The Paradigm Reconstruction of Popular Singing Skills under Digital Ecology — Taking Virtual Idols as an Example

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Abstract: As an emerging form of music performance under the digital ecology, virtual idol integrates various high-tech means, such as holographic projection, motion capture, augmented reality (AR), virtual reality (VR), and online live broadcasting and interaction. These technologies not only enable virtual idols to present highly realistic images and dynamic performances, but also bring audiences to an immersive audio-visual experience and the opportunity to interact directly with the idols. Holographic projection technology makes virtual idols stand on the stage like real people, while motion capture technology realizes the smooth and natural movements of virtual idols. Augmented reality technology brings the audience a unique visual effect of combining virtual and real conditions, while virtual reality technology provides an immersive viewing experience. In addition, online live broadcasting and interaction have become an important bridge between virtual idols and fans, enabling fans to participate in the singing and interaction of virtual idols in real time. These diversified forms of performance not only enrich the music content of virtual idols, but also bring new opportunities for the development of the music industry.

***Keywords*:** digital ecology, Pop singing skills, paradigm reconstruction, virtual idol

1. Introduction

1.1 The impact of digital ecology on the music industry

The rapid development of digital ecology has had a far-reaching impact on the music industry, and each link from creation, production, dissemination to consumption has experienced significant changes. The widespread use of digital audio workstations, virtual instruments and speech synthesis technologies has lowered the threshold of music creation [1]. With the popularity of digital creation tools, more people are able to participate in music production, especially in the era of artificial intelligence development, AI technology can assist in generating melodies, harmonies and even lyrics, providing inspiration and technical support for creators, and at the same time giving rise to new forms of musical expression. The virtual idols emerging in this context have become a new vehicle for music creation through voice synthesis and 3D modelling technology, and their singing skills and stage performance are highly dependent on breakthroughs in digital technology. While traditional singers have broken through physical limitations, digital platforms such as NetEase Cloud Music and Apple Music have replaced physical records as the main distribution channel, changing the traditional record sales model, and music works are more likely to reach a global audience through short-video platforms such as TikTok and algorithmic recommendations, which has greatly enhanced the speed and breadth of music distribution.

In the digital ecosystem, musicians can release their works directly through the Internet without relying on traditional record companies, forming a more open and diversified music market. Based on big data and artificial intelligence recommendation algorithms, the platform can provide personalised song lists based on users' listening habits, enhancing their music consumption experience. Virtual idol concerts provide an immersive and interactive experience through holographic projection and virtual reality technology, and audiences can also participate in the performance through pop-ups and virtual gifts. Music is no longer limited to the traditional listening scene, but is also deeply integrated with games, live broadcasts, short videos and other forms of entertainment, expanding the application scenarios of music.

With the digital integration of the music industry ecosystem, all links in the industry chain from creation, production, distribution to marketing have been digitally upgraded, and music copyright management has become more transparent while improving efficiency and reducing costs. The application of blockchain technology provides new solutions for copyright protection and revenue distribution. The development of emerging business models such as virtual idols, digital albums and virtual concerts has brought new growth points to the music industry, while changing the traditional profit model.

Online music courses, virtual instruments, teaching software and other digital education tools make music learning more convenient and efficient, and at the same time, it also promotes the integration of music education and technology education[2] . Digital ecology breaks regional restrictions, promotes music from different backgrounds to be spread to the world

quickly, and promotes the diversity and integration of music culture. As a representative of digital culture, virtual idols can cross languages and break cultural barriers, and attract global fans to become a new carrier of cultural output.

1.2 Paradigm reconstruction of pop singing skills in the digital ecology

Through speech synthesis technology, virtual idols can realize diversified timbre design, create a unique singing style, and break through the timbre restrictions of traditional singers. With the development of artificial intelligence, AI technology can optimize intonation, rhythm and emotional expression, making the singing of virtual idols more accurate and expressive. Moreover, the concert of virtual idols provides audiences with an immersive audio-visual experience through holographic projection and virtual reality technology, redefining the expression form of singing skills. The emotional expression of virtual idols depends on algorithms and data analysis[3] . Therefore, digital emotional transmission is realized by simulating human emotional characteristics, and singing skills are further digital expressed. According to the needs of the works and the audience, virtual idols can quickly adjust their singing style, showing a high degree of flexibility and personalization. In addition to its vocal singing skills, Rhino wants to further achieve a multi-dimensional interaction with the audience through cross-media interaction, through motion capture, facial expressions, and virtual stage design. Through working with real singers, the two learn from each other in singing skills and form a new form of artistic expression. Traditional singers can improve their singing skills through digital tools.

1.3 The rise of virtual idols and their challenges to popular singing skills

The rise of virtual idols is due to the rapid development and mature application of voice synthesis technology, 3D modelling technology, motion capture technology and artificial intelligence technology. Through these technologies, virtual characters are able to sing in a highly realistic form. Virtual idols represented by Hatsune Miku have rapidly accumulated a large fan base worldwide and become an important part of pop culture [4]. Virtual idols are not only successful in the field of music, but also involved in advertising, games, live broadcasting and other fields, showing strong commercial potential.

The popularity of virtual idols has also brought new challenges to pop singing techniques: their singing is not restricted by human physiological conditions, and they can easily achieve ultra-high range, complex timbre and uninterrupted singing; their emotional expression through algorithms and programming is very different from the traditional singer's interpretation based on real emotional experience. In the form of performance, the virtual idol relies on holographic projection, virtual reality and other technologies, so that the audience experience extends from pure hearing to visual and interactive multi-dimensional space. The deep fusion of technology and art makes virtual idols achieve an effective balance between technological expressiveness and artistic infectiousness.

2. Digital ecology and the rise of virtual idols

2.1 Definition and characteristics of digital ecology

Digital ecology refers to the construction of a highly interconnected, intelligent and digital ecosystem with digital technology as the core and through Internet big data, artificial intelligence, blockchain and other technological means. In the music industry, digital ecology covers the whole process from music creation, production, and dissemination to consumption, and forms a new technology-driven and user-centered industrial model[5] . The technology-driven transformation of the music industry is mainly reflected in the digitalization of creation tools, intelligent production process, virtualization of performance forms, and data-driven decision-making. At the same time, music creation, communication and consumption patterns have changed fundamentally. Internet musicians can transcend geographical restrictions and cooperate with creators around the world to form a variety of music styles, and encourage ordinary users to participate in music creation through open platforms. Recommended by the algorithm based on big data artificial intelligence, and personalized playlists for users according to their listening habits. The communication mode is more efficient and decentralized, the consumption mode is more personalized, and the scene provides infinite possibilities for the innovation and development of music art.

2.2 Development process and current situation of virtual idols

Virtual idols are digital characters created through computer graphics, speech synthesis technology, motion capture, and artificial intelligence technology. These characters have anthropomorphic appearance, personality, voice, and are capable of extended performance and interaction. According to the technical implementation mode and functional characteristics, virtual idols can be divided into voice synthesis virtual idols, reality-driven virtual idols AI autonomous virtual idols, and cross-media virtual idols. Among them, the speech synthesis virtual idol, represented by Hatsune Future Luo Tianyi, mainly relies on the speech synthesis technology for singing. Its voice is generated by the algorithm, which can realize a variety of timbre and styles. The human driven virtual idol controls the movements and expressions of the virtual characters by the

real actors through the motion capture technology. AI autonomous virtual idols are based on artificial intelligence technology, which can learn and interact with themselves, such as Harbin in China. Cross-media virtual idol, not only active in the music field, but also involved in games, animation, advertising in many fieldsHatsune Miku (Hatsune Miku): Launched by Crypton Future Media in 2007 and based on Vocaloid speech synthesis technology. With its iconic double ponytail image and electronic timbre, it quickly became a world-famous virtual icon.

He has held a number of holographic projection concerts and cooperated with a number of international brands, becoming an important representative of Japanese cultural export. Kizuna AI (Tie-up Love): The Japanese virtual YouTuber, launched in 2016, is considered to be a combination of virtual idol and human-driven technology. With its lively personality and high interactivity, it has attracted a large number of fans, creating a new virtual YouTuber. Cooperate with a number of enterprises, launched their own music works and peripheral products. SUA (South Korea): Launched by South Korean AI company Pulse9, based on artificial intelligence technology. Ability to learn and interact independently, showing highly anthropomorphic behavior patterns. Has accumulated a huge following on social media.

2.3 The influence of virtual idols on pop music

Virtual idols have had a profound influence on pop music.

Because virtual idols are not restricted by human physiological conditions, they are able to demonstrate singing skills beyond reality and achieve personalised customisation according to users' needs, which not only broadens the possibilities of musical expression, but also meets the audience's pursuit of diversified and personalised music content. Virtual idols innovate music forms through the combination of technology and art, which can bring a brand new audiovisual experience and promote the transformation and upgrading of the music industry while enriching the types of products in the music market. With the innovative development of advanced technologies such as motion capture, AI generation, deep convolutional neural network, and the further maturation of voice synthesis technology, virtual idols are provided with stronger technical support - these technologies not only make the image of virtual idols more realistic and their movements more natural, but also give them the ability to adjust their performance and interaction in real time according to pop-ups. The ability to adjust the performance and interaction in real time according to the pop-ups is also given to the virtual idol.

The rapid development of the idol market can meet the actual needs of fans for high-quality content, and promote the continuous upgrading and innovation of relevant technologies. At the same time, technology and art promote each other and develop together, bringing new development opportunities for the music industry.

3. The traditional paradigm of pop singing skills

3.1 The core elements of traditional pop singing skills

The core elements of traditional pop singing skills cover a variety of dimensions such as breathing control, vocal techniques, pitch and rhythm, emotional expression, diction, stage presence and tonal diversity. Breathing is the foundation of singing, and good breathing control through abdominal breathing deeply mobilises the diaphragm to ensure the stability and durability of the voice; scientific vocal techniques need to flexibly use the head voice, chest voice, mixed voice and other different vocal styles, which can not only protect the vocal cords but also optimise the performance of the sound quality. Accurate pitch and rhythm directly affect the effect of musical expression, through auditory training and rhythmic exercises to enhance the sensitivity to pitch and beat, to ensure the accuracy of singing.

As the soul of music, emotion requires singers to deeply understand the lyrics and the emotional core of the melody, and to realise the transmission of emotion through dynamic changes in voice strength, speed and pitch. Clear diction can strengthen the infectiousness of the song, and it is necessary to pay attention to the pronunciation of vowels and consonants to ensure the accuracy and infectiousness of the lyrics. Stage performance is enhanced by body language, facial expression and interaction with the audience, which enhances the vividness and attractiveness of the performance. Tone diversity gives the music a sense of hierarchy and richness, the singer needs to be based on the style and emotional needs of the song, through the flexible use of different tone techniques, to create a diversified voice expression.

3.2 Limitations of traditional singing skills

Traditional singing skills have accumulated rich experience and unique charm in the long-term artistic practice, but there are certain limitations. First of all, in terms of skills and expression, the traditional singing method pays more attention to the vocal system, which resonates through the head cavity and chest cavity and conveys the voice. It will limit the singer's diversity in the vocal range and timbre.

Traditional singing techniques have multiple limitations in practice: some singers have technical bottlenecks in pitch

and resonance control in the treble and bass registers, making it difficult for them to steadily master wide-range works. The solidified skills system in traditional vocal education (e.g. breath control, resonance chamber application, etc.) has been trained in a long-term mode, resulting in a high threshold requirement for singers' voice conditions - beautiful tone, even range and other innate endowments have become important screening criteria, objectively restricting the universality of the technique. At the same time, with the diversification of music styles, modern pop music is constantly innovating and breaking through in terms of rhythmic patterns, melodic directions, harmonic arrangements, etc., traditional singing techniques are facing challenges in terms of technical suitability, resulting in compatibility barriers with the expression needs of some pioneering music works.

Due to the relative solidity of traditional singing techniques in terms of timbre presentation and style interpretation, and the lack of diversity and innovation, the long-term monotonous listening experience is prone to aesthetic fatigue of the audience. What's more, modern music performances emphasise more and more on interactive and immersive experiences, while traditional techniques focus too much on the display of professional skills of singers, and there is an obvious lack of real-time interactive design and multi-dimensional sensory stimulation, which makes it difficult for audiences to get a deep sense of participation and emotional resonance in the performance.

4. Paradigm reconstruction of pop singing skills in the digital ecology

4.1 Technical support of virtual idol singing skills

The Vocaloid series of voice synthesis programmes is one of the core technical supports for the virtual idol singing technique. The system adopts splicing synthesis technology, by digitally splicing the base voice data recorded by the voice actor with the notes and lyrics input by the user, and finally generating a complete song - this intelligent arranging system based on the phoneme unit enables the virtual singer to break through the physical boundaries of traditional vocal creation, and realise the full dimension from pitch accuracy to timbre style Digital regulation.

Users can adjust the tone, parameters, and so on, to simulate the similar human breathing, mouth shape and even trill, making the virtual idol song more realistic and vivid. Besides Vocaloid systems, other speech synthesis technologies are also evolving. Through deep learning and neural network and other advanced algorithms to improve speech synthesis nature and fidelity.

The paradigm of pop singing skills in the digital ecology is undergoing a profound reconstruction. Among them, the virtual idol singing skills get strong technical support, which can not only promote the innovation of virtual idols in the music field, but also bring new enlightenment to the traditional pop singing skills.

Motion capture technology is the key to the virtual idol to s realistic action performance. Through high precision motion capture equipment can accurately capture the details of the actors, and converted to virtual stage action, bring the audience more real experience, motion capture system can real-time transmission and process the actor action data, ensure that the virtual idol on the stage and actor synchronization, enhance the interaction between the audience and the virtual idol, artificial intelligence technology according to capture data to form the image of the virtual idol, and according to the barrage real-time data adjustment set and performance style, prompting idol can better interact with the audience.3d modeling and rendering technology are the basis of creating a virtual idol image. Through high fidelity digital human creation technology generate realistic virtual idol image image, has a high degree of visual sense, and through motion capture and speech synthesis technology to realize dynamic performance and interaction, real-time rendering technology, make the virtual idol on the stage performance more smooth lifelike, and by adjusting the light and shadow effect, the parameters such as material to further enhance the visual expression of virtual idol.

4.2 Innovative characteristics of virtual idol singing skills

The evolution of virtual idol singing skills is inseparable from multiple technological breakthroughs: voice synthesis technology has evolved from the early mechanical monotonous tone output to the present day technology that can simulate the texture of real human voices and the ups and downs of emotions, so that the virtual voices have both sweetness and emotional expressiveness; motion capture technology maps the actor's body movements in real time to the virtual character through high-precision sensing equipment, which is combined with the optimisation of the rendering engine to achieve a leap forward in the smoothness and realism of the movements. Motion capture technology maps the actor's body movements to the virtual character in real time through high-precision sensing devices, and optimises the rendering engine to achieve a leapfrog improvement in the smoothness and realism of the movements, and to achieve the stage precision of synchronising the sound and picture. Social media and live broadcast platforms have reconstructed the relationship between the audience and the performance - the virtual idol can respond to fans' pop-up questions in real time, dynamically adjust the details of

the performance according to the comment area, and even generate customised content through AI analysis of fans' preferences, thus building a unique participatory fan culture ecology. In the virtual concert scene, the audience is deeply involved in the performance process through digital means such as liking, ranking, AR effects interaction, etc., forming an immersive experience that blends reality with reality. This technological integration of music production, computer graphics, artificial intelligence and other multidisciplinary knowledge is continuing to expand the boundaries of digital art expression.

Through holographic projection technology, virtual idols can present realistic three-dimensional images on the stage and interact with the audience face to face

4.3 Performance form of virtual idol singing skills

The fusion of science and technology and art of virtual idol singing technology presents diversified innovative features, and its technical realisation path mainly includes the following dimensions: holographic projection technology, as the most common performance form, uses the principle of interference diffraction to record and reproduce the three-dimensional image of objects, so that the audience can watch the three-dimensional virtual image without wearing equipment. Hatsune Miku as a representative of the virtual idol concert, through high-precision holographic imaging system will be three-dimensional modeling projected to the stage in the middle, its body rhythm, micro-expressions and other details can be accurately reproduced, with the surround sound field to create a sense of immersive audio-visual interaction. Motion capture technology collects real-time skeletal data of real actors through wearable sensor arrays, and after algorithm optimisation, drives the virtual characters to complete natural and smooth choreography, realising the technological breakthrough of millisecond synchronisation between sound and picture.

Augmented reality (AR) technology reconstructs the performance space by superimposing the real and the imaginary, integrating digital special effects and virtual characters in the real stage. A virtual idol group uses AR optical tracking technology to enable physical interaction between virtual members and physical props, and particle effects engines to generate dynamic light and shadow changes, building a surreal audiovisual landscape. Although the application of virtual reality (VR) technology in concerts is still in the exploratory stage, the immersive experience it creates has demonstrated the potential for innovation - the audience can enter the digital theatre by wearing a headset device, and interact with the virtual idol through the handle to simulate the real interaction, which breaks through the physical boundaries of the viewing mode of the show heralds the evolution of the future of the form of entertainment! direction.

5. Summary

The performance skills of virtual idols have been greatly innovated and enriched under the digital ecology. Through the application of high-tech means, virtual idols can present a highly realistic image and dynamic performance, bringing unprecedented audio-visual feast and interactive experience to the audience. These diversified forms of performance not only meet the audience's needs for freshness and personalized experience, but also bring new development opportunities and challenges for the music industry. In the future, with the continuous progress and innovation of technology, the singing skills of virtual idols will be more diversified, personalized and intelligent, bringing more rich and wonderful audio-visual enjoyment to the audience.

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