

Exploring the Applications and Drawbacks of Artificial Intelligence in Gaming

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Abstract:

In the domain of gaming, Artificial Intelligence (AI) technology is emerging as a significant force driving game development, exerting profound influences on both players and developers. This paper delves into the applications of AI within the gaming industry and its transformative role in modern gaming experiences. Through a review of literature and information gathering, the paper provides a detailed analysis of AI's applications in areas such as automated testing, text analysis, anti-cheating systems, non-player character (NPC) behaviors, and game graphics, exploring the operational mechanisms of these technologies. Additionally, the paper discusses several challenges posed by AI, including issues of privacy and security, the transparency of AI algorithms, and concerns of fairness. These issues necessitate resolution through ongoing technological advancements and stringent security protocols. Overall, the application of AI in the gaming industry holds broad prospects, with expectations that it will further propel innovations in game development and player experiences in the future.

Keywords: Game; AI; AI application; drawbacks e.

1. Introduction

In recent years, with the swift development of global technology, artificial intelligence (AI) has advanced rapidly. AI is no longer just a theoretical concept, but has become an important tool in practical applications, having a profound impact on multiple industries. Especially in the entertainment industry, the application of AI technology is becoming increasingly widespread, bringing unprecedented changes. The increasing demand for intelligence and automation in society has also prompted the deep integration of AI in multiple fields, and the gaming industry is one of them. In this highly competitive and innovation driv-

en industry, AI technology has moved from behind the scenes to the forefront, becoming a key force driving game development and player experience.

Through AI, game developers can create richer and more diverse game scenes, design intelligent NPC behaviors, and adjust game difficulty based on real-time feedback from players, making the game experience more personalized and immersive. These years, many professional players have openly cheated in international competitions, which shows just how rampant cheating software has become in games. AI also plays an important role in anti-cheating systems, effectively preventing cheating behavior by analyzing player behavior patterns. AI can also

reduce system requirements, allowing more users to enjoy a better experience. In addition, the application of AI technology is not limited to game content itself, it has also penetrated into various aspects such as marketing and player feedback, bringing comprehensive improvements to the gaming industry. These innovative applications of AI not only improve the overall quality of games, but also greatly enhance player engagement and satisfaction.

A search through academic databases such as Google Scholar has revealed that research literature on the application of artificial intelligence in the gaming industry is relatively scarce, with the majority of the findings published prior to 2020. Given the current lack of systematic research on the latest game AI technologies, this study focuses on several of the most cutting-edge and prominent AI gaming technologies and provides a detailed exploration and analysis of their operational principles.

2. Advantage

With the rapid development of AI, it has permeated various aspects of gaming and is widely applied in Automated testing, Anti-cheating, Map design, Character behavior, Game graphics, And player data analysis.

2.1 Automated Testing

As technology progresses, the size of games has grown significantly, with many games now exceeding 100GB. Consequently, the number of bugs has increased proportionally, and programmers alone can no longer fully manage the task of debugging the vast number of issues in games. The automation testing of AI has replaced a large part of the work of programmers and become a key link in ensuring the quality and stability of complex game systems. Fault Tree Analysis (FTA) and Reinforcement Learning (RL) technologies play an important role in this field, providing advanced tools for identifying, analyzing, and mitigating faults that may interrupt the gaming experience.

FTA is commonly used in high-risk industries such as aerospace and nuclear energy to predict and prevent potential system failures. Due to its systematic bug identification method, it has also been used in game testing. FTA is a top-down hierarchical diagram, with the main faults at the top and possible causes branching down. Each branch represents a possible cause of a fault, and Boolean logic gates (such as AND, OR, NOT, XOR) are used to represent the relationship between different fault events. In game testing, FTA is suitable for diagnosing issues related to system crashes, performance bottlenecks, or unexpected behavior in complex scenarios. For example, when a multiplayer game crashes, FTA can help trace the root

cause of the problem, whether it's server failures, network errors, or vulnerabilities in game code. Developers can more easily and quickly identify and fix problems by troubleshooting through tree structure [1, 2].

On the other hand, RL represents a more dynamic approach to automated testing. RL trains intelligent agents to perform tasks by rewarding them for achieving expected outcomes and punishing them for unexpected outcomes. In the game testing, RL can be used to develop intelligent agents for autonomous navigation and interactive gaming environments, such as autonomous driving and AlphaGo. Unlike supervised learning and unsupervised learning, the core of RL lies in the agent gradually optimizing its behavioral strategy through trial and error and reward feedback. Therefore, in a large number of iterations, RL agents may encounter vulnerabilities and logical errors that programmers did not anticipate or discover that traditional scripts cannot recognize, thereby discovering hidden bugs. For example, crossing walls through missing collision grids or finding stuck areas on the map. By adopting RL technology, developers will have wider testing aspects and discover hidden issues.

FTA provides a structured approach to screen for errors, while RL actively discovers subtle issues through extensive testing. When these two technologies are combined, they can enhance the robustness of automated testing frameworks, ultimately improving game quality and the smoothness of player experience. At the same time, it also reduces the work pressure of developers.

2.2 Text Analysis

The work of developers is not completed after the game is launched. Listening to players' suggestions and improving the same development process is an important part. Extracting useful information from numerous comments and exchanges is quite laborious. For example, in World of Warcraft, the official feedback website receives thousands of feedback submissions every day, and there are countless exchanges on the forum alone. It is impossible for the staff alone to take care of so many players. In this case, the application of natural language processing (NLP) technology is particularly important, as it can process and parse large amounts of textual data, extracting meaningful suggestions or opinions from it [3].

NLP can be used to analyze player feedback, in-game chat records, forum posts, and social media interactions, in order to analyze key sentences and emotional trends. For example, sentiment analysis is one of the core components of NLP, which can determine whether the emotional tendencies of player comments are positive, negative, or neutral. This enables developers to assess overall player

satisfaction, identify common issues, and evaluate the quality and effectiveness of recently updated content. Through emotional inclination, AI will automatically classify feedback, and developers can prioritize improvement areas based on player emotions.

NLP can also extract problems from unstructured languages. By analyzing the text generated by players, AI systems can detect the emotional tendencies of players and the trends of game content. This includes identifying

emerging issues, understanding player preferences, and predicting future behavior based on historical data. For example, if Play 7 frequently mentions dissatisfaction with specific features, developers can use this information to solve problems and improve user satisfaction.

In addition, NLP analyzes the interactions and preferences of individual players, and by understanding the language and emotions in player communication, AI can customize game content to support personalized experiences (Fig.1).

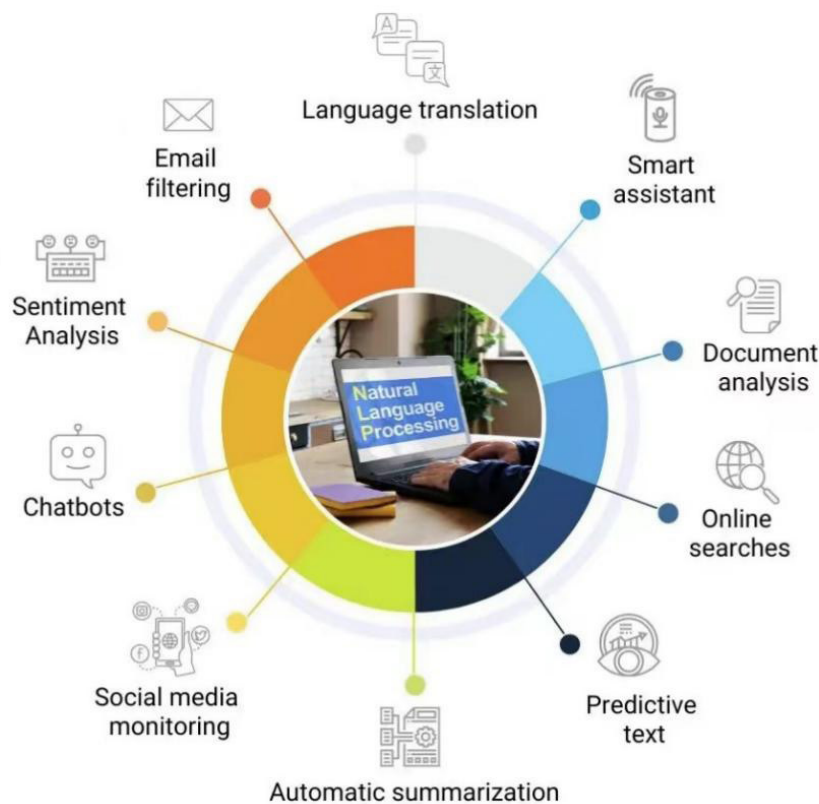


Fig. 1 Applications of Natural Language Processing [4]

2.3 Anti-Cheating

With the popularity of video games, the challenge of maintaining game fairness has become increasingly complex. Cheating not only damages the gaming experience, but also weakens the fairness of the competitive environment. Traditional anti cheating methods often rely on pre-defined rules and manual review, which may appear slow and inadequate in dealing with the constantly emerging complex cheating methods. To address this issue, developers have turned to artificial intelligence (AI). As an advanced tool for detecting and preventing cheating, AI can analyze large amounts of data, recognize patterns, and adapt to constantly evolving cheating methods. AI anti cheating technology has become an indispensable part of many games. A key advantage of AI is behavior analy-

sis, which detects cheating by monitoring and evaluating players' behavior in the game. AI systems can identify possible abnormal behaviors by comparing these behaviors with established norms, rather than traditional pre-set rules. For example, if a player consistently demonstrates perfect accuracy or reaction time far beyond human level, AI systems may label this behavior for further investigation. This ability to detect subtle anomalies makes AI particularly effective in identifying cheating behaviors that are not easily detected, while also reducing the probability of misjudgment. Another powerful application is pattern recognition. Cheating often leaves specific traces, such as abnormal application access or abnormal code. AI systems are adept at identifying this information in massive amounts of data. By training on a large dataset, AI mod-

els can distinguish the true face hidden deep in the data, thereby reducing the number of cheating behaviors that go unnoticed.

The most well-known AI anti cheat software in recent years should be VACnet, which is a system developed by Valve for Counter Strike: Global Offensive (CS), focusing on detecting auxiliary aiming software (aimbots). VACnet uses deep learning technology and convolutional neural networks (CNN) to analyze game data and identify aimbots (Fig.2). By reviewing competition videos, VACnet can accurately identify suspicious accounts and help maintain fair competition in the game [5].

Another software is Tencent's Anti Cheat Expert (ACE). ACE's system detects abnormal behavior by collecting and analyzing players' game behavior data, such as kill rate, in-game reaction time, etc. ACE identifies cheating

behavior by identifying anomalies in player data, such as exceptional reaction speed or extremely high accuracy.

One important feature of ACE is its real-time detection capability. The system can analyze player behavior data in real-time and take immediate action upon detecting anomalies, such as automatically banning accounts or marking suspicious behavior for further review.

VACnet and ACE are two of the many types of AI anti cheating technologies that combat cheating from different perspectives. Unlike traditional anti cheating, AI anti cheating does not defend against known viruses like vaccination, but rather works like its own immune system to defend against all known or unknown viruses. Even with the emergence of new cheating methods, AI models can continuously update to ensure the effectiveness of the system.

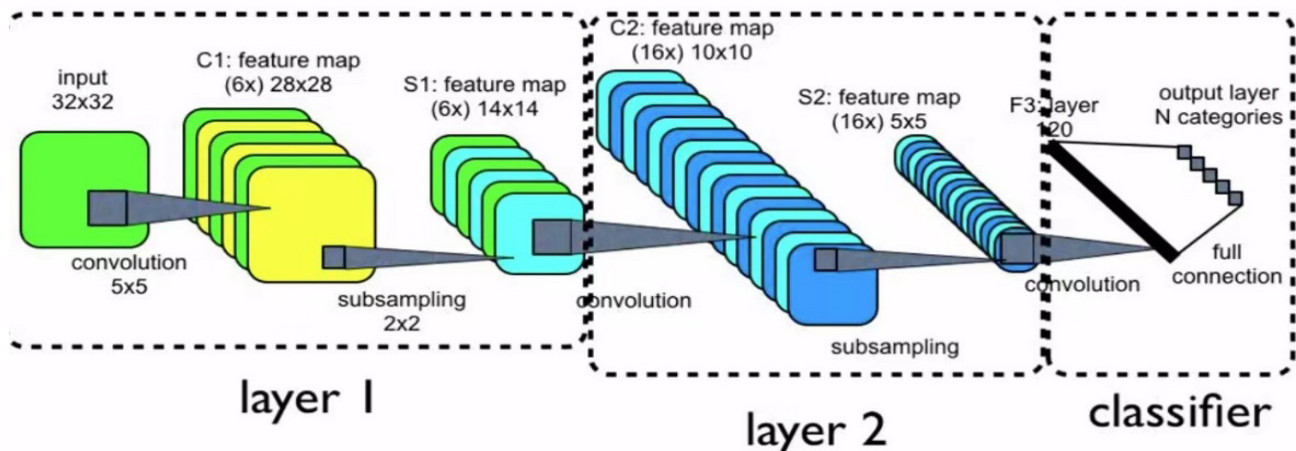


Fig. 2 The Principles and steps of CNN [6]

2.4 NPC Behaviors

The application of AI in games is changing the behavior and interaction of virtual characters, enabling players to experience a more realistic and dynamic gaming world. Driven by AI, characters in games are not only able to exhibit complex behaviors, but also naturally alert to language conversations, thereby enhancing the immersion and interactivity of the game.

In traditional game design, the dialogue and behavior of characters are usually driven by pre-set rules and scripts, which limits the scope of character performance and leads to repetitive and predictable interactions. With the advancement of AI technology, game developers are now able to create smarter and more adaptive characters. These characters can not only understand the player's language and actions, but also make corresponding responses based on context and environment [7, 8].

One specific application is natural language dialogue systems. Modern AI enables game characters to engage in complex conversations with players, rather than just responding based on pre-set options. This system allows characters to dynamically adjust based on the player's tone, choices, and historical interactions, simulating more realistic dialogue scenarios. NVIDIA's ACE is a great example of how AI can apply natural language processing in games to enhance character interactivity. ACE utilizes advanced deep learning models to enable characters to generate humanoid dialogue responses, providing more natural and emotionally rich interactions. This also makes the game plot like a tree diagram, creating infinite dialogue texts based on the player's choices.

However, AI is simulating much more than just conversational systems. Through technologies such as GOAP, AI can enable NPCs to analyze changes in complex game environments and make real-time responses based on dy-

dynamic changes in the game, such as weather, enemy positions, player actions, etc. For example, if it suddenly rains on a sunny day, the NPC will automatically seek shelter from the rain, instead of standing still even if it gets wet according to the code in the past (Fig.3). At the same time, subtle aspects of the character's facial expressions, body movements, posture, etc. can also be adjusted according to the real-time environment, greatly enhancing the player's immersion [9, 10].

AI characters can make decisions that fit the context, mak-

ing the game world more realistic and dynamic. Whether in action games, role-playing games, or open world games, the application of AI can significantly enhance the complexity of character behavior and the depth of interaction. In Red Dead Redemption 2, the behavior, actions, and language of NPCs demonstrate a far superior level of technical power compared to their contemporaries, making it unique among many games and one of the reasons why it is still so popular today.

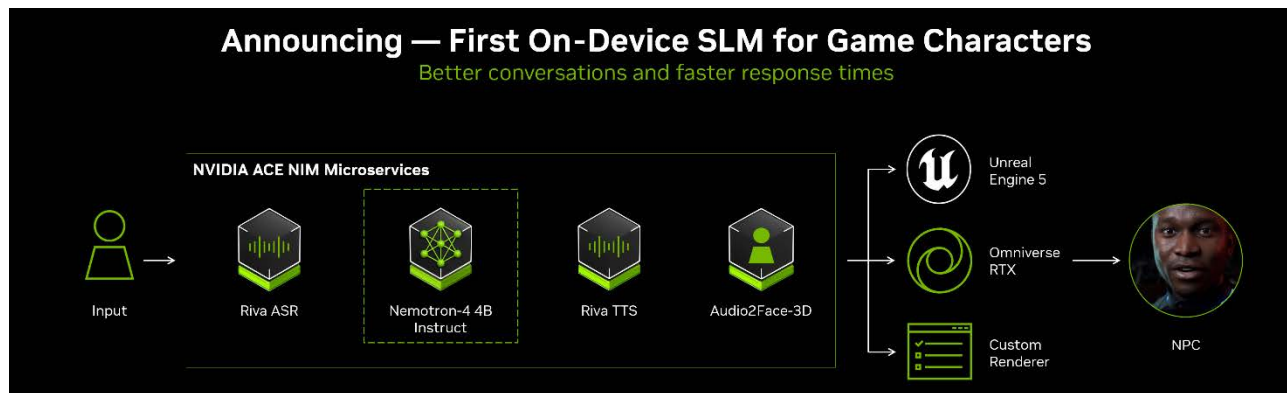


Fig. 3 NPC Creation Process [11]

2.5 Game Graphics

The impact of AI in the gaming industry is not only on game content, but also on player hardware. In traditional game rendering, high-resolution graphics require enormous computing resources. Running games with 4K resolution can impose a significant burden on both the graphics processing unit (GPU) and central processing unit (CPU), and may lead to issues such as frame rate drop. Although oversampling anti-aliasing (SSAA) can solve this problem by rendering at high resolution and then shrinking, its performance consumption is very high [12, 13].

But NVIDIA's deep learning oversampling technology (DLSS) utilizes AI to enhance game performance and visual effects, allowing games to run at higher frame rates while maintaining image clarity and quality. DLSS is not the traditional way of rendering the entire game at high resolution, but rather the opposite. Through deep learning and neural network analysis of thousands of game images, these neural networks are trained to render images at lower resolutions using AI algorithms to enlarge them into high-resolution images, reaching 4k or even 8k, without losing key details. Especially in high-speed motion or visually complex scenes, this technology can present clearer and more detailed images [12].

The application of DLSS has particular advantages in games with high graphics requirements, especially in

games where visual effects are crucial. For example, in Cyberpunk 2077, DLSS allows players to experience a rich and detailed gaming environment without sacrificing performance. In these games, whether it's complex city landscapes, intricate lighting effects, or delicate textures, DLSS ensures that players can enjoy high-quality graphics even on devices with weak hardware performance.

Moreover, DLSS is a technology that can adapt to multiple hardware configurations. Whether on mid-range gaming devices or high-end systems, DLSS can optimize the balance between performance and visual quality to provide players with the best graphics. For players of older GPUs, DLSS can make games that were previously unable to run smoothly viable, thereby extending the lifespan of hardware.

3. Drawbacks

3.1 Privacy Security

In game development and operation, the application of AI has significantly improved personalized experience and player satisfaction. However, this relies on the collection of a large amount of user data, which brings concerns about privacy and security. AI will collect players' gaming behavior, personal preferences, and even some sensitive information to optimize the gaming experience and im-

plement certain functions. If these data are not securely stored or managed, it may lead to privacy breaches or data leaks. To protect users, game companies often implement data encryption measures and transparent data usage policies to ensure data security. However, this cannot completely prevent information leakage, so privacy and security remain one of the main issues in AI to this day.

3.2 AI Algorithm Transparency

Another drawback of AI is the black box problem, which refers to the opacity of the decision-making process in AI systems. This has caused a lot of trouble for developers and players. Generally speaking, people cannot fully understand how AI algorithms come to conclusions, especially in complex systems such as AI driven game mechanics, NPC behavior, and anti-cheat programs. This opacity makes it difficult to predict, test, or debug AI behavior, and due to the inability to understand the underlying decision-making process, it also hinders staff from improving AI programs, making adjustments and optimizations extremely challenging. Meanwhile, due to users' inability to clearly understand how AI draws conclusions, this opacity may raise questions about the fairness of decision-making, especially when the decision results appear unfair. When the basis for decision-making is hidden, the feeling of being treated unfairly becomes more severe.

3.3 Fairness Issues

In addition, because the operation of AI is opaque, it also raises the third drawback of AI, the issue of fairness. AI systems typically rely on large amounts of data, but these data may contain inherent biases such as race, gender, or socio-economic discrimination. If not effectively addressed, AI models trained on these biased data may continue or even exacerbate these biases, resulting in extremely unfair outcomes. For example, AI recruitment algorithms may unintentionally favor certain groups while causing harm to others. Therefore, although AI is fairer than humans, objective AI may inherently carry subjectivity.

4. Summary

In summary, this article delves into the latest and cutting-edge applications of AI in the gaming industry, highlighting its pivotal role in shaping the modern gaming landscape. The multifaceted contributions of AI in game development, content generation, and enhancing player hardware are undeniable, underscoring its transformative impact on the interactive entertainment medium. Despite numerous advantages, the integration of AI is not without

challenges. Concerns regarding privacy, security, and fairness have emerged, often intertwined with the operational complexities of AI systems. While these issues may not be entirely resolved, they can be mitigated through continuous technological advancements and stringent safety protocols. It is worth noting that the presence of AI in the gaming domain has evolved over many years, with new technologies emerging and maturing in their application. However, this technology remains a supplementary tool rather than a replacement for human creativity and intuition, which are critical in crafting immersive gaming experiences.

Looking ahead, the future of AI in the gaming sector is brimming with potential. As technology advances, it is anticipated that AI will further streamline development processes, enrich the creative palette of game designers, and enhance the immersion of player experiences. It is hoped that AI will not only more effectively facilitate game creation but also elevate the overall quality of player experiences, ensuring that the gaming industry continues to thrive and innovate at the intersection of technology and human creativity.

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