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Overview of the application of artificial intelligence in computer animation

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Abstract. With the flourishing development of artificial intelligence and computer animation technologies, there has been an increasing intersection between these two. In the field of computer animation, the use of artificial intelligence significantly reduces the difficulties in design, production, and post-production processes, which has a massive impact on the entire field. The paper attempts to discuss the relationship between artificial intelligence and computer animation. Not only does the paper elaborate on the related applications of artificial intelligence in various subfields of computer animation, but it also analyzes existing problems and future development trends. The research indicates that AI has achieved significant breakthroughs in computer animation, such as auto-generation of animations, real-time character driving, and emotionally responsive animation creation. However, it also faces challenges like handling interactions in complex scenarios, maintaining realism, and animating high-level abstract concepts. Despite these challenges, it is believed that in the future, AI will further propel the development of computer animation, aiding creators in producing animations that are more vibrant, intricate, and personalized.

Keywords: Computer Animation, Artificial Intelligence, Deep Learning, Neural Network.

1. Introduction

As highlighted by Hoden et al., AI's applications have penetrated various industries, one notable example being computer animation [1]. Concurrently, computer animation has undergone significant evolution, transitioning from simple 2D images to intricate 3D renderings that mimic real-world physics [2]. In the realm of this research, Smith utilized deep learning methods to generate the facial expressions of animated characters [3]. His results indicated a marked advancement in elevating the realism of animations. Meanwhile, Lee approached the subject from the perspective of physical modeling, applying reinforcement learning theories to simulate object movements in animations, which underscored AI's advantage in simulating object collisions and dynamics [4]. As a result, the paper delves into the current status and further advancement of AI applications within the computer animation field. To begin with, the paper traced and analyzed the history and progression of AI applications in computer animation from the early stages to the present to find out what the historical evolution of AI's integration into computer animation is. Then, respectively, examine the application of AI in various aspects of computer animation, such as modeling, rendering, and special effects, to solve the question of how AI has been applied in those fields. Next, based on the question that how AI influenced the quality, efficiency, and creativity

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in the production of computer animations, the author assess the impact of AI applications on the overall quality, efficiency, and creativity of computer animations, drawing on case studies and industry examples [5]. Finally, the paper will identify and discuss the existing problems faced in the implementation of AI in computer animation and anticipate future trends based on current advancements to discuss what the current issues and future trends are in the application of AI in computer animation.

2. Concepts of artificial intelligence and computer animation

2.1. Development history of artificial intelligence

In 1942, with the publication of “I, Robots”, people started to focus on the theory and foundational concepts of AI. Then, the Dartmouth Conference in 1956 marked the formal beginning of the field of AI, defining its main goals and expectations [6]. Right after that, Frank Rosenblatt proposed the concept of the perceptron and constructed the electromechanical model "Mark I" of the perceptron in 1957. The Perceptron uses a supervised learning algorithm to iteratively solve linear binary classification problems, greatly expanding the types of problems that machines can solve.

However, in 1969, Marvin Minsky and Seymour Papert wrote a book called "Perceptrons," in which they questioned Rosenblatt's perceptron. This is because a single-layer perceptron is essentially a linear classifier and cannot solve nonlinear classification problems. This limitation of the single-layer perceptron led to skepticism about connectionism, and combined with the stagnation of practical applications of AI, the first AI winter arrived. Minsky's criticism of the perceptron even led to a decade-long stagnation in neural network research.

Since the 1990s, with an increase in computational power, AI has started to rebound. At the beginning of the 21st century, deep learning began to rise, sparking an algorithm revolution [7]. With the rapid development of the Internet, mankind has entered the era of big data, providing a vast application space for the development of artificial intelligence. At the same time, the emergence of new software and hardware platforms has spurred a computing power revolution.

The need for processing large amounts of data has driven the revolutionary development of GPU clusters, big data clusters, and even dedicated AI chips. The increase in computing power has expanded the exploration space for algorithms, with compute-intensive algorithms like reinforcement learning and AutoML continually making breakthroughs. Various neural network variants also continually emerge; complex models like convolutional neural networks (CNNs), recurrent neural networks (RNNs), long short-term memory networks (LSTMs), and so on increasingly require high-quality and large quantities of training data. Meanwhile, the continuous development of the Internet provides ample data sources and efficient annotation tools and platforms, leading to the generation of many high-quality public datasets.

Algorithms, data, and computing power complement each other, propelling the development of artificial intelligence onto the fast track and giving birth to the current boom in artificial intelligence technology.

2.2. Development history of computer animation

The origins of computer animation can be traced back to the 1960s, when computer animation was primarily used for scientific research and military simulation. In 1961, Edward E. Zajac created a simple computer animation depicting the orbit of a satellite, which is now considered the first computer animation [8].

In the 1970s, computer animation began to appear on television and in movies. Initially, it was used for opening sequences, titles, and special effects. During the 1980s to 1990s, computer animation technology became more matured and began to be widely used in various animated films and video games. During that period, Pixar Animation Studios released the first computer animated films known as “Toy Story”, thereby establishing the place of computer animation in the film industry [9].

In the 21st century, with the enhancement of computing capabilities, which derived from the computing power revolution, computer animation has developed to unprecedented levels of detail and

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realism. And now, the use of AI technology has made the behavior of animated characters more natural and realistic [10].

2.3. Intersection of Artificial Intelligence and Computer Animation

AI is used to generate realistic animated character behaviors, which can save tons of modeling time. In addition, AI plays an important role in the animation rendering process; it could generate realistic images by simulating the propagation of light and the physical properties of object surfaces [11]. This idea is achieved through various technical means. One important technology is machine learning, which involves training models to learn and understand animation data, such as the behaviors and expressions of animated characters. Additionally, deep learning is another important area where artificial intelligence and computer animation intersect. For example, generative adversarial networks (GANs) are a type of deep learning model that can generate realistic images, including animations. Moreover, deep learning is also used to produce complex environmental effects [12].

3. Applications of artificial intelligence in computer animation

3.1. Application of artificial intelligence in character behavior modeling

Creating believable and convincing character behavior has always been one of the great challenges in the field of computer animation. Though this task is pretty hard for humans, AI can play a better role in this area. For example, recurrent neural networks (RNNs) and other deep learning techniques can generate highly realistic dynamic character animation [13]. When creating animation sequences for complex 3D characters to walk, run, or jump, traditional methods might require frame-by-frame manual drawing or rely on captured animation data. However, by using an RNN, one can train a model to learn from existing animation datasets. Once this RNN model is well-trained, just by feeding it an initial pose and a target action, it can generate a sequence of continuous, realistic character movements. Furthermore, the introduction of reinforcement learning also endows our animated characters with the ability to decide and act by themselves, enabling them to adapt to unknown environments and situations [14]. These technologies are particularly valuable in video games as they allow characters to adapt to the complex environment and high dynamics of the genre.

Speaking of game production, “AI Behavior trees” can’t be ignored, which is another widely used AI technology. “AI Behavior trees” can simulate the decision-making process of characters and is widely used in video games and animated films [15]. Behavior tree models often have a clear structure and are easy to understand and implement. But they still can represent complex behaviors and adapt to environmental changes, enabling characters to make dynamic decisions based on the environment with only little computational power.

3.2. Application of artificial intelligence in animation rendering

The application of artificial intelligence in animation rendering is particularly notable. Traditional rendering techniques usually consume tons of time and computational resources in order to generate realistic images. However, deep learning technology, especially generative adversarial networks (GANs), has offered us a game-changing tool. GANs consist of two interacting networks: a generator and a discriminator. The generator aims to create images that are as realistic as possible from random noise, while the discriminator's target is to distinguish between generated images and real images. It offers a swift and iterative workflow, allowing artists and engineers to see their modifications in real-time, achieving the desired visual outcomes more quickly instead of waiting hours or even days for a high-quality render [16]. Furthermore, neural networks have demonstrated great potential in understanding and simulating the propagation of light in 3D environments, based on which NVIDIA has produced its RTX GPU, which can implement real-time ray tracing at the hardware level [17].

In addition, some studies have used AI technology to optimize the rendering process. For instance, machine learning can be employed to predict the possible noise in the rendering process, thereby improving the rendering speed without sacrificing image quality [18]. In the field of anti aliasing, there

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is a new technology called DLSS (Deep Learning Super Sampling), which reduces the rendering resolution within the game and uses AI algorithm models and AI acceleration hardware units to stretch the output screen and improve the display resolution. We can have a better resolution without losing the frame rate. Notably, when it comes to the phenomena in nature, such as fire, water, smoke, and more, which are considered challenging to simulate in computer graphics, AI always has a better understanding and simulation [19].

3.3. Application of artificial intelligence in editing and special effects

Nowadays, AI can automatically recognize and edit key frames and key events in videos, greatly reducing the workload and technical requirements of video editing. A great example is Google's AutoML Video Intelligence model, which can not only recognize the key frames but also edit them automatically. In terms of special effects, AI can help creators quickly achieve complex visual effects, such as color correction, style transfer and so on. Adobe After Effects 'Content-Aware Fill uses AI algorithms to automatically recognize and fill in blank areas in videos, achieving seamless video special effects [20]. These applications not only greatly improve the efficiency of animation production, but also open up new creative spaces for the engineers to free up their hands and make more creative and exciting works.

4. Development trends and issues of artificial intelligence in the field of computer animation

4.1. Trends of artificial intelligence in the field of computer animation

In the 21st century, the field of computer animation continues to evolve rapidly with the advancement of artificial intelligence. Firstly, the most focused development at present is the automation of character behavior. Machine learning models can analyze and learn from real-world human motion data, thereby further improving the continuity and realism of actions in character animation design [21]. Now, the latest technology has come to the era of deep fakes and animation generation. We can even generate corresponding videos by just giving a few keywords, or directly replacing one person's face with another person's face. Although the current limitations are still relatively large, there is still huge room for development.

4.2. Problems encountered by artificial intelligence in computer animation

If an AI model wants to be trained effectively, vast amounts of data are required. However, obtaining high-quality animation data for training can be challenging; in many cases, we cannot collect that amount of data for the model training. Even trainers could have the data; overfitting is another great problem. No one can say that AI predictions are 100% correct; the accuracy of AI predictions has reached a threshold. So many problems exist, such as the difficulty in capturing nuance since capturing the subtleties and nuances that human animators bring can be challenging, and there are always concerns about ethical problems because the rise of deepfakes and other AI-generated content can blur the lines between reality and fiction.

5. Summery and outlook

The application of AI in character behavior modeling, real-time rendering, editing, and special effects showcased the transformative power of algorithms and machine learning models. Looking forward, the horizon of AI in computer animation seems limitless. As algorithms become more refined and datasets more comprehensive, people can anticipate more fascinating animations than ever. Challenges, such as reaching a plateau in AI prediction accuracy, will surely arise. Yet, these will propel researchers and animators to innovate further, ensuring that the symbiosis between AI and animation remains dynamic. The paper provides a detailed overview of the application and evolution of artificial intelligence in the field of computer animation, but there are still some deficiencies in terms of data and evidence. While the article covers the intersection of artificial intelligence with computer animation, it lacks a deep exploration of certain specific technologies and their precise applications. Furthermore, ethical issues

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arising from AI are only briefly mentioned in the text. The use of AI-generated content in computer animation, especially deep fake technologies, may have serious social and cultural implications. This is also an important area that deserves further exploration. Considering these shortcomings, future research can further validate how AI affects the quality, efficiency, and creativity of animation through actual experiments and case studies.

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