Research on User-Defined Game Generation Based on AI

Chengyu Ma[a]
Institute of Problem Solving, Shanxi University, No. 63, South Zhonghuan East Street, Xiaodian District, Taiyuan, Shanxi, China

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Abstract: In today's digital age, the traditional game production process usually requires professional game developers to invest a lot of time and energy, and it is difficult for ordinary users to participate in game creation. This article reviews the existing results of game design using artificial intelligence technology, aiming to lower the threshold of game development for the development of automatic game generation systems for ordinary users, improve development efficiency, enrich players' gaming experience, and promote innovation and development in the game industry. At present, three types of methods have been summarized, namely, methods based on reinforcement learning, methods based on generative adversarial networks, and methods based on convolutional neural networks to achieve auxiliary game design. This study is conducive to promoting the formation of a new entertainment ecology in which all people can participate in creation. This research topic takes user needs as the starting point and integrates artificial intelligence related technologies. It is highly innovative and practical.

1 INTRODUCTION

Since the rise of artificial intelligence technology, games have always been one of its important application scenarios. Recently, at the 2024 Game Developers Conference (GDC) conference, many domestic and foreign manufacturers focused on discussing the application of artificial intelligence in the game development process. (Game Developers Conference, 2020) The rapid advancement of artificial intelligence technology has greatly influenced and transformed all aspects of game development. From content generation, design optimization, to player behavior analysis and personalized experience, artificial intelligence has become a key tool for modern game development. The GDC conference showcased the latest AI-driven innovations and explored how to use technologies such as machine learning to automate and enhance game development. AI-driven player modeling and adaptive mechanisms make it possible to create more attractive gaming experiences. As the game industry continues to develop, artificial intelligence has shown great potential in changing the way games are conceived, developed, and experienced, and will surely shape the future of interactive entertainment. Driven by the diversification of content needs and the optimization of development efficiency, AI-assisted game design is widely anticipated and is also a hot area of academic attention. Game software development is an important research direction in the field of game development, aiming to use computer algorithms to automatically generate levels, characters, storylines and other content in the game to improve the playability and creativity of the game.

Game artificial intelligence has always been an indispensable and important part of computer game development. AI characters can effectively enhance the player's gaming experience by supporting the player's pause state and dynamically managing dramatic environments. In addition, AI designers use procedural content generation technology to support and enhance the development of individual games. (Riedl, Zook, 2013) In the future, it is envisioned that AI production engineers will take on more new roles, not only enhancing and expanding the game production process, but also supporting the entire

[a] https://orcid.org/0009-0000-3471-9556

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real-time operation process in the game, promoting cross-game interoperability, cultivating a strong player community, and realizing the integration of real and virtual environments. The realization of this vision is due to the large amount of data resources accumulated by the game development industry. By integrating AI technology, game development will move to a new stage, bringing players a more immersive and personalized gaming experience.

In addition, AI technology is also promoting the democratization of 3D model creation, especially in the field of VR games. Tools like Google Genie enable creators to generate game content through prompts and sketches, although converting 2D to 3D still faces challenges in data sets and computing requirements. Artificial intelligence can reduce the motivation of game development, stimulate innovation, and simplify content creation, allowing more creators to realize their vision of the virtual world. As technology develops, user-generated VR experiences will become more convenient, and future VR games will enhance diversity and creativity (Begemann, Hutson, 2024).

This article will explore the various applications of AI in game production and look forward to its future development trends.

This article introduces three different types of AI-assisted game design methods: reinforcement learning-based methods, generative adversarial network-based methods, and convolutional neural network-based methods.

In the field of game plot generation, researchers have proposed several innovative methods based on machine learning. First, the reinforcement learning-based method allows AI agents to learn to generate the best game plots through interaction with the environment, and optimize the generation quality based on player feedback to provide players with a personalized gaming experience. Second, the method of using generative adversarial networks (GANs) can produce high-quality, realistic game content, break through the limitations of rule-based games, and generate a unique gaming environment. Third, convolutional neural networks, with their powerful visual perception capabilities, can help AI agents understand and analyze game scenes, provide important contextual basis for plot generation, and combine reinforcement learning to learn the optimal decision-making strategy. These innovative machine learning-based methods have opened up new possibilities in the field of game plot generation. From the perspective of difficulty and implementation, there are still some differences in these three directions. (Andrew, James, 2024) The first and second are relatively more feasible, while the third may require more technical breakthroughs.

2 GAME LEVEL RECOMMENDATION METHOD AND DEVICE BASED ON REINFORCEMENT LEARNING

Reinforcement learning is an innovative method of machine learning that allows intelligent agents to complete tasks through interactive learning with the environment. The agent first observes the state of the environment, selects and executes actions, and obtains corresponding reward feedback. Although there is no pre-labeled training data and no evaluation of each action, the agent can learn from the lagged overall feedback and ultimately obtain the optimal decision-making strategy to obtain the maximum cumulative reward. This learning model is suitable for many application scenarios that require autonomous learning, such as autonomous driving and robot control, and provides new possibilities for the development of these fields.

The goal of this chapter is to give a case study of game reinforcement learning applications and to explore in depth the working mechanism and failure reasons of reinforcement learning algorithms in practice. Although these algorithms can converge to the optimal strategy under ideal conditions in theory, these ideal conditions are often difficult to meet in complex game environments, so it is necessary to further study the performance of reinforcement learning in practical applications.

In addition to the algorithm itself, other factors such as the choice of representation, the encoding of domain knowledge, and heuristic methods also have an important impact on the application effect of reinforcement learning in games.

This example provides a game level recommendation device and method based on reinforcement learning as shown in Figure 1. The device includes:

A state input unit, which collects game-related data of the player.

A first neural network, which recommends game levels of matching difficulty to the player based on the game-related data collected by the state input unit.

A second neural network, which generates evaluation information based on the game-related

data collected by the state input unit and the game levels recommended by the first neural network.

And a parameter updating unit, which updates the first parameter of the first neural network and the second parameter of the second neural network based on the evaluation information. Through the embodiment of the present application, game levels of appropriate difficulty are adaptively recommended to players (Zhu, 2023).

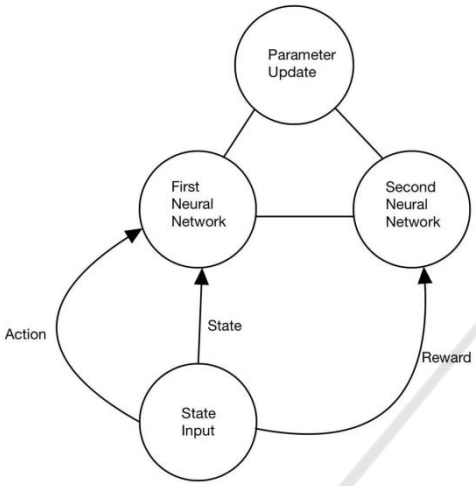

Figure 1: Device diagram (Picture credit: Original).

Therefore, adaptive deep reinforcement learning is used to dynamically and real-time adjust and match the game difficulty according to the player's skill level and game status, so that the player's skill level and the difficulty of the game level are fully matched, allowing the player to obtain a satisfactory gaming experience.

3 ANIME-STYLE GAME BACKGROUND GENERATION METHOD AND PLATFORM BASED ON GENERATIVE ADVERSARIAL NETWORK

Next, the paper will give a specific example involving the field of robot control, and more specifically, a method and platform for generating anime-style game backgrounds based on generative adversarial networks.

3.1 Specific Steps

First, a dataset of game background images is constructed. Each scene contains images at three different time nodes, and each image is labeled with attributes. Next, a color transfer network for generating color segmentation maps and a style reconstruction network for reconstructing anime style maps are constructed. The pre-trained Visual Geometry Group (VGG) network and Gram matrix loss function are used to optimize the structure and style of the generated images. In the model preparation stage, Python is used to create a generative adversarial network for anime style transfer. The edge detection and image segmentation algorithms are used in the input stage to generate line drawings and color block drawings of photos, which are combined with anime style pictures for unsupervised training. Then, a conditional generative adversarial network is used to perform color transfer on the color segmentation map of the photo. The color block map is combined with the time node label and input into the generator to generate images at different time nodes. Finally, the edge extraction and color segmentation algorithms are used to process the training pictures, and the network models of the color transfer and style reconstruction stages are established. The photos and time node labels are input into the generator to generate the target anime style game background images (Liu, Wang, Zhu, 2022).

Generators G1 and G2 are composed of two parts: encoding and decoding. The encoding part includes a fully connected layer, a downsampling layer, and multiple residual blocks, and the decoding part includes an upsampling layer and a fully connected layer. Each time the sample is downsampled, the feature map size is halved, and each time the sample is upsampled, the feature map size is doubled.

G1 is responsible for converting the color segmentation map of the photo into the color features of a specific time node. The photo and time tag are input into G1, and the color segmentation map that conforms to the time semantics is output. Discriminator D1 determines whether the input is an anime color segmentation map.

G2 is responsible for encoding and decoding the line map and the color segmentation map into a complete anime-style picture. The line map of edge detection and the color segmentation map output by G1 are spliced and input into G2, and the target anime-style background is output. Discriminator D2 determines whether the input is an anime picture.

The framework is implemented through two generative adversarial networks. G1 and D1 are trained first, and then G2 and D2 are trained, and finally an anime-style game background is generated.

3.2 Analysis

This method uses the powerful ability of generative adversarial networks to convert the color and style features of images into anime styles, providing a new solution for game background generation. The generator uses the encoding-decoding structure to fully explore the potential features of the image, and the discriminator ensures that the output results meet the requirements of the anime style. This end-to-end learning method saves a lot of manual design and debugging, and can greatly improve the efficiency of game background generation. However, in practical applications, some key technical problems still need to be solved, such as how to further improve the authenticity and diversity of the generated effects, and how to achieve the deep integration of automatic generation and manual creation.

Table 1 below is a comparison table of the generation effects of this example and various methods. Each group of rows from top to bottom are the outputs under the daytime, dusk, and night labels. The lower right corner of each image in the output result of NST is the selected style image. When the style map is selected appropriately, good results can be output, but in practical applications it is difficult to ensure that each photo input has a suitable style map. The output result of CycleGAN has the color of anime pictures, but the texture is too complex, and it is impossible to generate images with different time features. MUNIT can generate style images with different time features, but the images generated by MUNIT have largely lost the original image structure. Based on CartoonGAN, the paper adds temporal condition input and name it CartoonGAN. Its output image has temporal features, but the color is dim and the texture is not smooth enough.

Table 1: Comparison results (Liu, Wang, Zhu, 2022).

Way	NST	Cycle GAN	MUNIT	Cartoon GAN	ECartoon GAN	Result
Cartoon Style	234.32	154.16	144.37	117.22	80.2	72.48
Cartoon Daytime	276.41	212.37	217.95	163.97	158.50	143.87
Cartoon Dusk	255.35	223.7	214.06	171.39	159.32	145.19
Cartoon Night	238.69	209.27	215.95	167.48	162.53	153.69

3.3 Result

This example outputs colors with different temporal features and smooth textures. The lines of the fences and branches on the road become straight, and the distant view is filled with a uniform atmosphere color, which is a technique often used in game original painting. In order to make the evaluation more objective, the FID distance indicator is used to evaluate the quality of the generated image. FID is an indicator used to evaluate the effect of image processing. It uses a pre-trained ImageNet model to extract high-level features of the image and calculate the distance between the two image domains. When calculating FID for anime image domains with different temporal features, CycleGAN and CartoonGAN each use the same output domain, while other methods use the output of each group of specific time labels and the corresponding anime time feature domain for calculation. Therefore, this example not only achieves the best results in the anime style FID indicator, but also achieves the best results in the comparison of FID indicators in each temporal feature domain.

4 DESIGN OF AI FOR THE DARK SOULS GAME BASED ON CONVOLUTIONAL NEURAL NETWORK

Game developers are trying to apply artificial intelligence and machine learning to games to improve the behavioral logic of game characters and the adaptability of the game difficulty curve, so that the behavior of virtual characters is closer to that of intelligent creatures, thus enhancing the player's sense of involvement and achievement.

In terms of game screen data training, this example uses an improved convolutional neural network model, such as AlexNet, to achieve efficient and accurate model training effects. Taking "Dark Soul" as an example, it shows how to use deep learning technology to enable game characters to achieve automated and adaptive attack and defense, and create virtual characters that are closer to human behavior. Through artificial intelligence and machine learning technology, game developers are working hard to improve the intelligence level of game characters and enhance players' gaming experience. This is a vibrant research direction (Kusiak, 2019).

Through methods such as Canny edge detection algorithm and color space compression, the numerical processing of the game UI is realized, and Grab Cut technology is used to extract the main body of the image, accumulating a large amount of data for

subsequent model training. Based on deep learning, the AlexNet model was selected as the basis, and through hyperparameter tuning, the error function of the model was significantly reduced and the performance was improved. The trained program was applied to the actual game environment for testing, which verified that the proposed game AI can simulate some of the player's behaviors in the game.

This research makes full use of computer vision and deep learning technology to achieve preprocessing and efficient modeling of game UI data, providing strong support for the intelligence of game characters. Through verification in actual games, the effectiveness of the proposed method is also proved. This idea of applying artificial intelligence to game development helps to promote the intelligence of game character behavior and the optimization of game experience.

4.1 in Terms of Image Preprocessing

The following image preprocessing measures provide a high-quality data foundation for subsequent model training.

Using the Canny edge detection algorithm, blood bar information is extracted from the game UI, and the character blood volume value is obtained by analyzing the edge ratio. The Canny algorithm includes Gaussian filtering, gradient calculation, weak edge suppression, and hysteresis processing.

In order to reduce the computational complexity, the RGB color space is converted to the grayscale space A, and the image subject is highlighted by increasing the contrast. Specifically, the formula

$A^* = A \pm 1.3\sigma$ is used for transformation.

The GrabCut algorithm is used to extract the image subject. The algorithm uses image texture and boundary information to achieve interactive image segmentation through the minimum cut algorithm.

4.2 in Terms of Model Training

This study chose to use the Adam optimization algorithm. Adam is a stochastic optimization method based on adaptive learning rate. It has the advantages of simple implementation, high computational efficiency, and low memory requirements. It is very suitable for processing large-scale data and parameter optimization problems. Adam calculates the adaptive learning rate of different parameters by estimating the first-order and second-order moments of the gradient. It has the advantage of convergence speed in the online optimization framework, and its effect is better than other stochastic optimization methods in practice. Based on these advantages, this study chose to use the Adam optimization algorithm when optimizing the model loss function. The specific implementation details of Adam can be found in relevant literature and will not be repeated here (Wang,2022).

In general, the use of an efficient Adam optimizer in the model training stage helps to improve training performance and accelerate model convergence. This lays the foundation for the efficient training of game AI systems.

Implementation under the Tensor flow framework This paper simplifies the behavior of game characters into four types as shown in Table 2, which is the output of this set of vectors after the grayscale matrix is input into the entire convolutional neural network.

Then select the Adam optimizer for training. Select 100 batches in 20 epochs for iteration. It can be seen that as the number of training times decreases, the value of Loss Function continues to decrease. The Loss Function selected here is the cross entropy of the entire classification. This value can reflect the difference information between two probability distributions in Shannon information theory.

Table 2: Game character behavior.

Name	The corresponding vector	The corresponding button	Action
Attack	{1,0,0,0}	Left key	Cause damage to non-defensive enemies
Plus shield defense	{0,1,0,0}	Right key	Avoid opponent damage when you have enough energy
Roll to avoid	{0,0,1,0}	Space	Avoid enemy damage and distance
Drink element bottle	{1,0,0,1}	R	Reply HP

4.3 Actual test results of the model

During the game, Researchers can continuously take screenshots and let the previously trained model make predictions to give the operations that should be performed at this time. Researchers can also use Python programming to simulate the corresponding key presses on the keyboard to test the actual effect of the game AI here.

Hold the shield to defend and roll backwards when the enemy attacks. As shown in Figure 2.

Figure 2: Attack game action (Wang, 2022).

It can be found that when the model captures the enemy in the picture and shows an attacking tendency, it allows the player to adopt a defensive or backward rolling evasion strategy with a certain probability.

Active attack when the enemy is in a non-defense state, it can be found that when the model captures the enemy in the picture, it will actively attack the enemy in a non-defense state. As shown in Figure 3.

Figure 3: Non-defensive game moves (Wang, 2022).

5 CHALLENGES AND PROSPECTS

In fact, AI+games are facing some challenges, but their future development prospects still exist.

First, at the technical level, the application of new technologies such as AI needs further breakthroughs and maturity, and its application in game production, interaction, etc. needs further exploration and verification. At the same time, fluctuations in policy and regulatory environment may also affect the development of AI in the game field. In addition, there is uncertainty as to whether the recovery process of the game accommodation end continues and whether the application of AI technology can continue to keep up with the changing market demand.

But on the other hand, with the continuous breakthroughs of AI technology in content production, personalized experience, etc., AI+games will become an important driving force for the development of the industry. Under the general environment of policy support and revenue recovery, the application of AI in game production, operation and other links will be further deepened, bringing players a more immersive and interactive game experience. In the next five years, Shanghai Pudong New Area will invest more than 10 billion yuan to support content research and development and technological innovation in the game industry, which will inevitably drive AI+games. Overall, although AI+games are still facing some challenges, their development prospects are still valid. The dual-wheel drive of technological innovation and policy support will promote the wider and deeper application of AI in the field of game realization, bringing new innovation and development momentum to the game industry.

Overall, with favorable policies and continuous improvement in the input side, the deep integration of artificial intelligence and games will surely promote exciting innovation and development in the game industry. Game companies can further explore the potential of artificial intelligence in game production and operation, bring players a more immersive and interactive gaming experience, and promote the high-quality development of the entire industry. Overall, with favorable policies and continuous improvement in the input side, the deep integration of artificial intelligence and games will surely promote exciting innovation and development in the game industry. Game companies can further explore the potential of artificial intelligence in game production and operation, bring players a more immersive and interactive gaming experience, and promote the high-quality development of the entire industry. (CGIGC, 2024)

The application of AI in games is still in its infancy, and many legal, ethical and technical obstacles need to be resolved. At present, the legal ownership and copyright protection of games that use AI to generate assets are unclear, which makes it difficult for existing intellectual property owners to use third-party AI models in their production processes. However, the opportunity lies not only in making existing games faster and cheaper, but also in creating new AI games. With systems like generative agents, personalization, AI narratives, dynamic world building, and AI co-pilots, the paper may be on the verge of seeing the first “never-ending” game created by an AI developer.

6 CONCLUSION

In summary, this article reviews three existing methods for game-assisted design using artificial intelligence technology: methods based on

reinforcement learning, generative adversarial networks, and convolutional neural networks. These technologies help to automatically generate game content and provide a more user-friendly game creation environment for ordinary users.

Artificial intelligence technology has made great progress in the field of games. Starting from the success of reinforcement learning algorithms in the classic game TD-Gammon, AI technology has been widely used in various games, including video games, real-time strategy games, first-person shooters, and role-playing games. Although the success of TD-Gammon cannot be repeated in every game, there are still many promising results and valuable lessons to learn.

In terms of image generation, deep learning-based methods show great potential. With the popularization of the Internet, users can easily generate game backgrounds through a browser. This method can effectively convert the input image into anime-style game background images and differential images under different time conditions while maintaining clear edges. At the same time, the friendly user interaction interface and the web platform based on familiar interaction logic greatly improve the user experience.

Convolutional neural network is also an effective game AI design method. The game UI is processed by edge detection techniques such as Canny operator, image memory is reduced, and a convolutional neural network model based on AlexNet is constructed to simulate player behavior. Although this method performs well in actual game environment tests, it may have certain limitations in processing sequence data and dynamic decision-making and model interpretability compared to reinforcement learning and generative adversarial networks.

Generative adversarial networks are good at learning from existing sample data and generating new game materials, which improves the speed and accuracy of training. However, this method is difficult to train, prone to problems such as mode collapse, and the generated content may be unreasonable, and the computing resources required are also high.

In actual game design, multiple AI technologies are usually combined to give full play to their respective advantages to achieve better results and experience. In general, the use of artificial intelligence for game concept design and iterative optimization has injected new vitality into the game industry and provided valuable opportunities for the creative process.

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