

The Application of Artificial Intelligence in Game

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Abstract. AI has been extensively applied in various aspects of game development over the past few decades. One critical application is the use of AI algorithms to simulate intelligent decision-making processes for non-player character behavior. Another application is procedural content generation, where AI algorithms generate game content such as level designs or missions to enhance gameplay diversity. This paper aims to explore the application of AI in game development by analyzing specific cases and discussing the current state of the field. The paper also focuses on related topics such as motion and physics simulation, as well as dynamic adaptation. The current state of using AI to enhance realistic motion and physics simulation in game development is further examined. In summary, this paper provides a comprehensive overview of the application of AI in game development, highlighting its significance. The paper concludes with a summary and future outlook of the entire study.

Keywords: Application; game; AI.

1. Introduction

In today's rapidly advancing modern society, various computer technologies have permeated every aspect of our daily lives. Big data provides us with the latest information that interests us, and the Internet of Things allows us to access what we need without leaving our homes. In this era where technology serves human needs, "artificial intelligence" has gradually been applied in various fields. For the electronic gaming industry, which has a history of over half a century, such technology has been intertwined with it since its inception, albeit often overlooked, yet undeniably indispensable. Since the 1950s, game developers have been attempting to use various forms of artificial intelligence to provide better gaming experiences for their users: intelligent design, content generation, motion and physics, dynamic adaptation, and narrative storytelling. Each of these aspects has had a crucial impact on the popularity of electronic games over the past half-century. The use of artificial intelligence in the early days of the industry can undoubtedly be considered "long-standing," but its subsequent development requires further exploration.

In this paper, the author will integrate specific cases of the application of artificial intelligence in various aspects of game development over the past few decades. The subsequent paragraphs will summarize the specific drawbacks that still exist, and the concluding paragraph will serve as a summary of the entire content, summarizing all the aforementioned points, and discussing the future application of artificial intelligence in this field.

2. Application of Artificial Intelligence in Game Design

The work of artificial intelligence has evolved from its initial role of providing computed feedback to players to encompass various aspects within a game: from intelligent design and content generation to physical simulation and dynamic adaptation, even delving into narrative concepts that were once the sole domain of human creators.

2.1. Application of Artificial Intelligence in Game Intelligent Design

Game intelligent design refers to the use of specific algorithms to simulate the behavioral patterns of intelligent entities in order to respond to the decisions made by players during gameplay. This type of artificial intelligence is almost an indispensable key component of an electronic game, with its earliest cases tracing back to the game Nim released in 1952, where the electronic algorithm was

already competitive with human players [1]. Despite this, in the early 1960s and early 1970s, during the initial development phase of the electronic gaming industry, most games were still strictly based on multiplayer interactions, where real human players interacted with each other. The use of artificial intelligence was relatively scarce. With the arrival of the 1970s, more games began to incorporate computer-controlled non-player characters (NPCs) into single-player games [2].

Examples of such games include Star Trek, released in 1971, which required players to interact with characters controlled by computer algorithms through mostly text-based interactions [3]. Star Trek gained immediate popularity in the United States and, while part of this may be attributed to the high praise received by its original TV series, there is no denying that its relatively novel gameplay mode played an essential role in its widespread popularity across the United States [4]. Another early example of this kind of AI application is the precursor of the imitated game Spacewar! released in 1962, which also gained popularity among a wide range of players [5]. Although Spacewar! still required mutual interaction among multiple human players and could only output the reactions of "enemies" to players through a telegraph typewriter, the intelligence code itself was mature enough, and it was widely imitated by various game manufacturers once it was made public [6]. Star Trek used BASIC code that could run on the Sigma SDS 7 to synchronize the screen's electronic images with the reactions modeled after Spacewar! in response to the text produced. The game gave players the feeling of "traveling through an entire visually observable interstellar system," and subsequent release versions used the HP 2000 mini-computer to rewrite code compatible with more models, making it accessible to more players and thus allowing them to enjoy the fun of single-player games [7]. Artificial intelligence has been applied in a similar manner in various games since then, and players have long been free from the need to personally manage every move in the game, instead interacting with characters and environments controlled by pre-written computer algorithms just like real people.

2.2. Application of Artificial Intelligence in Content Generation

Procedural Content Generation (PCG), as a relatively emerging technique, involves the direct utilization of artificial intelligence algorithms to generate content. While this form may not be widely known, it has been applied and practiced by numerous game developers for many years. PCG refers to the method of using pre-written algorithms to automatically generate data, encompassing areas such as novels, movies, and, as discussed in this paper, electronic games [8]. In its early application, PCG algorithms were primarily used in 2D level-based games to generate the challenges that players would face in the subsequent stages. Early examples of such games include "Beneath Apple Manor," released in 1978, and "Rogue," released in 1980. The latter quickly gained popularity among college students in the 1980s, leading to the continuous development of similar games with algorithmic and gameplay patterns. This trend eventually led to the categorization of similar games under the label "Roguelike" (Fig.1) [9]. In the 2000s, during the "International Roguelike Conference," one of the defining characteristics of these games was identified as having "randomly generated environments," underscoring the direct and profound influence of PCG on this entire category of games [10].



Fig.1 FTL: Faster Than Light

However, as time progressed, the development of PCG in game development extended far beyond the generation of flat, randomly constructed levels. Instead, it increasingly leaned towards the

automatic generation of open-world game environments. In the years following the turn of the millennium, games employing three-dimensional technology became more prevalent. Consequently, more game developers began incorporating automatically generated data details within three-dimensional scenes. Although the initial attempt, *Krieg*, did not release a complete version as anticipated due to technical reasons, developers became progressively adept through accumulated trials and errors [11]. Most existing "open world" genre games necessitate the use of such technology: employing a pixel system generated by random numbers to construct a rough framework, and then using intelligent algorithms to analyze the effects each environment needs to present. Different "textures" are applied to render various environments, objects, and characters, ultimately presenting a realistic world before the player's eyes. Games utilizing this algorithm afford a tremendous degree of freedom to the environment. Due to the need for a specific material-based re-rendering with each startup, the widely acclaimed game *Minecraft* stands as an outstanding success story [12].

From the early days of generating flat levels in *Rogue*, PCG has now evolved to generate over 9 billion star systems in *No Man's Sky*, providing countless players with the opportunity to explore an infinite universe. Its application in numerous games has had an immeasurable impact, allowing players for decades to experience the joy that cutting-edge technology brings to gaming.

2.3. Application of Artificial Intelligence in Motion and Physics Simulation

In more modern game development, artificial intelligence also plays a crucial role in character motion, object interaction, and physics simulation. As the gaming industry continues to evolve, player expectations for games have correspondingly increased, narrowing the gap between the game and reality to meet user demands. In this process, in addition to the diligent efforts of creators, the application of AI systems makes various aspects of the game feel more natural and realistic.

2.3.1 Character Motion

In games with multiple characters, most non-player character (NPC) movements are controlled by artificial intelligence. By using carefully designed algorithms to manipulate their movement paths, NPCs in the game can intelligently navigate obstacles, track players, or perform various additional actions, providing a more challenging and interactive gaming experience. The use of AI-generated motion programs extends beyond interactive games and is also employed in animation films and other media with a broader audience [13].

2.3.2 Object Interaction

Beyond interactions between characters, AI can also manage interactions between objects. In games that mimic real-world environments, algorithms controlled physics systems are needed to simulate various physical laws present in the real world [14]. In physics simulation, AI can calculate and simulate mechanical effects in an extremely short amount of time, making the behavior of objects feel more realistic [15]. Objects in the game can be affected by factors such as gravity, collisions, and wind, allowing for a more accurate simulation of the real world.

3. Application of Artificial Intelligence in Dynamic Adaptation

For different players, artificial intelligence can be used to adjust the game algorithms according to their unique preferences and requirements. Dynamic game difficulty balancing refers to the automatic adjustment of difficulty and experience based on a player's performance and behavior to maintain the game's appeal and challenge. By analyzing a player's reactions during gameplay using artificial intelligence, the game can adjust the difficulty level accordingly. If a player performs well, the game can increase the difficulty, providing a greater challenge. If a player encounters difficulties, the game can lower the difficulty to ensure they can still enjoy the game.

At the same time, artificial intelligence can analyze a player's behavioral patterns, such as their decisions, preferences, and strategies. With this data, the game can predict a player's next actions and adjust the game experience accordingly to provide a more personalized gaming experience. AI can

customize game content based on a player's individual preferences, including adjusting the game's storyline, providing custom tasks or levels, and offering personalized game suggestions, enhancing player engagement and satisfaction.

Role of Artificial Intelligence in Plot Development and Dynamic Narrative

In game design, plot development and dynamic narrative are crucial for engaging players and conveying the game's story. AI can automatically generate game plots and missions. This means developers can create large-scale game worlds more quickly without manually scripting every detail of each mission. This provides more diversity and exploration, allowing players to experience more storylines within the game. AI can adjust the narrative development of the game based on a player's choices and actions. This means that each player can experience different story paths and endings, increasing the replayability and appeal of the game.

Problems Exist in the Application of Artificial Intelligence in Game Design

While the benefits of using artificial intelligence in game development, as mentioned in the previous sections, are substantial, it is undeniable that there are many challenges and issues that arise from employing these methods.

Interaction between Players and Artificial Intelligence

The interaction between players and artificial intelligence is crucial in games. However, if the behavior and responses of artificial intelligence are too predictable or lack variation, it may lead to a monotonous and dull player experience. Additionally, if artificial intelligence displays overly powerful capabilities in the game, it may make players feel defeated and frustrated, thereby affecting their gaming experience.

Human Creativity vs. AI Creation

The application of artificial intelligence in creative design has also sparked some discussions. While AI can generate a wide variety of game elements, the question of whether this will replace the creativity and unique perspective of human designers is a topic that requires deep consideration. Balancing the generative capabilities of artificial intelligence with the creativity of human designers is a challenge that needs to be addressed in the game development process.

Areas Unexplored by Artificial Intelligence

Artificial intelligence may face limitations when dealing with uncertainty and unknown areas. In certain situations, specific game scenarios or player behaviors may exceed the scope of artificial intelligence's capabilities, resulting in unexpected gaming experiences. Additionally, artificial intelligence may not always accurately predict a player's behavioral choices in the game, making the game's development unpredictable.

Ethical and Social Issues

The application of artificial intelligence in games has raised some ethical and social issues. For example, in virtual worlds, players may form emotional connections with AI characters, and there may even be strong emotional investment in virtual characters. This has sparked discussions about rights and moral responsibilities. Furthermore, the application of artificial intelligence in games may involve issues related to data privacy and security, necessitating the establishment of appropriate policies and regulations to protect the rights of players.

4. Conclusion

This article summarizes the significant role of artificial intelligence in game development. It brings diverse content, more realistic character motion and physical simulation, dynamic difficulty adaptation, and personalized plot development and narrative to games. The application of artificial intelligence enriches the gaming experience and provides powerful tools for game developers.

However, the application of artificial intelligence in game development also faces challenges and issues, such as player interaction with AI, balancing human creativity with AI-generated content, limitations of AI in unknown domains, and ethical and societal concerns. In the future, continued research and efforts will be needed to address these issues and further advance the role of artificial

intelligence in the gaming industry, ultimately achieving higher-quality and more personalized gaming experiences.

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