transparent, programmable rules. These contracts self-execute rewards (tokens, NFTs, reputation) when users meet predefined criteria like posting content or organizing events [8, 16]. For example, frequent contributors might receive governance tokens for input on platform updates [16, 20]. Algorithmic enforcement eliminates bias, ensuring fairness and clearly linking engagement to tangible value [8, 20]. This mechanism cultivates active communities and enables novel social experiments, such as decentralized autonomous organizations (DAOs) for collective decision-making [16].

3.3. Integrated Case: Decentraland and The Sandbox

Two prominent metaverse social platforms—Decentraland and The Sandbox—exemplify how AI and Web3 synergize to redefine social interactions, showcasing tangible applications and outcomes.

Decentraland is a virtual world where users own digital land like NFTs. Create, explore, and trade in a community-driven metaverse—shop, socialize, and play games, all built and governed by its users. It is a blockchain-based virtual world, integrating Web3's decentralized infrastructure with AI to enhance user experiences.

The Sandbox, another key platform, is a pixel-art virtual gaming world where players can freely create games, design items, turn them into NFT assets, earn rewards by playing or trading, and help run the platform.

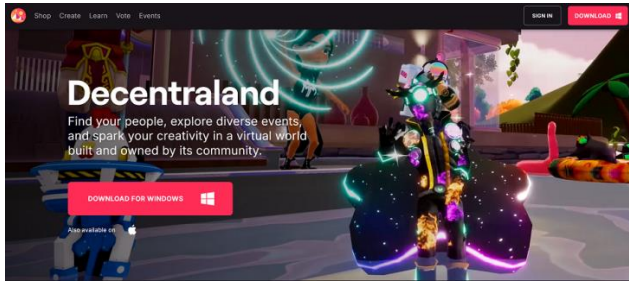


Fig. 1 Decentraland

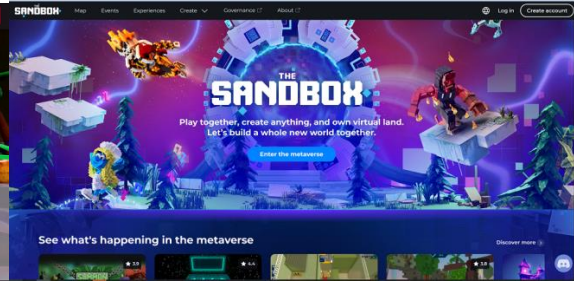


Fig. 2 The Sandbox

To illustrate the practical integration of AI and Web3 in metaverse social platforms, two representative cases—Decentraland and The Sandbox (Fig.1) are examined. While both employ blockchain-based asset ownership and AI-driven personalization, their design philosophies, technical implementations, and economic models differ significantly. The comparison in Table 1 summarizes these distinctions, highlighting how each platform leverages AI–Web3 synergies to serve different user communities and engagement strategies.

Table 1. Comparison of AI-Web3 in Decentraland and Sandbox.

Dimension	Decentraland	The Sandbox
Visual Style & Focus	Realistic 3D virtual world with emphasis on social interaction, events, and community governance	Voxel-art virtual gaming world focused on game creation and interactive play
Web3 Infrastructure	Ethereum - based NFTs for land and assets; decentralized ledger for secure ownership and transparent P2P transactions [6,22]	Ethereum-based NFTs for avatars, items, and land; smart contracts automate royalties [8,12]
AI Features	Personalized recommendations from behavioral analysis (e.g., location visits, interaction patterns) [8,23]; NLP chatbots enable multilingual real - time communication	“VoxEdit” generative model assists in 3D asset design [22]; AI - driven content curation for personalized project and space discovery [23]
Data & Privacy	User-controlled data storage via decentralized storage systems [6,22]	Web3-secured asset ownership; creator rights embedded in blockchain transactions [12,22]
Economic Activity	NFT land transactions > \$100M; 10,000 + monthly events; top creators earning \$5,000 + /month [6]	3M + registered users; \$200M + creator earnings from NFT sales [12,22]
Strengths	Strong social focus, governance by users, and vibrant event economy	Lower barrier for content creation, gamified engagement, and high creator revenue

Decentraland, a blockchain-based virtual world, empowers users to own digital land as NFTs. Web3 underpins its core functionality: virtual land and assets are tokenized as NFTs on Ethereum, facilitating secure ownership, peer-to-peer trading, and transparent transactions [6, 22]. AI enhances user experience through personalized engagement: recommendation systems analyze user behavior (e.g., frequented locations, interactions) to suggest events, venues, or contacts, increasing platform retention [8, 23]. AI-driven chatbots in social hubs employ natural language processing for real-time conversations, while Web3 ensures user data (e.g., chat histories) remains user-controlled via decentralized storage [6, 22]. This fusion has fostered a vibrant ecosystem, evidenced by over 10,000 monthly events and NFT land transactions exceeding \$100 million, demonstrating sustained user and economic activity [6].

The Sandbox, a pixel-art virtual gaming world, enables users to create games, design NFT assets, earn rewards, and participate in platform governance. Web3 secures asset ownership: users mint NFTs for custom avatars, items, and land, with smart contracts automating creator

royalties [8, 12]. AI empowers creation and discovery: the “VoxEdit” tool uses generative models to assist in 3D asset design, lowering barriers for non-technical users [22]. AI also curates personalized discovery feeds based on user-generated content, directing users to relevant social spaces or collaborations [23]. This integration has driven significant adoption, with over 3 million registered users and creator earnings from NFT sales surpassing \$200 million, highlighting how AI’s accessibility combined with Web3’s ownership security boosts participation [12, 22].

These cases illustrate that the fusion of AI and Web3—where AI optimizes usability and personalization, and Web3 ensures trust and ownership—creates resilient, user-driven ecosystems, effectively driving both social engagement and economic activity in metaverse platforms.

4. Challenges and Future Directions

The evolution of metaverse social platforms faces significant hurdles across technical, user, and industry dimensions, yet targeted innovations and strategies present clear pathways forward.

4.1. Technical Dimension

4.1.1. Limitations

Metaverse social platforms face significant technical hurdles in AI, Web3, and their integration. In AI, the key issues are achieving avatar realism and natural interaction while controlling costs. Despite deep learning advances [1, 2], avatars still struggle to reproduce subtle micro-expressions and smooth motion transitions, often resulting in *uncanny valley* effects that reduce immersion. Real-time rendering of high-fidelity avatars requires substantial GPU resources and complex neural networks, driving up operational costs and limiting scalability for smaller platforms [2, 6].

In Web3, blockchain performance and usability are major bottlenecks. While secure, blockchains—especially proof-of-work systems—suffer from slow transaction speeds and high energy consumption, hindering real-time activities such as instant NFT trades [1, 6]. Moreover, the complexity of private key management, wallet operations, and decentralized governance creates steep learning curves for users accustomed to centralized platforms, reducing adoption [2, 11].

AI-Web3 integration adds compatibility challenges. AI’s data-intensive models conflict with Web3’s privacy-focused, immutable frameworks [3], creating tension between data needs and ownership rights. Securing data exchanges between AI services (e.g., recommendation engines) and blockchain infrastructure is critical, as vulnerabilities in either layer could lead to data leaks or fraudulent transactions [2, 8].

4.1.2. Innovations

Overcoming these limitations requires targeted innovation in AI, Web3, and cross-technology integration.

For AI, lightweight GANs and optimized 3D diffusion models will enable real-time, high-fidelity avatar rendering on consumer devices [1, 3]. Training on diverse datasets will capture finer details—such as skin textures and muscle micro-movements—reducing *uncanny valley* effects. Multimodal emotion recognition combining facial, vocal, and physiological cues will enhance empathy in interactions [2, 10], while improved NLP models will better interpret sarcasm and cultural nuances, supporting natural cross-cultural communication [8].

For Web3, scalability solutions such as sharding, layer-2 protocols, and proof-of-stake (PoS) enhancements will cut transaction latency and energy consumption, enabling instant trades

and real-time social engagement [7]. Usability will improve with simplified wallets, intuitive decentralized identity (DID) systems, and guided onboarding processes [2, 11]. Standardized asset interoperability protocols will allow virtual items to transfer seamlessly across platforms, expanding their value [13].

Cross-technology integration will merge AI and Web3 with IoT, 5G/6G, and edge computing to enhance immersion and responsiveness. Ultra-low-latency 5G/6G networks (<10 ms) will support seamless avatar interactions and high-quality 3D streaming [5, 9]. IoT devices, such as smart glasses and haptic gloves, will feed real-world data into the metaverse for precise avatar mirroring [9, 12]. AI-driven edge computing will process data locally, improving privacy and reducing reliance on centralized servers [3, 5]. For example, IoT sensors could synchronize virtual environments with a user's real-world conditions, blurring the boundaries between physical and digital spaces [12].

4.2. User Dimension

4.2.1. Barriers

Metaverse social platforms face three primary user-level challenges: cognitive gaps, privacy concerns, and social balance issues.

First, user awareness and acceptance remain low. Many perceive the metaverse as niche or futuristic rather than a viable tool for daily social interaction [8, 16]. Access complexity—navigating VR headsets, managing digital wallets, and conducting blockchain transactions—can intimidate non-technical users [2, 11]. Even among early adopters, misunderstandings about NFT ownership or decentralized governance persist [16]. This limited awareness is exacerbated by fragmented marketing and inconsistent platform standards, making it difficult for users to identify the core value of metaverse-based social engagement [8].

Second, privacy and data security concerns are significant. Platforms collect sensitive user information, including biometric data (facial expressions, voice patterns), behavioral traces (interaction histories, movement data), and personal preferences [17, 21]. While Web3 tools like blockchain and decentralized identity (DID) offer enhanced security [1, 9], skepticism remains. Users fear breaches, identity theft, and misuse of biometric data for fraud or surveillance, even when encryption is applied [17, 21]. Such distrust discourages personal data sharing, undermining the immersive and personalized interactions central to metaverse social platforms [2].

Third, balancing virtual and real-world interactions is challenging. Immersive experiences risk overuse, with users spending disproportionate time in virtual spaces at the expense of real-world relationships [8, 10]. Research links excessive virtual engagement to reduced face-to-face communication skills and emotional detachment from physical communities [10]. Furthermore, blurred boundaries between virtual and physical identities can cause social dissonance, as users may prioritize virtual achievements (e.g., NFT collections, social status) over real-world responsibilities [8]. Without healthy integration, these imbalances threaten the long-term sustainability of metaverse social ecosystems.

4.2.2. Engagement Strategies

Addressing user-level challenges and fostering sustainable engagement in metaverse social platforms requires a coordinated approach that enhances accessibility, improves experience, safeguards privacy, and promotes balanced participation. These measures must be user-centered, technically robust, and aligned with the vision of inclusive, trustworthy virtual communities.

First, building awareness is essential. Platforms should implement multi-channel educational campaigns—leveraging social media, influencer collaborations, and interactive demonstrations—to convey the practical benefits of metaverse socialization [8, 16]. Clear,

step-by-step onboarding guides can simplify wallet setup, NFT transactions, and avatar customization [2, 11], while community-driven initiatives such as user-generated content challenges and virtual open days can further lower entry barriers [13].

Second, enhancing user experience through usability and inclusivity is critical. Streamlined interfaces, latency reduction via optimized network protocols, and culturally adaptive AI-driven interactions can boost engagement [2, 10]. Personalized recommendation engines can connect users to relevant events, spaces, and contacts [8], while gamified incentives encourage participation and retention [19]. Ensuring cross-platform interoperability allows users to maintain identities and assets across metaverse ecosystems [13].

Third, safeguarding privacy underpins user trust. Core measures include end-to-end encryption, user-controlled decentralized identity (DID) systems, and transparent governance over data usage [1,17]. Advanced tools like zero-knowledge proofs (ZKPs) enable authentication without revealing personal information [9], while decentralized storage solutions (e.g., IPFS) mitigate single-point failure risks [21]. Regular security audits and adherence to emerging data standards further strengthen credibility.

Finally, promoting healthy integration with the physical world is vital for long-term sustainability. Digital wellbeing features—usage reminders, activity dashboards, sensory moderation—and design elements that bridge virtual and real-world interactions help maintain balance [8, 10]. Community guidelines, reinforced through decentralized governance, can institutionalize respectful and healthy engagement practices across diverse cultural contexts.

In summary, overcoming user-related barriers requires a holistic strategy that combines education, seamless design, robust privacy protection, and wellbeing-oriented mechanisms. Aligning technical innovation with human-centered values will enable metaverse social platforms to build accessible, secure, and socially sustainable ecosystems.

4.3. Industry Dimension

4.3.1. Structural Challenges

The metaverse social platform industry faces systemic obstacles that constrain its sustainable growth, notably regulatory ambiguity, market homogenization, and fragile business models.

First, the absence of comprehensive regulatory frameworks and unified industry standards creates substantial uncertainty. As a nascent domain, the metaverse operates largely in a legal grey area, with few jurisdictions offering clear rules on virtual asset ownership, user data protection, or cross-platform interactions [21, 22]. Disparate legal regimes further complicate global operations, while the lack of standardized technical protocols—such as avatar interoperability or NFT trading—fragments the ecosystem and hinders asset or relationship transfer between platforms [2, 11]. These gaps elevate compliance risks for developers and erode user confidence in the sector’s long-term stability [21, 22].

Second, intensified competition has led to severe feature homogenization. Many platforms duplicate core elements—virtual land sales, avatar customization, social hubs—without offering distinctive value propositions [8, 13]. This sameness limits user differentiation, shortens engagement cycles, and increases churn. While pioneers like Decentraland and The Sandbox introduced virtual real estate, newer entrants often replicate their models without innovating in social functions [4, 13], diverting resources toward imitation rather than breakthrough experiences [8].

Third, unclear profit models threaten long-term viability. Heavy reliance on one-off revenue streams—such as NFT launches or virtual land sales—fails to sustain ongoing operations [13, 18]. Scalable income sources like subscriptions, targeted advertising, or transaction fees face user resistance or monetization–accessibility trade-offs [8, 16]. Moreover, the high costs of

maintaining 3D environments, AI systems, and blockchain networks burden especially smaller platforms lacking substantial funding [2, 6]. These financial instabilities raise doubts about the industry's capacity to deliver persistent, evolving social spaces [18].

4.3.2. Strategic Solutions

Overcoming these challenges requires coordinated efforts from platforms, policymakers, and users, with a focus on standardization, innovation, and sustainable economics.

Industry alliances should be established to develop unified technical protocols that guarantee asset interoperability, data security, and effective content moderation [21, 22]. Governments must provide clear and consistent regulatory frameworks that safeguard user rights, reduce legal uncertainty, and encourage responsible innovation [21, 22].

Innovation and differentiation are equally critical. Platforms need to move beyond replicating existing features by investing in unique social functionalities, novel interaction models, and specialized community experiences. A supportive environment for experimentation can stimulate the creation of new engagement formats and value propositions, driving long-term competitiveness.

Financial sustainability demands diversified revenue models. Potential approaches include tiered subscription plans for premium features, creator royalty systems that reward user-generated content, and blockchain-enabled microtransactions to support innovative tokenomics while maintaining accessibility [13, 18]. Additionally, optimizing infrastructure costs through technological efficiency and shared resources can further strengthen operational resilience.

Collectively, these measures can lay the foundation for a more resilient, innovative, and user-centric metaverse ecosystem, capable of sustaining growth while delivering meaningful social value.

5. Future Directions for Innovation in Metaverse Social Platforms

5.1. Directions for Technological Innovation

Advancing metaverse social platforms hinges on targeted innovations in AI, Web3, and cross-technology integration, addressing current limitations while enhancing user experiences.

AI technology will see significant optimization to boost realism and efficiency. More efficient virtual avatar generation algorithms, such as lightweight GAN variants and 3D diffusion models with reduced computational demands, will enable real-time rendering of high-fidelity avatars on consumer devices [1,3]. These models will learn from diverse datasets to capture finer details—like skin textures and subtle muscle movements—reducing the "uncanny valley" effect. Meanwhile, emotion recognition models will become more precise, integrating multimodal data (facial expressions, voice intonations, and even physiological signals) to detect nuanced emotions, allowing avatars to respond with greater empathy [2,10]. For example, improved NLP models will better interpret sarcasm or cultural nuances, making cross-cultural virtual interactions more natural [8].

Web3 technologies will undergo upgrades to enhance performance and accessibility. Blockchain scalability solutions—such as sharding, layer-2 protocols, and proof-of-stake enhancements—will reduce transaction latency and energy consumption, enabling instant NFT trades and real-time social interactions [7]. Efforts to lower technical barriers will include user-friendly wallets with simplified key management, intuitive decentralized identity (DID) interfaces, and guided onboarding processes, making Web3 tools accessible to non-technical users [2,11]. Standardized protocols for asset interoperability will also emerge, allowing virtual items to flow seamlessly across platforms, increasing their utility and social value [13].

Cross-technology integration will deepen, merging AI, Web3 with IoT, 5G/6G, and other emerging technologies to elevate social experiences. 5G/6G networks will provide ultra-low latency (sub-10ms) and high bandwidth, enabling seamless real-time avatar interactions and immersive 3D content streaming [5,9]. IoT devices—such as smart glasses and haptic gloves—will feed real-world data into the metaverse, allowing avatars to mirror physical movements with precision [9,12]. AI-driven edge computing will process this data locally, reducing reliance on centralized servers and enhancing privacy [3,5]. For instance, IoT sensors in a user’s physical environment could adjust a virtual social space’s lighting or temperature to match, blurring the line between physical and virtual interactions [12]. Together, these integrations will create more cohesive, immersive, and responsive metaverse social ecosystems.

5.2. Expansion of Application Scenarios

Metaverse social platforms are poised to expand into diverse domains, such as education, entertainment and business sectors, fostering innovative integrations across industries and enabling new forms of cross-border interaction.

In education, metaverse social tools are transforming collaborative learning. Virtual classrooms, powered by AI avatars and Web3-enabled content ownership, allow students worldwide to interact in immersive environments—conducting virtual lab experiments, role-playing historical events, or collaborating on projects in real time [19,20]. Instructors can mint educational materials as NFTs, ensuring secure distribution and tracking usage, while AI-driven tutors adapt to individual learning styles, enhancing engagement [6,19].

Entertainment and business sectors are also embracing metaverse socialization. Virtual concerts and festivals leverage Web3 for ticket NFTs, enabling secure resale and exclusive backstage access, while AI optimizes crowd dynamics and personalized experiences [9,13]. Business meetings in metaverse spaces—equipped with 3D presentations and real-time translation via NLP—reduce geographical barriers, with smart contracts automating logistics like agenda sharing and attendance tracking [10,16]. Cross-border social and cultural exchanges are redefined through these platforms. Users from different nations can engage in virtual cultural fairs, where AI facilitates real-time language translation and cultural context explanations, while Web3 ensures digital artifacts (e.g., traditional art replicas) are authentically shared as NFTs [8,22]. Such interactions foster global understanding, with decentralized governance allowing communities to co-create cross-cultural events, breaking down traditional communication barriers [6,22]. These expansions position metaverse social platforms as versatile hubs for diverse human activities.

5.3. Strategic Recommendations for Development

Addressing the multifaceted challenges of metaverse social platforms requires targeted strategies spanning technology, user engagement, and industry coordination.

To overcome technical hurdles, increased investment in R&D and strengthened industry-academia-research collaboration are critical. Governments and enterprises should allocate funds to advance AI algorithms—such as optimizing avatar rendering and emotion recognition—and Web3 solutions like scalable blockchains [2,6]. Partnerships between tech firms, universities, and research institutions can accelerate innovation, for example, developing lightweight AI models for low-cost devices or interoperable Web3 protocols [3,11]. Collaborative labs focused on cross-technology integration (e.g., AI-Web3-IoT) can also streamline breakthroughs in immersive social experiences [5,9].

For user-centric challenges, efforts should focus on awareness, experience, and privacy. Platforms need targeted marketing campaigns—via social media and educational content—to demystify metaverse concepts, using simple tutorials to guide users through features like NFT

transactions and avatar customization [8,16]. Enhancing user experience involves simplifying interfaces, reducing latency, and refining AI-driven interactions to feel more natural [2,10]. Crucially, robust privacy frameworks—such as end-to-end encryption for data and user-controlled DID systems—must be prioritized, with transparent policies to build trust [1,17].

To tackle industry issues, stakeholders should collaborate on standards and diversified revenue models. Industry alliances involving developers, policymakers, and users can establish unified protocols for asset interoperability, data security, and content moderation [21,22]. Exploring sustainable profit models is equally vital: platforms could adopt tiered subscriptions (offering premium features), creator royalties for user-generated content, or blockchain-based microtransactions to balance profitability with accessibility [13,18]. Governments can support this by providing regulatory clarity, fostering a stable environment for innovation while protecting user rights [21,22]. These strategies collectively aim to build a more inclusive, secure, and sustainable metaverse social ecosystem.

6. Conclusion

The convergence of AI and Web3 is redefining metaverse social platforms, enabling immersive, personalized, and trust-enhanced virtual interactions. AI contributes realism, contextual intelligence, and adaptive experiences, while Web3 ensures secure ownership, decentralized governance, and transparent transactions. Their synergy fosters sustainable social ecosystems exemplified by platforms such as Decentraland and The Sandbox, which integrate personalized engagement with verifiable digital asset management.

Nevertheless, realizing the full potential of AI-Web3 integration requires addressing persistent challenges—ranging from technical constraints and user adoption barriers to industry-wide regulatory and economic uncertainties. Future development must prioritize interoperable standards, scalable architecture, privacy-preserving intelligence, and inclusive design principles to ensure accessibility, trust, and long-term viability. By aligning technological innovation with human-centric values, metaverse social platforms can evolve into resilient, equitable, and socially meaningful digital environments.

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