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Realization of Composing Music Based on State-of-art AI Approaches

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Abstract: As a matter of fact, AI techniques has witnessed tremendous rapid development especially among recent years with the boosting of the GPU ability. Among various application fields, AI-assisting music composition has become widely investigated contemporarily. Amidst the burgeoning technological landscape, AI has penetrated music composition in various fields. With this in mind, this paper delves into the state-of-art AI scenarios for music creation with various situations. To be specific, it covers revealing AI models' capacity to generate diverse pieces but also their struggles in emulating human-like emotional depth. According to the analysis, the realization principles for different models, applications in different situations as well as limitations and prospects are demonstrated and evaluated. Overall, these results shed light on guiding further exploration of AI composing music. At the same time, this study offers new tools and paves the way for future research of music composition based on the state-of-art AI models in this evolving field.

Keywords: AI music, music composition, AI models

1. Introduction

The history of computer music has unfolded as a remarkable journey of evolution in recent years. As documented in research from the early 2020s [1], the incipient efforts in computer-assisted composition, which originated in the mid - 20th century, have experienced a profound metamorphosis with the advent of advanced software and hardware technologies. Digital audio workstations (DAWs), exemplified by Ableton Live and Logic Pro, have attained a high degree of sophistication. These DAWs are replete with an extensive suite of features, including intricate multi - track recording mechanisms, a comprehensive palette of virtual instruments, and advanced signal processing algorithms. This enables musicians to engage in the creative process with enhanced efficacy and manipulate musical elements with an unprecedented level of precision and ingenuity [2]. Moreover, the availability of large - scale music datasets, as meticulously explored in [3], has provided a fertile ground for the development of AI-based music composition. These datasets encapsulate a diverse range of musical knowledge, spanning melodies, harmonies, and rhythms across various musical genres and historical periods. Nevertheless, it is crucial to recognize that traditional computer - assisted composition remains highly dependent on human intervention. In this paradigm, the computer predominantly serves as a facilitator for basic sound manipulation, such as pitch correction, amplitude adjustment, and for performing elementary sequencing operations, rather than autonomously generating elaborate musical compositions.

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Artificial intelligence has experienced an exponential growth spurt in recent years, permeating numerous disciplines with remarkable impact. Convolutional Neural Networks (CNNs), renowned for their prowess in image processing, have found innovative applications beyond their traditional domain. Recurrent Neural Networks (RNNs), along with their sophisticated derivative, the Long Short - Term Memory (LSTM) networks, have been extensively and rigorously applied across a wide spectrum of fields [4]. These include, but are not limited to, time - series analysis in finance, speech recognition in telecommunications, and now, they are making significant inroads in the realm of music composition. In music composition, these models have revealed substantial potential to revolutionize the creative process. For instance, they can analyze complex musical structures, patterns, and styles, and then generate new compositions based on learned knowledge. Generative Adversarial Networks (GANs) have also emerged as a pivotal and transformative factor in this area. As [5] convincingly demonstrated, GANs are structured with a generator network. This network is responsible for creating music samples, while a discriminator network is tasked with discerning real from generated samples. Through an iterative process of competition and refinement between the two networks, this setup enables the generation of music that closely emulates human - composed pieces, often achieving a level of authenticity that was previously challenging to attain. Moreover, Transformer - based models, which have achieved unparalleled success in natural language processing, have been adapted for music generation [6]. By leveraging their unique ability to handle sequential data with long - range dependencies effectively, these models open new and exciting avenues in the domain of music composition, offering composers novel tools and approaches to explore uncharted musical territories.

The motivation for this research lies in exploring how state-of-art AI approaches can revolutionize music composition. Existing AI - based music composition methods often lack emotional resonance and struggle to fully understand musical semantics. By leveraging the latest AI techniques, this study aims to develop more advanced music composition systems capable of producing high-quality, emotionally-rich music. The research framework is as follows. Section 2 will describe several AI models commonly used in music composition, including their architectures and functions. Section 3 will explore the application scenarios of music generated by these models. Section 4 will conduct a performance analysis of the AI - generated music using objective metrics. Section 5 will discuss the limitations of current AI - based music composition and prospects for the future. Finally, Section 6 will summarize the entire study.

2. Descriptions of AI models

MuseNet, an innovative creation by OpenAI, is firmly grounded in the advanced Transformer architecture, as meticulously detailed in [6]. Fig. 1 vividly portrays the intricate operational workflow of MuseNet [6]. At the onset, the input musical data is subjected to a crucial initial transformation. This involves embedding the data into a high - dimensional space. This embedding process is of utmost significance as it converts the musical data into a format that is highly conducive to the model's internal processing mechanisms. By representing the data in this high dimensional space, the model can more effectively extract and analyze the relevant musical features, enabling seamless processing by the subsequent components of the architecture. Subsequently, the embedded data traverses through multiple layers of self - attention and feed - forward neural networks. The self - attention mechanism within MuseNet assumes a pivotal role in its functionality. This mechanism endows the model with the remarkable ability to effectively capture long - range dependencies within musical sequences. In music, long - range dependencies are crucial for understanding how elements such as a melody's development over time, the harmonious relationship between different chords played at various intervals, and the rhythmic patterns that span across different sections of a composition are interconnected. By discerning these dependencies, MuseNet can comprehensively decipher the

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intricate and often subtle relationships among melody, harmony, and rhythm. This deep understanding is the cornerstone for generating high - quality, musically coherent outputs. Having been trained on an extensive and diverse corpus of music that spans across different genres and eras, MuseNet showcases extraordinary versatility. It draws knowledge from centuries-old classical symphonies, with their complex orchestrations, strict musical forms, and profound emotional expressions, to the contemporary and ever-evolving dynamic rhythms of modern pop tunes, which often incorporate the latest production techniques and catchy, ear-worm melodies. This exposure during training equips MuseNet to generate music in a wide gamut of styles. On the other hand, Jukebox, another remarkable creation by OpenAI, is a hierarchical generative model, as clearly depicted in Fig. 2 [7]. This model's operational paradigm is distinct. It commences by generating a high - level musical style. This initial step involves establishing the overarching musical framework, which could include elements such as the genre - specific chord progressions, tempo ranges, and general sonic characteristics associated with a particular style, be it rock, jazz, or hip - hop. Once this high - level style is defined, Jukebox refines it to produce detailed musical sequences. Rock music, with its energetic guitar riffs, driving rhythms, and powerful vocals, requires a different set of musical elements compared to the improvisational nature and complex harmonies of jazz or the rhythmic beats and lyrical flow of hip - hop. Jukebox's architecture, with its hierarchical structure, enables it to build upon the initial style concept. It can add more layers of musical detail and complexity as it progresses in the generation process. This unique architecture gives Jukebox an edge over some other models in generating longer and more complex musical compositions. The hierarchical approach allows for a more structured and nuanced generation, ensuring that the generated music can maintain the listener's interest over extended durations and exhibit a high degree of musical sophistication. For instance, in a long - form rock composition, Jukebox can develop the initial high-level style into a multi - movement piece with distinct sections, each contributing to the overall narrative and emotional arc of the music. In jazz, it can generate extended improvisational passages that adhere to the established style while also introducing novel musical ideas. In hip-hop, it can create complex rhythmic patterns and lyrical structures that engage the audience on multiple levels.

Figure 1: Multi-track music generation: an overview of relevant elements [6]

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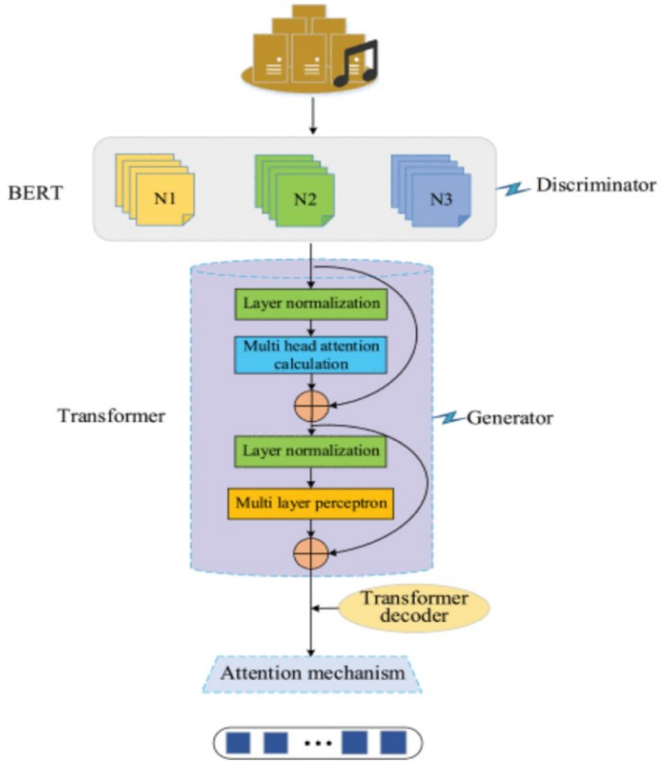

Figure 2: Music generation: schematic illustration of BERT–transformer architecture [7]

3. Application

In the film and television domain, AI generated music has emerged as a transformative force. According to Briot et al., the utilization of deep - learning techniques in music generation allows for the creation of scores that are highly attuned to the specific requirements of each scene. For example, in a period drama, AI can analyze the historical context, character emotions, and the overall narrative arc to generate music that enhances the authenticity and emotional resonance of the scenes. This might involve using period appropriate instruments and musical styles to create a more immersive viewing experience. Huang et al. introduced MusicLM, which can generate music from text. In film and television production, this means that directors and composers can simply describe the mood, tempo, and genre of the music they need for a particular scene, such as "a melancholic, slow paced piece for a sad farewell scene", and MusicLM can generate a relevant musical composition. This streamlines the music creation process, saving time and providing a wider range of creative possibilities. Stable Audio Team proposed a commercial-grade music generation method via latent diffusion. In film scoring, this technology can produce high-quality music with a rich sonic palette. For instance, in a science - fiction film, it can generate otherworldly sounds and complex musical arrangements that complement the visual spectacle, adding an extra layer of depth to the storytelling [8].

AI-generated music has revolutionized the video game industry by enhancing player game interaction. As per Briot et al., deep learning - based AI models can analyze in game factors like player location, actions, and events to generate dynamic music. In a role-playing game, when a player approaches a dangerous area, the AI can generate suspenseful music with a rising tempo and dissonant chords, heightening the sense of anticipation. Stable Audio's technology, as described by Stable Audio Team can generate music in real - time based on game specific prompts. For example, in a racing game, the music can change in sync with the speed of the vehicle. When the player accelerates,

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the music becomes more energetic and fast - paced, while during slower sections, it can be more subdued. This real - time adaptation of music based on gameplay actions significantly enhances the immersive quality of the game. Huang et al. suggest that MusicLM could be integrated into game development. Players could potentially input text - based commands related to the mood or atmosphere they want in the game, and MusicLM would generate corresponding music. For example, a player exploring a mysterious cave might input "mysterious, echoing music", and the game would generate music that matches this description [9].

Streaming platforms are increasingly using AI-generated music to offer personalized user experiences. Huang et al. proposed that MusicLM can generate music based on text descriptions. Streaming platforms can leverage this technology to analyze user listening habits and preferences. For example, if a user frequently listens to acoustic folk music, the platform can use MusicLM to generate new, similar-style music by inputting text prompts like "acoustic folk with a warm, nostalgic feel". Stable Audio Team offers a method for generating commercial - grade music. Streaming platforms can use this technology to create high - quality, exclusive music for their users. This can attract more subscribers and increase user engagement. Additionally, by analyzing user data, the platform can generate playlists that are tailored to different user moods and activities, such as "relaxing music for bedtime" or "energetic music for workouts" [10]. Briot et al. also emphasize the role of deep - learning techniques in music generation for streaming platforms. These techniques can analyze large amounts of music data and user behavior to generate music that aligns with user tastes. This not only provides users with fresh and interesting music but also helps platforms stand out in a competitive market.

4. Performances analysis

In the pursuit of understanding the capabilities of AI - generated music, a pivotal study by delved into evaluating the resemblance between AI-crafted and human-composed musical pieces [11]. The researchers employed the Structural Similarity Index (SSIM), a well-established metric in the field of signal processing. SSIM measures the similarity between two signals by comparing their luminance, contrast, and structure. When applied to music, it assesses how closely the elements such as melody, harmony, and rhythm in AI-generated music mirror those in human-composed works. The results, offered valuable insights. Some advanced AI models, notably MuseNet, managed to achieve relatively high similarity scores. MuseNet, with its sophisticated architecture based on the Transformer model, demonstrated an ability to capture and replicate many of the musical patterns found in human - composed music. For example, it could generate melodies with appropriate contour and rhythm, and harmonies that adhered to traditional music theory. However, despite these achievements, a discernible gap remained when compared to the richness and complexity of human - composed music. Human composers draw on a lifetime of experiences, cultural influences, and emotional nuances, resulting in music that often contains subtle variations and unexpected twists that are difficult for AI to replicate.

Complementary to the similarity analysis, another study focused on the emotional expression of AI generated music [12]. Recognizing that emotional impact is a crucial aspect of music, the researchers opted for a subjective evaluation approach. Participants were presented with both AI-generated and human-composed music and asked to rate each piece on a scale of 1 - 5. This scale measured the emotional intensity and authenticity, with 1 indicating a lack of emotional presence and 5 representing a highly intense and genuine emotional experience. The findings were telling. The average score for AI-generated music hovered around 3.0, suggesting that while it could evoke some emotions, it fell short in terms of depth and authenticity. In contrast, human-composed music received an average score of 3.8. Human - composed music often conveys a wide spectrum of emotions, from the elation of joy to the heart - wrenching pain of grief. Composers use various musical elements such

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as tempo, dynamics, and timbre to create a profound emotional connection with the listener. AI-generated music, on the other hand, struggles to create such a deep-seated emotional resonance. It may produce music that appears to be sad or happy on the surface, but fails to convey the complex layers of emotions that human-composed music can evoke.

In conclusion, while AI-generated music has made significant strides in emulating human - composed music in terms of structure and similarity, it still lags in terms of emotional expression. These studies underscore the need for continued research to bridge this gap and enhance the emotional intelligence of AI in music composition.

5. Limitations and prospects

Current AI-based music composition, despite its remarkable technological advancements, grapples with several notable limitations. A fundamental shortcoming lies in the lack of true creativity and emotional understanding within AI models. While these models excel at identifying and replicating patterns found in vast musical databases, they often fall short of generating truly original pieces that resonate on an emotional level with listeners. For example, human composers draw from a deep well of personal experiences, cultural backgrounds, and emotional states. They can infuse a piece of music with a complex range of feelings, from the celebration of life to the profound sorrow of loss. AI, on the other hand, struggles to capture such nuances. Even if it generates music that follows the correct musical structure, it may lack the soul-stirring quality that makes human-composed music so powerful. Moreover, the training of these AI models demands an enormous amount of data and substantial computational resources. Collecting, organizing, and preprocessing large-scale music datasets is a time-consuming and resource-intensive task. High performance GPUs are often required to train these models in a reasonable time frame, and the cost of maintaining such computing infrastructure is prohibitively expensive for many individuals and smaller organizations. This restricts the widespread adoption of AI-based music composition technologies, limiting their reach to only well-funded research institutions and large corporations. There are also pressing ethical and legal issues surrounding AI-generated music. Determining the ownership and copyright of such music is a complex and murky area.

Despite these limitations, the future of AI-based music composition holds great promise. As technology continues to evolve, more advanced AI algorithms are being developed. For instance, new neural network architectures and machine-learning techniques are emerging that may enable AI models to better understand and generate complex emotional content in music. With the availability of even larger and more diverse music datasets, AI will have more information to draw from, potentially leading to the creation of more creative and emotionally rich music. The collaboration between AI and human musicians represents a particularly exciting prospect. AI can serve as a source of inspiration, generating initial musical ideas, melodies, or chord progressions. Human musicians can then take these AI-generated elements and refine them, adding their own unique artistic vision, interpretation, and emotional depth. This synergy could lead to the creation of entirely new forms of music, blurring the boundaries between traditional and AI-assisted composition. For example, in a live performance, an AI could generate real-time musical accompaniment based on the improvisations of a human musician, creating a dynamic and ever-changing musical experience.

In conclusion, while AI-based music composition currently faces significant challenges, the future is rife with possibilities. With continued research and development, as well as a clear resolution of ethical and legal issues, AI has the potential to revolutionize the music industry and open new creative horizons for musicians and music lovers alike.

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6. Conclusion

To sum up, this paper delved deeply into the application of cutting-edge AI technologies in music composition. Through extensive exploration and experimentation, it shed light on the capabilities and limitations of AI in this creative domain. The research findings indicate that although AI models have made remarkable progress in generating a wide variety of musical works, they still fall short when it comes to emulating the profound emotional resonance and boundless creativity inherent in music composed by humans. For instance, human-composed music often reflects the composer's unique life experiences, cultural background, and complex emotions, which are difficult for AI to replicate accurately. Nonetheless, AI has brought new and innovative creative tools to the music industry. It can quickly generate basic musical frameworks, melodies, or chord progressions, significantly enhancing the efficiency of music production. Composers can use these AI-generated elements as a starting point and then infuse their own creativity to complete a work. Looking ahead, there is an urgent need for further research to refine AI-based music composition techniques. This includes improving the model's ability to understand and express emotions, as well as exploring more advanced algorithms to enhance creativity. At the same time, ethical and legal issues such as copyright of AI-generated music and the impact on human musicians need to be addressed. This study not only deepens our understanding of AI-based music composition but also offers valuable directions for future research and development in this emerging field.

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