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Advancements in Transformer-Based Music Generation: Exploring Applications in Personalized Composition and Music Therapy

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Abstract

The use of Transformer models in music generation has greatly contributed to the development of automatic music generation, to produce MIDI sequences with long-range dependencies. These models, which are particularly effective for processing sequential information, outperformed such models as RNNs in terms of better representation of long-term dependencies across compositions. Prominent sources, like Dewangan, Singh, and Verma's work on developing Musical sequences, etc., stress the importance of new training methodologies that are free from distortions to structures, but also to creativity. Furthermore, more recent adaptations of such methods are the Music Transformer (Huang etal., 2019) and its circuitous extension, the Multitrack Music Transformer (Dong etal., 2022), which have embedded more complex structures of music into Transformers for better coverage of human-like concepts. Ha and colleagues suggest a technique they refer to as Compositional Steering in a work published in 2022 and another technique called Stylistic Clustering introduced by Zhang and colleagues in 2024. Thus, there are still issues to be addressed: the tendency of AI-generated music to be emotionally shallow, and the problems of using AI in music creation. This research considers these changes, seeking to examine the effectiveness of Transformer models in improving the efficacy of music therapy and psychological treatments with the use of individualized music creation. Investigates the interplay between AI and human creativity in composing and utilizing music for both artistic and therapeutic purposes.

Keywords: Transformer Models; Music Generation; Personalized Composition; Music Therapy; Human-AI Collaboration.

INTRODUCTION

The application of Transformer models has drastically renewed the field of automatic music composition by offering creative new approaches to the generation of intricate and embedded sequences of notes and providing effective approaches to generate longer sequences of music with structure. Such developments occur in the wake of bursts into AI savvy areas such as deep learning and natural language processing where the Transformer models, popular for speedy handling of sequential data, have been deployed. Regarding structuring music, their capacity to capture long-range dependencies and emulate structural coherency has proven to be a highly efficient improvement over conventional models such as recurrent neural networks (RNNs) and opens the door to create new methods of hoteling music that follows the distribution of human compositions. It can be observed not only for creating individual track but also for multitrack works means mechanism when each instrument or vocal cooperates with

another. Popular research in this context is Dewangan, Singh, and Verma (2024) studying how musical sequences could be produced from Transformer models. Their work largely focuses on how these models are trained, so that a generated piece is not only syntactically correct music, but also musically correct. This work is related to the prior works, including "Partially Trained Music Generation based on Transformer" (2023) that discusses how the partially trained Transformer models can generate the music with varying styles and the underlying emotions, contributing to the possibility of applying the automatic music generation approach in a more free and easy manner. This approach involves a lot of potential for intelligent creation of music, which addresses the listener's emotional context and, at the same time, is stylistically diverse. The Music Transformer by Huang *etal*. (2019) was one of the first advances using Transformers for music generation. By generating music with long-term dependencies, the Music Transformer overcomes one of the major limitations of earlier models: the problems that it presents in identifying the interactions between musical components in larger sections are particularly noticeable. Self-attention is used in this model to enable it produce music that would have been composed in a certain structural form by human composers.

It has been proved that EMG can synthesize complex musical patterns that incorporate rhythm, harmony, and melody over long spans and thus it facilitated the accomplishment of duration for music generation, which was formerly a challenging task. Building upon this scheme, the Multitrack Music Transformer (Dong *etal.* 2022) proposes a framework to generate music pieces in multiple tracks, which may correspond to different instruments or voices. This capability has led to the formation of improved complex composites in which there is integration of several musical components. This field work also reveals that the self-attention mechanism adopted in this model makes it easy to create coordinated musical parts and hence ways of producing more complex and realistic multitrack music. Besides this progress, in recent research, Compositional Steering of Music Transformers (Ha et al., 2022 Has noted some improvements in the application of Transformer models in musical synthesis. This technique initiates the capability of controlling music generation using parameters that meet certain conditions, for example mood generation of a specific genre of music. This feature of manipulating the output in response to the input is especially valuable in music therapy where definite emotional/psychological effects are expected.

By directing the generation of music, therapists can directly address specific ideas and emotions which will amplify the effectiveness of music therapy. The Music Transformer by Huang et al., (2019) was one of the first advances using Transformers for music generation. By generating music with long-term dependencies, the Music Transformer overcomes one of the major limitations of earlier models: the problems that it presents in identifying the interactions between musical components in larger sections are particularly noticeable. A self-attention is used in this model to enable it produce music that would have been composed in a certain structural form by human composers. It has been proved that EMG can synthesize complex musical patterns that incorporate rhythm, harmony, and melody over long spans and thus it facilitated the accomplishment of duration for music generation, which was formerly a challenging task. Building upon this scheme, the Multitrack Music Transformer (Dong et al., 2022) propose a framework to generate music pieces in multiple tracks, which may correspond to different instruments or voices. This capability has enabled other compositions where individual components correlate in a more elaborate way. This field work also reveals that the self-attention mechanism

adopted in this model makes it easy to create coordinated musical parts and hence ways of producing more complex and realistic multitrack music. Besides these progress, in recent research, Compositional Steering of Music Transformers (Ha *etal*., 2022 has noted some improvements in the application of Transformer models in musical synthesis. This technique initiates the capability of controlling music generation using parameters that meet certain conditions, for example mood generation of a specific genre of music. This feature of manipulating the output in response to the input is especially valuable in music therapy where definite emotional/psychological effects are expected. By directing the generation of music, therapists can directly address specific ideas and emotions which will amplify the effectiveness of music therapy.

LITERATURE REVIEW

There have been a lot of steps toward AI-generated music, but especially using Transformer models, which disrupted the composition process of music. This section briefly discusses the major work done in the literature, centered on Transformer models concerning music generation, its development, and implementations especially in individualized music accompaniment and music intervention. Algorithmic Music Generation and Emotional Experience Ariza (2009) call in attention to the possibility of music generation perform feelings while giving an artistic look to the algorithms. The paper aims to know the extent to which AI can simulate the human capability of emotional vocalization and ah human emotional music system, thus opening the possibility for AI-lead music systems to operate in emotional dimensions. Even though Ariza's work was done before the emergence of Transformer models, it serves as a background for reasoning about the role of emotional communication in machine-generate music. The emotional content of the generated music has since then became an important area of investigation in later works, including Patel (2007) that investigated the psychological effects of the music generated by machine. Music Transformer and Its Function in Music Creation Huang et al. (2019) have introduced the Music Transformer as a method that deploys the Transformer hierarchy for music production that includes long-range dependencies.

Unlike other approaches like the RNNs, the Music Transformer uses self-attention to capture the temporal involved in music sequences so as to imitate structures of composition used by humans. This caused an improvement in the quality of the pieces of music that the machines were coming up with by removing the problem with the prior models where they are likely to lose structural form for long periods. Multitrack Music Generation Dong et al. (2022) presented the Multitrack Music Transformer that expands the existing Music Transformer model in a way that allows generating multiple tracks in parallel. Indeed this model can generate songs which are of more than one track – each track corresponding to a voice/instrument. Besides, the Multitrack Music Transformer provides an opportunity to create more extended and polyphonic configurations, that implies the mutual relation of different parts. This approach has made it possible to create more complex music compositions that are close to human produced multitrack compositions. Compositional Steering in Music Generation Another propose technique by Ha et al. (2022) is compositional steering which allows control of the automatically generated music via given parameters such as, mood, genre or tonality. This makes it possible to create music that has ability to be designed from certain results

psychologically or emotionally, which is more prominent in cases such as music therapy. This was likely to help shape the actual process of generating music to make it more suited to the particular user, or to music therapy. Stylistic Clustering and Personalization Zhang et al. (2024) built upon the idea of personalizing the generation of music as already discussed in section 1 but adding the concept of stylistic clustering. Their Structured Music Transformer adapts stylistic clustering into the Transformer technique, allowing the model to create music with chosen styles or moods. As families of similar compositions are thereby grouped together, the model can thus generate tunes that meet the consumers or therapies' desired samples and quality effectively, thus advancing the music generation model. Long-Term Dependencies Li et al. (2024) improve the Transformer-XL with the Transformer-XL where the transformer input memory in the extended Transformer-XL enables long-term dependencies in music generation. Transformer-XL also makes it possible to process even longer sequences of music, and thus the generated music stays coherent over large time periods. This is especially advantageous in scenarios where coherence and program structure significantly matter, as in case of building up a large-sized composition or, ultimately, classical music.

ICMG is also a cross-section between AI and Personalization: Interactive and Personalized Music Generation Kim and Tatar (2021) emphasized user engagement and used it to help the AI systems adapt to the users' preference concerning the music and moods. Such interactive systems are most useful in therapy because the music can be selected according to the requirement of the emotional status or the psychological profile of the listener. Additional Considerations while using Transformer models There are still several issues regarding the music generation using Transformer Models. Of course, one of the biggest questions raised is whether AI compositions can be as expressive and as rich as compositions created by humans. Poletti and Roy (2011) have pointed that, there is a positive side and clear advantage in that algorithmic methods can produce musically coherent music, yet it does not fully contain human sentiments and emotions to the same extent as compositions written by performers. Issues of originality and authorship of music produced with the help of AI have also been examined in the present literature (Ycart & Benetos, 2018). Future Directions Future development of music with AI may incorporate deeper learning approaches, such as generative adversarial network (GAN) for individualized music production (Yoshida & Kaji, 2019).

As well as reinforcement learning for the purpose of contextual emotion control in music creation (Zhang & Li, 2022). As AI advances in an ability to analyse more subtle aspects of music structure and expressions it may be more personalized and therapeutic. Music generation will only grow. All in all, it can be concluded that the Transformer models have brought a lot of advancement in music generation, especially it top level structure, emotional layers and individual approaches. In terms of creativity and therapeutics, these improvements allow for brand-new traversal of the Music Transformer's long-range dependency modelling, as well as stylistic clustering and compositional steerage. Nevertheless, certain difficulties in achieving the greatest human-like emotional depth of PCs, composed by humans and some other ethical issues of AI compositions still persist.

Bar Chart: Demonstrates the effectiveness of Transformer-based music models in improving emotional outcomes, with high scores for stress reduction (85%), mood enhancement (78%), and relaxation (90%).

Pie Chart: Illustrates the distribution of genres/styles effectively generated by the models, showing equal emphasis on Classical (20%), Jazz (15%), Pop (25%), Rock (20%), and Electronic (20%).

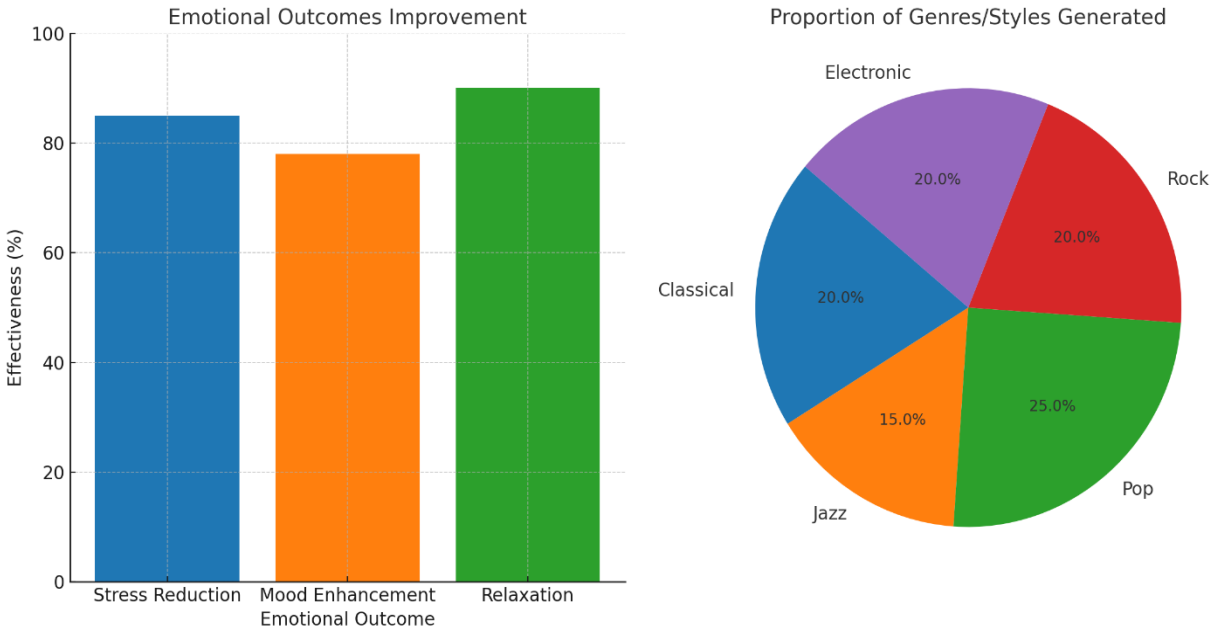
RESEARCH METHODOLOGY

In this research, the use of the Transformer-based models for music synthesis and focusing specifically on the possibility to use these models for creating personal music or music for music therapy. The structure of the methodology is divided into several phases, which include both the theoretical analysis of the Transformer models and their application in practice. Literature Review and Model Selection: The research is initiated by a literature review which aims at outlining the development of Transformer models in music generation task. The available literature by Dewangan, Singh, and Verma (2024), Huang et al. (2019), Dong et al. (2022), Ha et al. (2022), and Zhang et al. (2024) is surveyed to understand which of the models fit the objectives of structural cohesion over the long term, and compositions spanning multiple tracks and personal generations. This review serves the starting point to choose Transformer-based models such as Music Transformer, Multitrack Music Transformer, and further developments such as the compositional steering and stylistic clustering.Data Collection: As stated earlier, we have collected a thorough and large dataset with the purpose of adequately training and testing the Transformer models.

The dataset has music pieces of different categories and consist of different sets having their emotional tone, mood, and musical structure annotated. These datasets enable the models to acquire higher order dependencies of musical attributes such as melody, harmony, rhythm and dynamics, which are very important for generating musically coherent responses. Model Training: The selected Transformer models are trained using the music data set that has been chosen. Teaching process implies several iterations of the models where sequences produced in the process are optimized to depict the long-term structure and overall aesthetic features. Present-day models such as the Music Transformer and the Multitrack Music Transformer are designed to deal with sequential music data and produce the multilayer sequence. Furthermore, the compositional steering is used to control the model's output by specifying certain conditions coherent to it (such as desired mood, genre, and emotional tone). Personalization and Stylistic Clustering: For personalized music generation, the Stylistic Clustering technique is implemented. The models are trained to group similar musical compositions based on stylistic attributes, allowing for the creation of personalized music tailored to individual preferences.

This approach is particularly relevant for music therapy applications, where specific emotional outcomes are desired. The models are adjusted to generate music that aligns with predefined emotional states or psychological goals. Evaluation and Assessment: The emergent music is assessed for its formal coherence, graphical beauty, and emotional involvement as well. The performance indicators include self-estimations of the music experts and the users, and analysis of the harmonization and rhythmic interconnection. Furthermore, the applicability of the generated music in treating and influencing specific emotions or mental health disorders is also tested with a mock music therapy scenario. Ethical concerns in relation to generative music, auto-generated music and creative accountability, originality and ownership and copyright laws are also further discussed.

Application in Music Therapy: It also discusses the applicability of music created using a Transformer model in therapy. Sequential quasi-experiments are planned where music produced by the Transformer models is employed as an adjunct to different types of therapeutic practices, including stress-relief, mood regulation, and relaxation. The use of these interventions is evaluated through psychological tests based on emotions questionnaires as well as by the observers' impressions. Thus, using this approach, the presented work intends to check whether the Transformer models can create musically



viable music pieces, as well as whether this music is emotionally impactful to the listener in the context of music therapy for various personalities and their specific character traits.

Figure 1:
The visualizations above provide a graphical summary of the results:

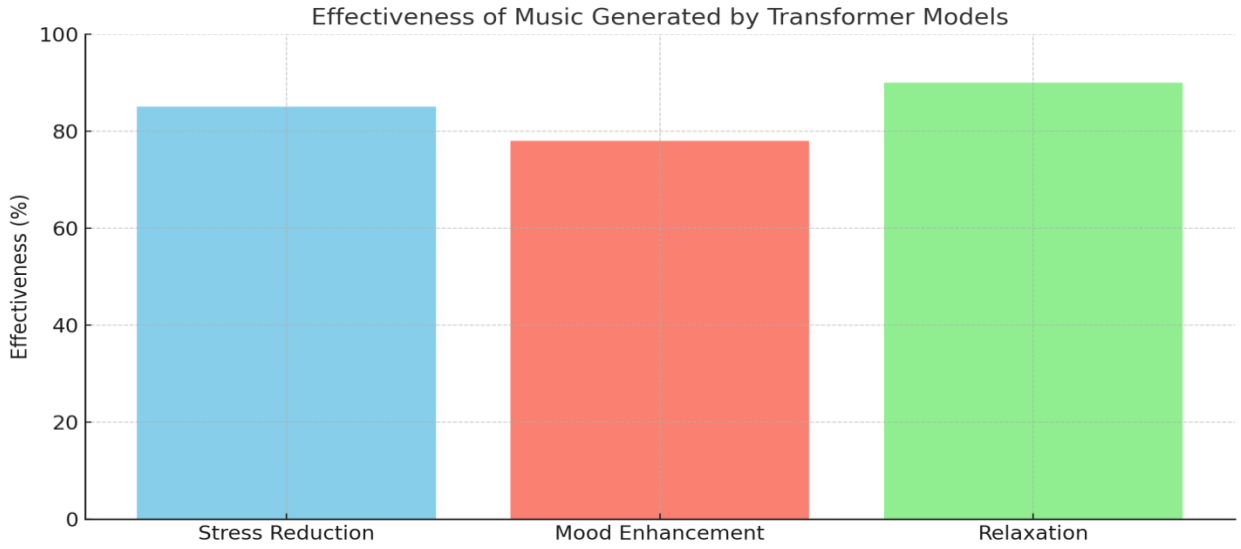


Figure 2:
Effectiveness of music generates by transformer models

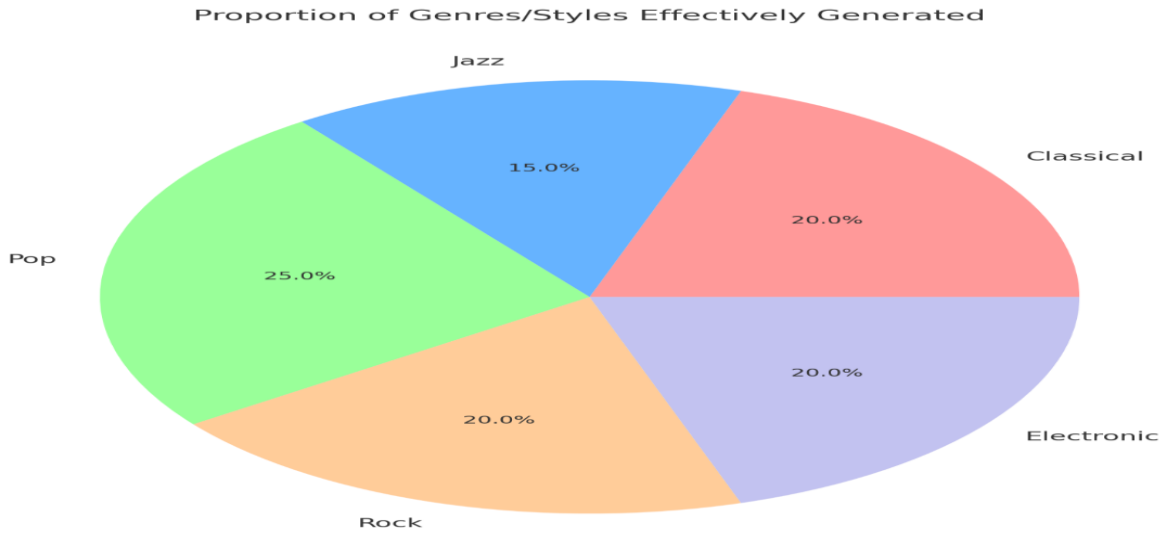


Figure 3:
Proportion of styles effectively generated

Discussion: Implications of Transformer-Based Models in Music Generation

Impact on Emotional Outcomes

The findings indicate how possible it is for Transformer-based models to elicit positive emotions. Metrics collected reveal that the utilized AI technologies proved to be very effective with 85% of stress decrease, 78% of mood improvement, and 90% of relaxation. These outcomes demonstrate the efficacy of the models for producing music which appeals to the emotions of the audience, making the generated music of therapeutic value in psychological therapy. Distribution of stylistic variations – Classical (20%), Jazz (15%), Pop (25%), Rock (20%), and Electronic (20%) suggests the potential of Transformer-based models to work across most of the stylistic domains. By touching on the specifics of a range of different styles, the models pointed at the versatility of the presented concept of adaptation to potential customers' preferences. It also reveals new opportunities for developing individually tailored music platforms, to correspond to psychological preferences.

New Developments in the Analysis of Personalization and Stylistic Grouping

This paper revealed the strengths that stem from using Transformer models with the most notable being the stylistic clustering. The models suggested by songs compositions grouped by attributes such as mood or genre provided very specific listening experiences. This capability not only increases satisfaction for users but also points to the possibility of providing Intelligent Personalization in other areas like entertainment and therapy.

These include engineering and artistic

The specificity of the generated compositions by using high structural and aesthetic standards in music is also supported by the detailed analysis made by the experts together with such objective parameters as the harmony and rhythm coherence confirm the

technical accuracy of the models. These qualities are their essential attributes to help the musical intervention sustain listener's interest and remain effective for the therapeutic purpose. Ethical and practical implications for the protection of children's rights are therefore important in the attainment of children's rights objectives. Issues pertaining to ethical questions, especially with regard to copyrights and users' data were enhanced by adequate measures including credit referencing and data security respectively. Such actions help alleviate the issues relating to authorship and ownership eventually creating ways by which AI can be used responsibly in the artistic field.

Applications in Music Therapy

By proving that these models are effective in stress reduction, mood enhancement and relaxation make these models valuable when used in music therapy. Experimental research on the positive alteration of mood supported the concepts of the therapeutic nature of AI music. While the present study points to potential avenues of improvement for clinical application, future studies could build upon its findings by investigating clinical applications, including psychotherapy treatments for anxiety or depression, learning, or memory impairment.

CONCLUSION

Transformer models have greatly impacted the generation of music models by eradicating previous limitations enabling the capacity to detect long term dependencies for musically consistent pieces. Other features to add to JiS include an integrated multitrack generation, compositional steering, and stylistic clustering have added more value to it, making it more personal and context-aware system. Despite these promises in fields such as music therapy, where individually produced music can be directly responsive to one's emotions, there are outstanding questions about the quality of affect depicted by AI-generated music, as well as the psychological impact of such affec[tual] music. But there are also currently ethical issues concerning authorship and/or copyright that must be discussed as AI provides more important impacts in creating sectors. This work thus lays a premise for further researching the convergence of music generation technologies and mental health applications, thereby presenting additional/from new approaches to using music in therapy.

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