



The Application and Problems of Artificial Intelligence in Games

Yini Pan

The Affiliated High School to Hangzhou Normal University, No. 5 Zhenhua Road, Xihu District, Hangzhou, China
dejing.sun.16@uc1.ac.uk

Abstract. With the advancement of computer software and hardware technology, artificial intelligence (AI) has significantly enhanced gameplay in the gaming industry and has become a crucial determinant of a game's success or failure. This article provides an overview of the current applications and associated challenges of AI in the gaming domain. It explores the role of AI in various stages of game development, from the early stages of game design to the later phases of operation and promotion. Additionally, the article discusses the challenges faced in these areas. It specifically examines the applications of AI in game programming, intelligent character development, smart strategies, game testing, and game promotion, while analyzing the corresponding challenges and issues. The article concludes with a summary of current research advancements in the field and provides insights into future developments. Overall, this article highlights the significant contributions of AI in games and sheds light on the ongoing challenges and potential avenues for future exploration in this research area.

Keywords: AI, video games, computer science, dynamic difficulty adjustment.

1 Introduction

With the birth of a series of latest computer technologies such as big data, cloud services, ChatGPT, etc., AI technology is also constantly developing and changing. And with it comes the application of AI technology in many fields, including gaming. At present, AI technology has become one of the most important components in the gaming field, widely used in almost all types of games, from single player chess and cards to online competitions. From the most common and common automatic pathfinding, strategy selection, to the commonly unknown background automatic difficulty adjustment and computational resource allocation, all of which involve the application of AI technology. Ai technology achieves the goal of improving game experience and improving game development efficiency through relatively simple methods that are difficult to achieve with traditional technology or require significant cost consumption. However, not only has AI improved in games, but games have also developed in AI research [1]. It can be expected that in the future, AI technology will

also become more important and widespread in the gaming field. However, due to the current objective problems of AI technology and some related legal and moral issues that need to be addressed, there are still some challenges in the application of AI technology in the gaming field.

The main purpose of this article is to summarize the application and existing problems of some AI technologies in the gaming field so far, in order to provide convenience for others' subsequent research and summary. This article mainly discusses the application and existing problems of AI in game programming, intelligent characters, intelligent strategies, game promotion, and other aspects.

2 Analysis of AI Applications in Gaming

This section mainly discusses the application of AI in the gaming field from five aspects: programming, intelligent characters, intelligent strategies, game testing, and game promotion.

2.1 Programming

The application of AI programs in game development has a wide range of uses, such as enhancing game expression and realism through graphic rendering, physics simulation, and collision detection.

Firstly, AI technology assists developers in creating game narratives by utilizing algorithms. Developers can generate a substantial amount of game content quickly, enriching the storyline. Moreover, the use of source code generators significantly improves work efficiency by avoiding tedious, repetitive, and error-prone tasks. The game development industry has witnessed the emergence of various source code generators that provide convenience. For instance, in the past, developers had to manually write numerous configuration files and classes when utilizing object-relational mapping tools like Nhibernate. This manual process was not only laborious but also susceptible to errors, thereby increasing project complexity [2]. Currently, source code generators are widely adopted in game development, saving developers time and effort. For example, in Java 2 Micro Edition (J2ME) mobile game development, source code generators parse Game Definition Language (GDL) description files and connect them with the Game Foundation Classes (GFC) applicable to the target phone, thereby generating J2ME mobile game source code [3].

The integration of AI programs into game development significantly enhances content creation and development efficiency. Leveraging AI technology enables developers to rapidly generate a substantial amount of game content, reducing repetitive labor while providing players with immersive and realistic gaming experiences. There are now games that are almost entirely generated by AI. For example, here is a web click game created using AI within 72 hours (Fig.1). This presents ample opportunities for innovation and growth within the gaming industry.



Fig. 1. Generated Adventure by Luden.io (itch.io)[4]

The implementation of intelligent characters in games involves the application of various techniques and methods to make them more intelligent and realistic.

Firstly, for simulating intelligent behavior, AI can utilize rule-based systems or algorithms such as decision trees and finite state machines to guide the actions and decision-making of intelligent characters. By setting predefined behavioral patterns and conditions, intelligent characters can react accordingly based on the game context and player behavior. This allows intelligent characters to demonstrate a wide range of behavioral strategies, such as selecting appropriate attack methods or tactical maneuvers in combat scenarios. For instance, in a stealth-based game, intelligent characters can utilize AI algorithms to analyze the player's movements, predict their possible paths, and strategically position themselves to detect or avoid the player. They can exhibit behaviors like patrolling, hiding, or actively searching for the player based on the game's mechanics and the player's actions. This creates a more immersive and challenging gameplay experience, as intelligent characters act and react smartly, making it harder for the player to progress undetected.

Secondly, the learning capabilities of AI are crucial for the development of intelligent characters. Through techniques like supervised learning and reinforcement learning, intelligent characters can learn from game data and continuously improve their performance based on feedback. By simulating numerous game scenarios and utilizing training data, intelligent characters can gradually enhance their skills and decision-making abilities, providing players with more challenging and personalized gaming experiences. AI can enable intelligent characters to coordinate and cooperate effectively in team-based games. They can strategize, communicate, and execute synchronized actions, enhancing gameplay tactics during multiplayer matches. For example, in a multiplayer shooter, intelligent team members can flank the enemy, provide cover fire, or revive fallen comrades based on dynamic situational analysis.

Furthermore, AI can be employed in emotion interaction to give intelligent characters more lifelike and human-like attributes. Through emotion recognition and modeling, intelligent characters can perceive the emotional state of players and respond accordingly, such as adjusting their behavior or dialogue based on player preferences. This emotional interaction enhances the emotional resonance and interactivity of the game, making players more immersed in the game world.

The application of AI in intelligent characters in games enables virtual characters to better simulate human player behavior and thinking, providing more diverse, realistic, and personalized gaming experiences. Through the simulation of intelligent behavior, the utilization of learning capabilities, and the implementation of emotion interaction, intelligent characters can interact with players and adapt to different game scenarios, offering deeper and more engaging game experiences.

2.2 Intelligent strategy

AI can also provide assistance in game path planning. By utilizing techniques such as reinforcement learning and evolutionary algorithms, AI can analyze game maps, character positions, and surrounding environments to generate optimal path planning solutions. AI takes into account various factors, including terrain, obstacles, and virtual character attributes, in order to offer more intelligent and realistic movement behavior. This path planning capability not only enhances player immersion, but also ensures more natural and orderly actions for virtual characters. A widely used algorithm in this context is the A-star (A*) algorithm, which greatly improves gameplay by enabling better attack, evasion, pathfinding, blocking, turning, jumping, and other behaviors, as well as enhancing virtual space perception.

Another significant application lies in tactical selection. AI, through pre-trained models and data analysis, can provide more intelligent and flexible combat strategies for hostile characters. AI can determine optimal skill usage and adaptive tactics based on the game context and objectives, thereby enriching the depth and strategic nature of in-game battles. Additionally, AI can learn players' real-time behavior patterns, adjust its own strategies and tactics accordingly, and provide a more challenging gaming experience. For example, the most popular algorithm now is the A*, which is widely used in large electronic games to improve game playing including attack, evasion, pathfinding, blocking, turning, jumping, and other behaviors, as well as the perception of virtual space, and the routing algorithm flowchart (Fig.2) is here [5].

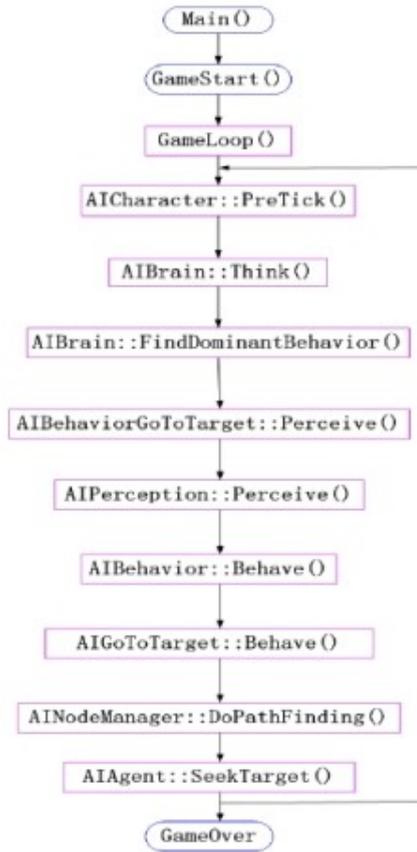


Fig. 1. The routing algorithm flowchart [5]

These applications showcase the pivotal role of AI in game design, enabling more intelligent and realistic behaviors and strategies, thereby enhancing the enjoyment and challenge of gameplay. AI can also provide assistance in game path planning. By utilizing techniques such as reinforcement learning and evolutionary algorithms, AI can analyze game maps, character positions, and surrounding environments to generate the best path planning solution. AI can consider various factors, such as terrain, obstacles, and virtual character attributes, to provide more intelligent and realistic movement behavior. This path planning function not only enhances players' immersion, but also makes virtual characters' actions more natural and orderly [6].

In summary, the application of AI in games expands beyond mere code programming, facilitating the creation of engaging and challenging gaming experiences. By enabling intelligent behavior design and adaptive adjustments, AI contributes to more immersive and captivating games, delivering enhanced realism and enjoyment for players.

2.3 Game testing

AI plays a significant role in game testing, particularly in automated testing and game error detection, aimed at enhancing game quality and stability. Currently, AI is widely employed in various testing domains, including stability and program compatibility testing for games. For instance, Testin cloud testing leverages AI automation scripts to address the majority of runtime issues encountered during the launch of new software and products [7]. Moreover, AI can even predict the time of a player's character death based on factors such as item availability and skill cooldown [8]. This technology enables developers to adjust game data to achieve a better balance without the need for extensive time and monetary investments in manual testing.

To tackle the major challenges faced by developers in software and system testing, including process management difficulties, low testing efficiency, limited availability of professional testing talents, and inadequate specialized testing capabilities, AI testing endeavors to improve software quality and efficiency by establishing a comprehensive architecture for an automated testing platform. This platform integrates advanced AI automation core capabilities and offers comprehensive intelligent testing solutions.

These advancements in AI testing are poised to have a positive impact on the game development process, assisting developers in the creation of high-quality and stable gaming experiences.

2.4 Game promotion

AI can also be utilized for game promotion. In fact, it is becoming increasingly popular for websites and software to employ AI in order to enhance the sales of their games. AI leverages real-time and historical data, employing machine learning algorithms and data mining techniques to analyze users' basic behavior habits, extract popular topics, and analyze emotional semantics to gain insights into consumer needs. Based on brand marketing requirements and the characteristics of downstream executors, intelligent matching is achieved through mediation, considering factors such as the timing and intensity of discounts. AI enables automated output of standardized copywriting, design elements, graphic posters, and more, expediting the placement process. This improves advertising accuracy and reduces budgetary waste. Notably, even renowned game platforms like Steam adopt this approach, as evidenced by the creation of recommender systems that leverage the data collected by video game platforms, thereby continuing the trend of annual game releases [9].

AI's applications extend to recommending games that align with users' preferences, thereby increasing their exposure and sales. By analyzing users' gaming preferences, playtime, and social relationships, AI can accurately identify their needs and present relevant game information to them. Furthermore, AI enhances advertising efficacy by delivering personalized ads and precise user targeting, thereby improving click-through rates and conversion rates, ultimately expanding the audience and boosting sales.

In addition to recommender systems, AI facilitates optimization and personalized customization in game interfaces, user experiences, and game content. Through analysis of gamers' behavior and habits, AI dynamically adjusts game difficulty and challenges based on players' skill levels, game progress, and interest preferences, thereby delivering an enhanced gaming experience. Moreover, AI can adaptively learn and adjust based on player feedback and behavior data, continually refining game design and functionality to enhance user satisfaction and engagement.

In conclusion, AI holds great potential for game promotion. By leveraging AI's technical advantages, more precise user targeting, personalized advertising, and superior gaming experiences can be achieved, enhancing a game's competitiveness and market share.

3 The Challenges of AI in the Gaming Field

While AI has brought significant advantages to game developers, it is important to acknowledge the objective challenges that AI faces in the current stage of its development.

3.1 Inflexible Behavior

One notable challenge is the relative rigidity of AI behavior. AI relies on existing knowledge and predefined operational logic, which can limit its flexibility and accurate judgment in certain situations. One of the ethical and design dilemmas arises from the fact that most AI approaches optimize metrics, but they might not efficiently address human concerns. This often results in undesired outcomes, such as manipulation, gaming of the system, and a focus on short-term quantities rather than long-term considerations [10].

3.2 Legal and Ethical Concerns

There have been ongoing discussions about the moral and legal implications of AI since its inception. The copyright issue surrounding AI-generated content remains a topic of debate. Moreover, as AI systems become more autonomous, it becomes challenging to attribute outcomes to human choices and assign responsibility to a specific entity [11]. A notable instance is the Allegheny Family Screening Tool (AFST), a predictive model used to anticipate child neglect and abuse. In the UNESCO COMEST Preliminary Study on the Ethics of AI [12], it is highlighted that the AFST exacerbates structural discrimination against the underprivileged and disproportionately impacts vulnerable communities due to oversampling and the use of proxies.

3.3 Lack of Emotions and Creativity

Furthermore, the lack of emotions and creativity in AI remains a significant challenge. Unlike humans, AI systems cannot possess genuine emotions or create with purpose. Their creations are typically a combination of existing elements and random factors, devoid of a specific human-like intent [13]. Although AI can produce creative outputs, it is important to consider them as a form of pseudo-creativity, as the characteristics exhibited by human creativity are often absent, and the creative procedures are drastically different.

In summary, while AI has made notable contributions in the gaming field, it faces challenges related to inflexible behavior, ethical considerations, and limitations in emotions and creativity. Addressing these challenges will be crucial in further advancing the potential of AI in the gaming industry.

4 Conclusion

This article delves into the extensive application and the existing challenges associated with AI in game programming. One significant area where AI is making substantial contributions is in the development of intelligent characters. By employing AI algorithms, game developers can create characters that exhibit more realistic behaviors, making the gaming experience more immersive and engaging for players. Another aspect of game programming where AI is utilized is in the development of intelligent strategies. AI algorithms can analyze player behavior patterns, make predictions, and adapt gameplay accordingly. This not only enhances the game's challenge and variety but also allows for dynamic and unpredictable gameplay experiences.

Furthermore, AI plays a crucial role in game promotion. By utilizing machine learning algorithms, developers can tailor personalized advertisements and recommendations to individual players, thus enhancing user engagement and maximizing revenue potential. However, it is essential to acknowledge the limitations of AI in its current stage. Despite the significant advancements made, AI still lacks the flexibility and creativity exhibited by human intelligence. AI systems primarily operate within a predefined framework, which limits their adaptability and ability to respond creatively to unforeseen situations. Additionally, legal and ethical concerns surrounding AI in gaming need to be addressed. Issues related to data privacy, fairness, and accountability arise when algorithms make decisions that impact player experiences or target advertising strategies. Striking a balance between leveraging AI's potential and ensuring ethical implementation is crucial.

Nonetheless, as computer technology continues to progress, solutions to current challenges are likely to be proposed and effectively implemented. The increasing accessibility of AI technology will lower the threshold for integrating AI into games, leading to its widespread adoption and indispensable role in the gaming industry.

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