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AI and the Metaverse: Procedural Level Generation for Enhanced Immersive User Experiences

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Abstract

This paper explores how AI-driven Procedural Content Generation (PCG) enhances user experience in games and metaverse environments. PCG plays a critical role in automatically generating large-scale content, offering personalized experiences, and reducing development time and costs. The study analyzes various examples of AI and PCG applications to show how dynamic environments increase user immersion. Additionally, the paper presents systems that leverage AI techniques, such as reinforcement learning, to adjust user experience and dynamically balance game difficulty in real-time.

Keywords : AI, Metaverse, Procedural Content Generation (PCG), User Experience, Reinforcement Learning (RL)

AI and the Metaverse: Procedural Level Generation for Enhanced Immersive User Experiences

1. Introduction

1.1 Research Background

The metaverse has evolved into a digital space combining Virtual Reality(VR) and Augmented Reality(AR) technologies, offering users real-time interaction and immersive experiences. Procedural Content Generation(PCG) plays a key role in providing continuous new content to users in these environments, as manually creating content is inefficient. PCG automates large-scale content creation, reducing development time and cost while maintaining dynamic user experiences(Park & Oh, 2020) Games like Minecraft and No Man's Sky exemplify PCG's potential, generating new terrains and planets procedurally, offering unique experiences each time users explore(Pedersen, 2012). The integration of AI and PCG is becoming increasingly crucial for personalized user experiences in the metaverse. AI-driven systems, such as AltspaceVR and Super Mario Bros., have demonstrated the power of adapting environments and gameplay by learning from user behavior and adjusting difficulty in real-time(Ebner, 2013).

1.2 Research Purpose and Significance

This study aims to explore how AI-based procedural level generation enhances user experiences in the metaverse, proposing strategies for creating more immersive and efficient environments. The research examines how AI and procedural generation technologies are applied in game design and metaverse settings to offer personalized experiences while reducing development costs and time(Park & Oh, 2020).

2. Literature Review Methodology

2.1 Overview of Literature Review

This section synthesizes previous research on AI and Procedural Content Generation(PCG) and deeply explores how these technologies impact user experiences in the metaverse. PCG is a technique that automatically generates large-scale content based on predefined rules, significantly reducing development time and costs in games and metaverse environments compared to manual content creation (Rupp et al., 2024). The key aspect of PCG is its ability to maintain fresh user experiences by providing dynamically changing environments. When combined with AI, it can generate personalized content tailored to player behavior(Bontrager & Togelius, 2021). This study aims to propose methodologies that enhance player immersion while maximizing efficiency in the game development process by integrating PCG with AI(Ebner, 2013).

This study systematically collected relevant research papers from major academic databases such as Google Scholar, IEEE Xplore, SpringerLink, and ACM Digital Library. Keywords such as "Procedural Content Generation(PCG)", "AI-based level generation", "Reinforcement Learning in games", and "Dynamic environments in the Metaverse" were used, focusing on studies published in the last ten years. The selected papers focus on dynamic level generation using AI-based reinforcement learning, pattern recognition via machine learning, and the integration of PCG with AI technologies (Baek et al., 2021). The collected papers were analyzed based on the following criteria:

- Scope of Application: Evaluating the dynamic implementation of AI and PCG technologies in games and metaverse environments, and their impact on user experience(Risi, 2017).

- Methodology: Comparative analysis of the implementation methods and performance of reinforcement learning, machine learning, and procedural generation algorithms used in each study(Nam et al., 2024).
- Results and Limitations: Identifying the strengths and limitations of the technologies presented and evaluating their applicability to metaverse environments(Bontrager & Togelius, 2021).

Through this, the study provides an in-depth analysis of dynamic level generation using reinforcement learning and how pattern recognition algorithms link automatically generated content to player immersion(Nam et al., 2024). Additionally, the study examines how AI-based content generation helps reduce game development time and costs(Pedersen, 2012).

3. Theoretical Background

3.1 The Concept and Evolution of the Metaverse

The metaverse has evolved into a digital space where users can experience immersive interactions, driven by advancements in virtual reality(VR) and augmented reality(AR) technologies. In this environment, users experience interactions similar to the real world, with AI and procedural content generation(PCG) technologies combining to offer more personalized experiences (Bontrager & Togelius, 2021). These technologies analyze user interactions in real time and dynamically adjust content to enhance immersion(Risi, 2017).

A prime example of this is the global metaverse platform Roblox, which successfully applies AI and PCG technologies (Pedersen, 2012). Roblox allows users worldwide to create and explore various games and environments within a virtual space, largely centered on user-generated content(UGC). Using tools like Roblox Studio, users

can design their own games or levels, adjusting complexity through PCG and AI-based tools (Xia et al., 2020). For example, Roblox employs AI-based recommendation systems to automatically suggest games or experiences based on user preferences, delivering personalized experiences tailored to individual activity(Drageset et al., 2019).

These systems effectively strengthen real-time interaction and user personalization within the metaverse, significantly boosting user immersion and engagement(Xia et al., 2020). This illustrates how metaverse platforms use AI and PCG technologies to provide personalized experiences while maintaining ever-changing, dynamic environments(Nam et al., 2024).

3.2 Principles of Procedural Content Generation

Procedural Content Generation(PCG) is a technology that uses computer algorithms to automatically generate content, primarily applied in games and virtual spaces to create various elements dynamically(Bontrager & Togelius, 2021). The core of this technology is its ability to generate game levels, terrain, characters, and items based on predefined rules and algorithms, without requiring designers or developers to create everything manually(Bontrager & Togelius, 2021). This approach is seen as an efficient method to drastically reduce the time and cost of large-scale content production (Rupp et al., 2024).

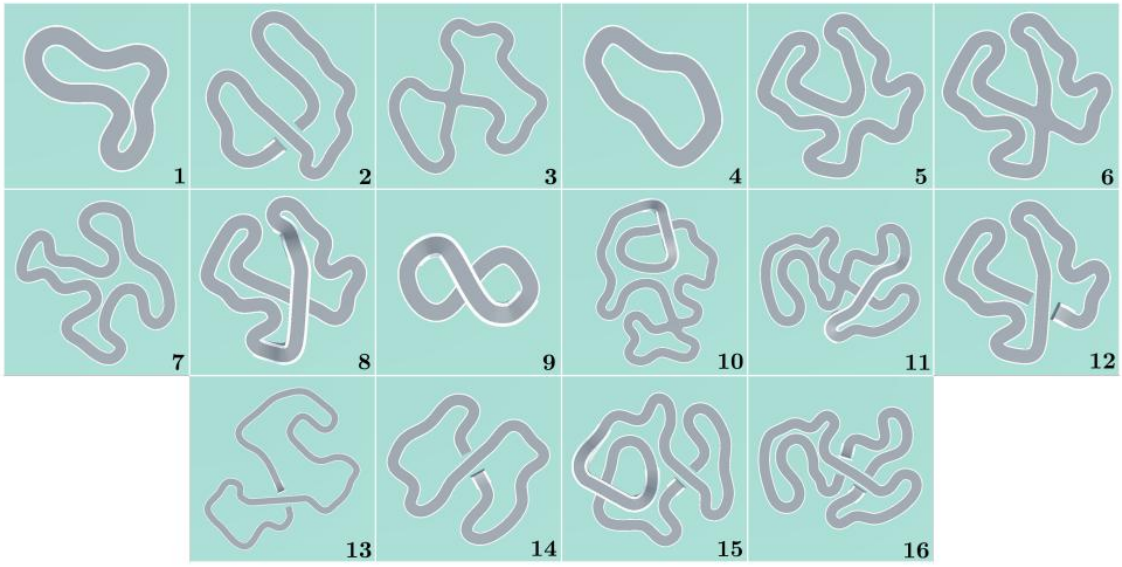
PCG has become an essential technology, particularly in large-scale and dynamic environments like the metaverse(Pedersen, 2012). To keep user experiences fresh and unique, content must continually evolve and update dynamically. Thus, PCG enables metaverse environments to maintain content diversity while reducing repetition and providing users with continually novel experiences and varied challenges(Risi, 2017).

Figure 1 shows racing tracks generated according to difficulty, arranged in order of increasing complexity. Each track is scaled to the same width for readability. As

difficulty increases, the tracks become more intricate. Easier tracks have more straight sections and less complex corners, while harder tracks feature sharper, winding curves, demanding more precise control from the player. Although the tracks are scaled to the same width, the sharpness and complexity of the curves vary based on difficulty. These tracks, generated by AI, illustrate how procedural generation provides players with varying challenges(Bontrager & Togelius, 2021).

Procedural generation's scalability and randomness are essential elements(Bontrager & Togelius, 2021). Content follows predetermined rules, but algorithms combine various elements or introduce randomness, producing different outcomes even with the same algorithm(Risi, 2017). For instance, in Minecraft, new terrains are generated each time players explore, ensuring fresh experiences(Pedersen, 2012). This is particularly effective in the metaverse, where it prevents users from encountering repetitive content(Xia et al., 2020).

Figure 1. *Tracks Generated and Ordered by Increasing Difficulty*



Note. Generated tracks ordered by increasing difficulty Tracks scaled for representation purposes—all of them have the same width. Not all tracks are optimized for isometry.

Moreover, the combination of PCG and AI enables more advanced content creation in the metaverse. AI analyzes user behavior in real-time and generates personalized content(Nam et al., 2024). For example, in Super Mario Bros., AI learns player gameplay patterns and dynamically adjusts the difficulty and levels to provide appropriate challenges(Ebner, 2013). PCG is thus a key technology for dynamically offering diverse content in the metaverse, reducing the burden of content creation and providing personalized experiences for large-scale user bases(Bontrager & Togelius, 2021).

3.3 AI-Based Procedural Level Generation

Through reinforcement learning, AI learns user behavior patterns and optimizes level design by dynamically adjusting the environment in real-time. This is crucial for delivering personalized experiences in the metaverse. Reinforcement learning studies user interactions and adapts the environment to provide more immersive and challenging experiences(Nam et al., 2024).

A notable example is AI-based level generation in Super Mario Bros.. The study shows how reinforcement learning algorithms allow AI to analyze player actions in real-time and dynamically adjust the difficulty of levels. For instance, as players improve, AI generates more challenging levels, and if players struggle, the difficulty is lowered to ensure smoother gameplay(Ebner, 2013). This AI-based level generation system is also highly useful in the metaverse. Since metaverse users have diverse experiences and needs, AI continuously learns from real-time data to deliver personalized content and environments(Nam et al., 2024).

In level generation, this process works as follows:

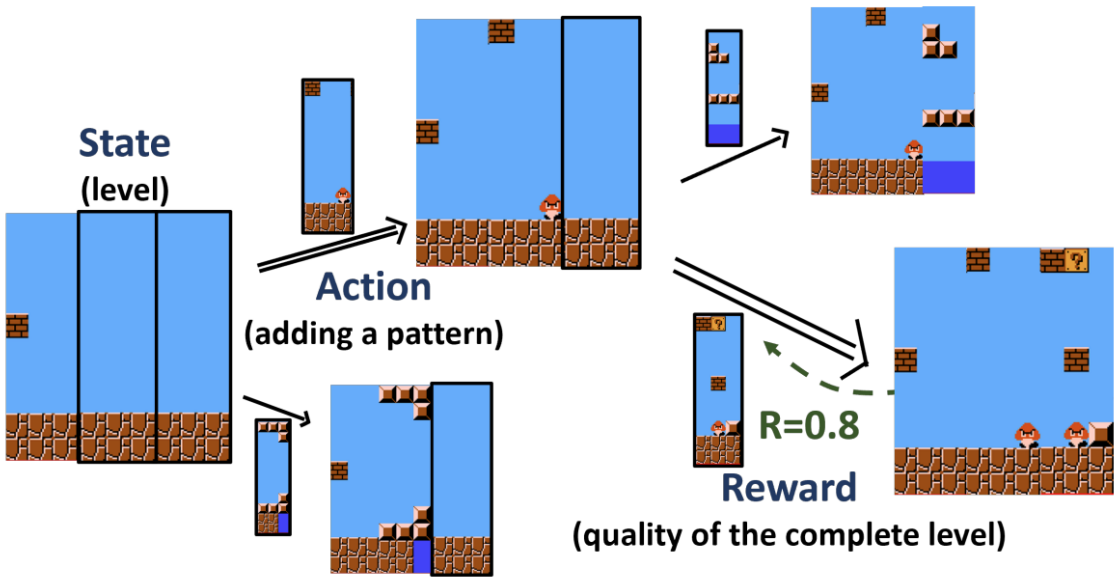
- Current State: The current part of the game level (e.g., tile arrangement or

player position) is defined as the 'state.'

- Action: The AI decides which element to generate next, such as adding bricks, placing enemies, or creating gaps.
- Reward: The AI receives feedback (positive or negative) based on how well the generated content matches the desired difficulty or pattern. Positive rewards are given for balanced and engaging content, while negative rewards are given for overly difficult or repetitive patterns.
- Next State: After the action, a new element is added to the level, resulting in a new state. This process is repeated to gradually complete the level.

The figure visually demonstrates how AI iterates through this state-action-reward-next state loop to dynamically build levels. By utilizing MDP, AI can adaptively create

Figure 2. *Illustrations of MDP for generating levels*



Note. Figure 2 illustrates the process of generating levels using a Markov Decision Process(MDP). MDP is a fundamental principle in AI decision-making, where actions are taken based on the current state, and rewards guide the transition to the next state.

levels that offer the right level of difficulty and challenge for players. This method is particularly useful in reinforcement learning-based level generation and plays a critical role in generating optimal levels in dynamically changing game environments. This AI-driven procedural level generation technology helps players continuously experience new challenges and environments in the metaverse, creating dynamic environments that respond to individual user behavior patterns in real-time(Nam et al., 2024).

3.4 User Experience Theory

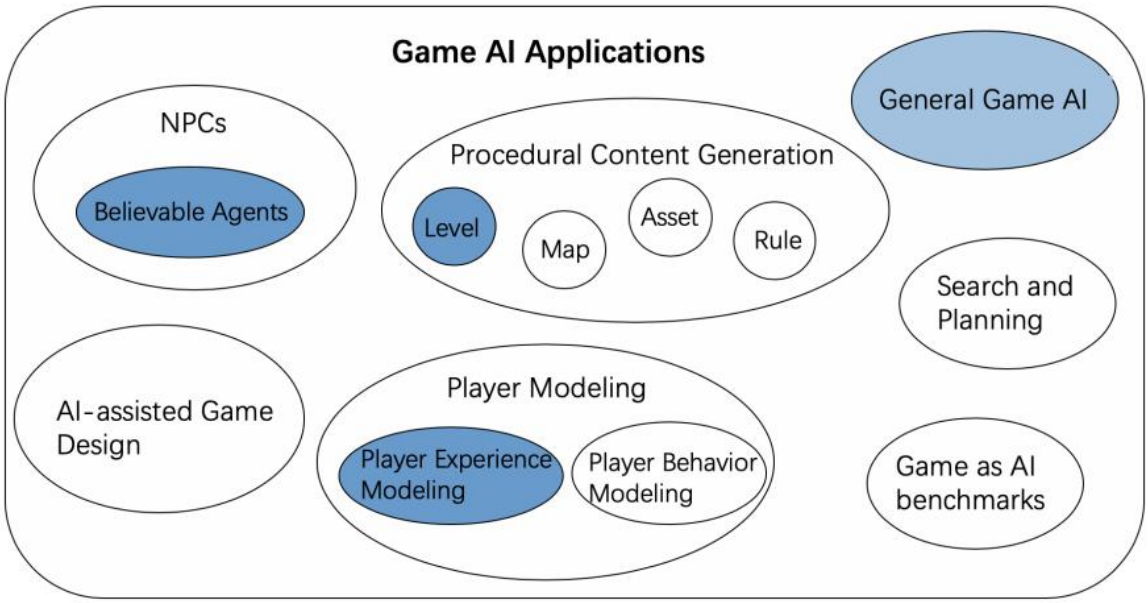
Immersive experiences are a key factor in ensuring users fully engage with virtual worlds in the metaverse. One of the essential technologies that maximizes immersion is AI(Risi, 2017). AI analyzes and learns from user behavior data in real time, allowing it to tailor the environment to each user's needs and behavior patterns, thereby enhancing immersion(Nam et al., 2024).

A prominent example is Roblox, a user-generated content(UGC) platform where players create and interact within the metaverse(Pedersen, 2012). AI is employed to recommend personalized content and games to users by analyzing their behavior patterns, suggesting suitable experiences in real time(Xia et al., 2020). This AI-driven recommendation system plays a critical role in maintaining user engagement by learning their preferences and offering content tailored to their next gameplay session(Drageset et al., 2019).

Moreover, AI is also used to adjust game difficulty in Roblox. By analyzing users' behavior and performance, AI fine-tunes the challenge level to maintain an optimal balance between difficulty and enjoyment, preventing frustration while keeping users engaged for extended periods(Xia et al., 2020). This dynamic difficulty adjustment is crucial for sustaining immersion over time in the metaverse(Drageset et al., 2019).

Thus, AI-driven personalized environments are a key factor in maximizing user immersion on metaverse platforms. By reflecting real-time user behavior data, AI can provide optimized content and interactions tailored to individual users, further enhancing the immersive experience(Drageset et al., 2019).

Figure 3. *Game AI Applications*



Note. Figure 3 Game AI Applications how AI is applied in games to enhance user experiences and immersion. NPCs(Non-Player Characters): AI controls characters that interact with players, making them act more realistically by predicting and responding to player actions. Procedural Level Generation(PLG): AI dynamically generates new game levels, offering players novel challenges, such as in Minecraft. Player Modeling: AI analyzes player behavior to personalize the gaming experience, including adjusting difficulty based on playstyle. AI-Assisted Game Design: AI helps designers create game structures and character behaviors automatically, simplifying the design process. Using Games as AI Benchmarks: Games serve as environments to test and improve AI, such as AlphaGo's success in Go, demonstrating AI's capabilities in solving complex problems

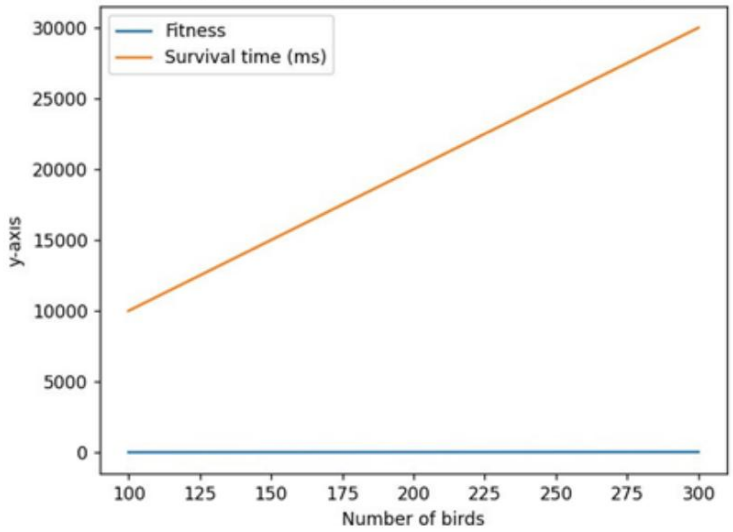
4. Impact of AI-Based Procedural Level Generation on User Experience

4.1 Relationship Between AI and Immersive Experiences

AI processes and analyzes data in real time to generate content, enabling personalized experiences. In dynamic environments like the metaverse, users come from various backgrounds with different abilities, making it difficult to maintain engagement with static content. AI addresses this issue by analyzing real-time data to offer optimized content and interactions for each user(Nam et al., 2024)

A study based on Flappy Bird applied reinforcement learning to propose a method where AI generates levels that match the player's skill level(Amato, 2019). The AI dynamically adjusts the difficulty, frequency, and placement of obstacles based on the player's real-time performance. As the player improves, the AI increases the level's challenge, and if the player struggles, the AI lowers the difficulty to keep the game

Figure 4. *Fitness and Survival time Vs Number of Birds*



Note. Figure 4 shows a graph illustrating the relationship between fitness and survival time versus the number of birds in an AI-generated map.

engaging. This approach helps players feel appropriately challenged, maintaining immersion throughout the game(Amato, 2019).

As the number of birds increases, it indicates more player attempts, and the AI adjusts the map accordingly. Both the fitness value (AI's performance) and the player's survival time (how long they survive) increase together. This demonstrates that as the player continues playing, the AI generates more difficult or easier maps based on the player's skill level, offering maps that improve player survival while the AI refines the map through feedback.

This approach is applicable to the metaverse, where fixed content may not suit all users due to varying backgrounds and abilities. AI-based content generation provides personalized experiences, analyzing user preferences and interaction patterns in real time to create tailored environments or content. Personalized experiences enhance user immersion and foster continuous interaction in the metaverse(Pedersen, 2012).

Moreover, AI not only generates environments in the metaverse but also learns and predicts user behavior to customize interactions. For example, in platforms like Roblox, AI analyzes user data to recommend personalized content and offer experiences similar to preferred activities(Xia et al., 2020) This mechanism deepens user engagement, making AI a crucial tool for providing unique and meaningful experiences in the metaverse(Pedersen, 2012).

4.2 Benefits of Procedural Level Generation

4.2.1 Advantages for Developers

Procedural Content Generation(PCG) offers many benefits to game developers. The primary advantage is that it significantly reduces repetitive content creation

tasks(Park & Oh, 2020). Traditional content creation requires designers to manually craft levels, terrains, and characters, which is time-consuming and resource-intensive(Flimmel et al., 2019). However, using PCG, content can be generated automatically based on predefined algorithms and rules, allowing for the efficient creation of large-scale content (Park & Oh, 2020). In games like Minecraft or No Man's Sky, for instance, the terrain or planets are procedurally generated, removing the need for developers to design every element beforehand(Pedersen, 2012).

This automation greatly reduces both time and costs associated with game development(Park & Oh, 2020). It also enables smaller development teams or indie developers to work faster and more efficiently(Bontrager & Togelius, 2021). Furthermore, PCG ensures content variety, preventing players from encountering repetitive or dull content, which keeps them engaged. This allows developers to maintain game quality while using resources more effectively(Pedersen, 2012).

4.2.2 Advantages for Users

The primary benefit of procedural generation for users is that it offers a constantly evolving environment(Pedersen, 2012). Players can quickly become bored when they encounter the same content repeatedly(Bontrager & Togelius, 2021). PCG ensures that new and unique content is generated each time players explore or interact with the game. For example, in Rogue-like games, procedurally generated levels or dungeons are always different, providing players with a fresh challenge every time they restart the game(Pedersen, 2012).

PCG also opens up the possibility for personalized content for users(Nam et al., 2024). By combining AI with procedural generation, content can be generated in real-

time based on a player's behavior patterns or preferences (Risi, 2017). This allows players to continuously experience challenges and interactions that match their abilities or playstyle(Nam et al., 2024), helping to maintain immersion and satisfaction by reducing repetitiveness and offering new challenges(Bontrager & Togelius, 2021).

In conclusion, procedural generation is a powerful tool that provides developers with efficiency, cost savings, and content diversity, while offering users unique and personalized experiences that enhance their engagement and immersion in games(Bontrager & Togelius, 2021).

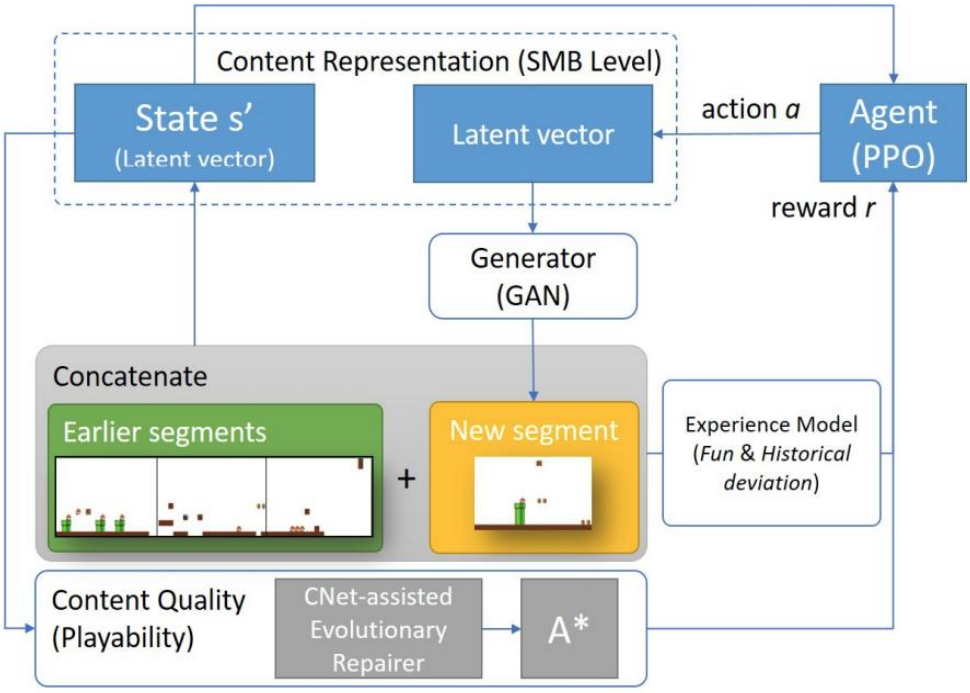
4.3 User Experience Enhancement Case Studies

Procedural generation has played a key role in enhancing user experiences in various games, and these technical applications can also be adapted to metaverse environments.

4.3.1 Dynamic Level Generation in Super Mario Bros.

In the Super Mario Bros. study, AI, based on reinforcement learning, learns a player's playstyle and skill level in real time, dynamically generating levels(Ebner, 2013). The AI analyzes player success, movement patterns, and jump frequency to automatically generate levels that match the player's skill, providing challenges that avoid being too easy or too difficult(Ebner, 2013). This prevents boredom or frustration by constantly adjusting the challenge to the player's ability, ensuring an appropriate level of difficulty at all times(Ebner, 2013).

Figure 5. *Implementing EDRL on Super Mario Bros: the MarioPuzzle framework.*



Note. Implementing EDRL in Super Mario Bros.: Mario Puzzle Framework Image describes a system that automatically generates levels of Super Mario Bros. by applying reinforcement learning (EDRL). The system is largely divided into three main components. (1) Generator and Repair: It automatically creates each section of the level, finds and fixes the wrong tile(e.g., the wrong pipe). The level generated through this becomes playable without problems. (2) AI Player: The AI tests that level to see if the section of the generated level is actually playable. The level is considered to have been generated normally only when the AI player successfully passes the section. (3) Reinforcement Learning Agent (RL Designer): The reinforcement learning agent that designs a level selects the next interval to be created based on the previously generated level interval and repeats it to continue creating new levels. In this process, the level is optimized based on the reward function.

The system can automatically generate infinitely playable levels, with a focus on maximizing fun elements and player experiences.

This method is very effective in maximizing the player's immersion. According to the Flow Theory, in order for humans to fall into an immersion state, the task should not be too easy, and at the same time, it should not be too difficult. In other words, the player's ability and the difficulty of the task must be properly balanced. Reinforcement learning-based dynamic level generation in Super Mario Bros. is a way that perfectly fits this theory, and AI maintains the flow state by grasping the player's level in real time and maintaining the level of difficulty accordingly(Baek et al., 2021).

Maximizing immersion and procedural creation such procedural creation based on reinforcement learning provides important implications for the metaverse as well. Since each user has different experiences and abilities even within the metaverse, providing the same content to all users may hinder immersion. Instead, combining AI and procedural creation, the metaverse can analyze each user's interaction data in real time to provide content and challenges that fit their abilities. For example, when a user explores a new area or performs a mission within the metaverse, the AI can identify the user's behavior pattern and create a new environment or mission that suits that user(Drageset et al., 2019).

Games like No Man's Sky leverage procedural creation technology to provide infinitely changing planets and environments. In the game, the player interacts with a different environment each time, which is an important factor that allows the player to immerse themselves in the game for a long time. In this way, it is possible for the metaverse to offer new experiences to keep users interested while continuing to experience different environments(Flimmel et al., 2019).

Real-world applications of immersion maximization, as well as in games like Candy Crush, AI analyzes players' play patterns and adjusts the level of difficulty and components in real time so that they do not feel bored. These procedural creation techniques allow players to maintain an appropriate level of challenge so that they do not clear the game too easily or get too frustrated, and players can continue to immerse themselves in the game(Summerville & Mateas, 2016).

Based on these examples, even in the metaverse, the combination of procedural generation technology and AI can play an important role in improving the user experience and maximizing immersion. AI enables users to constantly have new and challenging experiences by learning user interactions and changing the environment and content in real time accordingly. This is a key technology that helps users immerse themselves in the metaverse for a long time.

5. Consideration

AI-based procedural generation technology is effectively applied in various game and metaverse environments, but limitations may exist under certain conditions, which may negatively affect the user experience. Through these problems, I would like to present implications for future research and technological development directions.

5.1 Limitations of AI-based procedural level generation

AI-based procedural content generation technology is an important tool that can provide customized experiences to various users in large-scale dynamic environments such as the metaverse. However, one of the limitations that appears in games such as Candy Crush Saga is that it does not properly capture global patterns. AI tends to create individual content mainly by focusing on local patterns, which can cause difficulties in

maintaining the consistency or balance of overall content(Risi, 2017).

In addition, AI technologies such as Reinforcement Learning dynamically generate content based on the user's real-time data, but in complex environments, this technology may not be sufficiently sophisticated. For example, if the behavior patterns of a particular user group are too complex or unpredictable, AI may fail to provide the appropriate content, which implies the possibility that the user will not be able to provide the desired experience. These limitations show that AI-based content generation technologies have not yet been fully implemented. Therefore, future studies require the advancement of deep learning or reinforcement learning algorithms that may better recognize and reflect complex patterns(Risi, 2017).

5.2 Problems in terms of user experience

Although procedural generation techniques are very useful in providing diversity of content, on the other hand, unpredictable characteristics can negatively affect the user experience. When content is randomly generated, some users experience content that they do not expect, which can act as a factor that can hinder immersion. In particular, when users cannot predict their preferred environment or experience, this can cause confusion and worsen the user experience(Amato, 2019).

For example, when a new terrain or environment that a user explores in a game such as Minecraft is generated completely randomly, this randomness provides a fresh experience for some users, while providing an experience that lacks consistency for others, which can lead to less immersion. Even in a metaverse environment, when a user is faced with unpredictable content, users may feel confused when unexpected results are repeated. These problems demonstrate the need for more sophisticated algorithms

in user-customized content generation, and user behavior prediction models need to be strengthened to balance between randomness and consistency(Drageset et al., 2019).

In conclusion, AI-based procedural generation technology has great potential in personalizing the user experience in metaverse and game environments, but there are problems in terms of technology limitations and user experience. Future research should focus on technical improvements and better algorithm development to solve these problems.

5.3 Future Research Direction

AI and procedural content generation(PCG) technology covered in this study have shown great potential in providing customized experiences in metaverse and game environments, but there are also limitations of technology. Therefore, future research should overcome these limitations and seek various ways to develop a more sophisticated and adaptive AI system. To this end, we would like to present the common implications of related papers and future technological development directions in detail.

5.3.1 Advanced Content Generation System Combining Reinforcement Learning and Machine Learning

Current reinforcement learning algorithms mainly focus on local patterns, which are suitable for customized level generation based on players' real-time data (Summerville & Mateas, 2016), but there is a limit to recognizing global patterns in the overall context. Therefore, future research should focus on developing a system that can combine reinforcement learning and machine learning(ML) to learn local and global patterns simultaneously (Nam et al., 2024). For example, Super Mario Bros. needs a system that analyzes and reflects overall patterns of the game through deep learning while also generating levels in real time through reinforcement learning as shown in the

study(Ebner, 2013). This will be a way to provide an experience suitable for individual users while maintaining the consistency of the overall content .

5.3.2 Advances in User Behavior Prediction Models

Another research direction to overcome the limitations of AI-based procedural generation is the advancement of user behavior prediction models(Xia et al., 2020). Current AI systems mainly generate content based on real-time data, but advances in prediction models should enable more accurate analysis and prediction of long-term behavior patterns of users(Risi, 2017). On metaverse platforms such as Roblox, AI provides customized content by analyzing user's past activity data, but if these prediction models are further advanced, AI will be able to predict even content or interaction patterns that users will prefer in the future, providing a more detailed customized experience(Pedersen, 2012). This requires the development of deep learning algorithms that can handle complex interactions with larger datasets(Risi, 2017).

5.3.3 Adaptive AI System in the Metaverse

The metaverse is a very dynamic environment, a virtual space where a large number of users interact at the same time(Pedersen, 2012). In order for AI to have the ability to adapt in such a complex environment, an adaptive AI system is needed (Baek et al., 2021). Such a system should be able to analyze the user's various interactions in real time, and create or change content immediately accordingly(Risi, 2017). As shown in games such as No Man's Sky, procedural generation technology can infinitely change the environment in which users explore, but research is needed to develop this so that AI can analyze it more deeply and provide appropriate responses that are appropriate for the situation(Baek et al., 2021). A system that combines reinforcement learning and adaptive AI

should be designed to handle complex interaction patterns, thereby providing a more personalized immersive experience within the metaverse(Nam et al., 2024).

5.3.4 Collaborative Development of AI and PCG

AI and procedural content generation(PCG) technology are complementary to each other(Pedersen, 2012). AI plays a role in providing appropriate content by analyzing user's data in real time, and PCG plays a role in dynamically generating content based on that data(Nam et al., 2024). As shown in the Petalz study, PCG is very effective in generating customized content, especially in dynamic environments (Risi et al., 2016). Future research needs to focus on the collaborative development of these two technologies, allowing AI to control the overall content generation process and provide content in a predictable manner beyond the role of simply analyzing and commanding data(Pedersen, 2012).

5.3.5 User feedback based reinforcement system

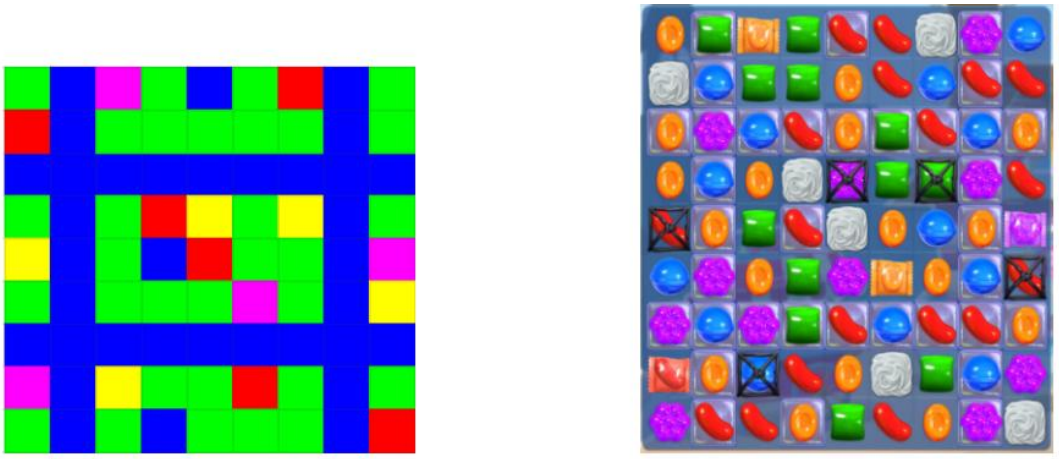
Finally, active integration of user feedback systems into AI and procedural generation technologies will be an important direction for future research(Summerville & Mateas, 2016). Once an AI system is established that can reflect user feedback in real time, content can be adjusted in real time based on user preference or satisfaction(Summerville & Mateas, 2016). This will greatly help increase the accuracy of user-customized content generation(Xia et al., 2020). In games such as Candy Crush, AI-based difficulty adjustments are already playing an important role in improving player experience, but the addition of improvements through the feedback system will provide more sophisticated customized experiences(Summerville & Mateas, 2016).

This difference is related to improvement through the feedback system. The feedback system can evaluate how users perceive patterns, and based on this, it is possible

to improve the game design or content generation method. The results of recognizing colors and game tiles differently show that visual elements in the game have a significant influence on the user experience, and that AI needs to reflect and adjust feedback to provide a more intuitive pattern when generating game tiles. Therefore, it is an example of the possibility of providing a clearer visual pattern through user feedback in the AI-based procedural generation system and improving it so that users can easily recognize patterns.

In conclusion, future research should focus on the combination of reinforcement learning and machine learning, the development of user behavior prediction models, the development of adaptive AI systems, the collaborative development of AI and PCG, and the integration of user feedback-based systems(Risi, 2017). This will enable more personalized and sophisticated user experiences within the metaverse and game(Nam et al., 2024).

Figure 6. *Validation example from the questionnaire*



(a) Abstract Representation (b) Visualisation in survey

Note.The figure in Fig. 6 is an example explaining the experimental results on how to perceive patterns visually. (a) certain patterns when seen in color look very clear, while (b) patterns become less clear when seen in game tiles.

6. Conclusion

In this study, it was discussed that AI-based procedural level creation plays an important role in providing a customized experience in the metaverse and game environment. The combination of procedural content generation(PCG) technology and AI is positioned as a key tool that can efficiently generate large-scale content and provide an optimized experience to each user(Bontrager & Togelius, 2021). Through this, not only time and cost can be reduced in the game development process, but also the degree of immersion can be maximized by continuously providing dynamic content to users (Nam et al., 2024).

Specifically, the AI system applying reinforcement learning provides a personalized experience by analyzing the user's real-time data and dynamically adjusting the level difficulty or environment accordingly(Ebner, 2013). This technology contributes to realizing the maximization of immersion by providing new content every time so that users are not bored (Nam et al., 2024). In addition, it provides developers with various possibilities to increase development efficiency and improve the user experience by reducing repetitive tasks through content automation(Xia et al., 2020).

However, as pointed out in the study, AI-based procedural generation still has limitations in capturing global patterns, and there is a problem that it may not be sufficiently sophisticated in complex environments(Risi, 2017). Randomness that occurs when a user's behavior pattern is unpredictable can also be a factor that hinders immersion(Pedersen, 2012). Therefore, future research will have to overcome these limitations by focusing on the combination of reinforcement learning and machine learning, the advancement of user behavior prediction models, and the development of

adaptive AI systems(Risi, 2017).

Furthermore, empirical experiments and studies on how effectively these technologies can be applied in practically metaverse environments are also needed(Xia et al., 2020). Since most of the current research relies on theoretical models or simulations, experiments with real-world users should verify the specific impact of AI and procedural generation technologies on user experience(Risi, 2017). For example, additional studies should be conducted to measure how AI-based content generation brings about changes in user immersion, satisfaction, and repetitive play intention (Nam et al., 2024). Through these empirical studies, it is important to obtain specific feedback on how AI and procedural generation technologies can be optimized and applied in real-world environments(Xia et al., 2020).

In conclusion, AI and procedural generation technologies are important technological innovations that can significantly improve the user experience in the metaverse and game environment, which should increase user immersion and maximize the efficiency of the development process(Bontrager & Togelius, 2021). At the same time, efforts to close the gap between theoretical models and practical applications are needed through empirical research supporting this(Nam et al., 2024).

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