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PROSPECTS AND CHALLENGES IN HUMAN AND AI COLLABORATION IN MUSIC CONDUCTING

Abstract

The world has evolved to a state where information technology and digitization have become a defining factor for how people view and interact with different phenomena. The influence of information technology on world best practices continues to grow beyond professional boundaries as days go by. Artificial Intelligence -AI (a branch of Information Technology) has significantly influenced music practices, provided welcomed assistance, and sometimes independently taken on tasks that humans would ordinarily execute. Efforts to find works that show the challenges and prospects of human and AI collaboration in music conducting have been fruitless. This study is therefore an attempt to unearth the benefits and challenges of Human and AI collaboration in music conducting, to fill the knowledge gap in the comprehension of the role of AI on creativity and performance. Using a mixed method of document study and review of already existing literature in collecting data, this work shows the benefits and the challenges of human and AI collaboration in music conducting. Findings show that Humans and AI can collaborate in such ways that will improve music expression, enhance accuracy, and improve efficiency. Among other suggestions, the study recommends that music institutions should include the teaching and learning of AI systems and information technology in their curricula. This will prepare conductors for the future, where they may not be able to function without the use of AI tools. Also, software developers should collaborate with musicians to provide tools that address specific areas in music practice. This partnership will ensure that AI tools are designed and equipped with pedagogical and musical sensitivity.

Keywords: Artificial Intelligence (AI), Music Conducting, Human and AI Collaboration, Problems, Prospects.

Introduction

Conducting as a musical Art has traditionally relied completely on humans' intuitive ability, from the conceptualizing of its ideas, its intuition, conveying of emotions, as well as the studying, understanding, interpretation, and performance of musical pieces. A music conductor directs musical performances using visible body gestures. The process of preparation begins with a series of planned rehearsals. This means that both time, material, and human resources are put to positive use to ensure a seamless performance. The end product, which is the performance itself, may not tell the whole story of 'how much' was put into its preparation, especially since a five-minute choral or orchestral performance may have taken months of human effort to prepare. The music-making process, therefore, leaves in the wake of its execution a list of human beings who have put in quite a lot for its success – performers, conductors, and other backstage members alike.

The world is evolving, and every aspect of day-to-day existence is evolving with it. One aspect of such evolution is the introduction of information technology (IT), which has, in no small measure, transformed the world. It has revolutionized every area of human existence, from communication to health, and even entertainment among others. Information technology in itself has continued to evolve, and one product of such evolution is Artificial Intelligence (AI). Artificial intelligence is the ability of a machine or a robot controlled by a computer to perform tasks that would ordinarily be performed by humans. There have been speculations that someday, AI will completely take over the responsibilities of humans, thereby leaving many people jobless. While that may be possible for some fields, it remains to be seen how AI can completely take the roles of musicians, especially in areas that require emotional intelligence, and the ability to think critically and make decisions on the spur, if the need arises.

This work is an attempt to explore the roles Artificial Intelligence can play, in collaboration with the human conductors, to enhance music conducting. By so doing, it highlights the indispensable role of technology, as well as preserving the expressive and artistic nature of music conducting.

Theoretical Framework

This work is anchored on two complementary theories – the Technology Acceptance Model theory by Fred Davis and the Collaborative Theory by Chris Huxham and Siv Vangen. The Technology Acceptance Model (TAM) theory provides an understanding and a foundation for how music conductors see and adopt AI tools in their musical practices. The technology acceptance model points out two primary factors that can influence the acceptance of technology: usefulness and ease of use. Contextually, it will mean how much the conductors believe these AI tools will enhance their usefulness and effectiveness, and how user-friendly the said AI tool is. The more complicated it is, the fewer conductors will adopt it for use. These factors influence a conductor's attitude towards AI use and acceptance, influencing their collaborations.

The collaboration theory, on the other hand, emphasizes the cooperative and interactive nature of relationships. Collaboration is usually born of mutual engagement, collective goals, joint decision making, trust, etc. These are essential elements for effective collaboration. In the case of AI and human collaboration, this theory provides a lens to x-ray how conductors and Artificial intelligence systems collaborate musically, to create musical interpretations, control, and adapt each other's inputs during rehearsals and performances.

Research Methods

This study adopts a qualitative research methodology, relying primarily on the systematic review and analysis of secondary sources to investigate the prospects and challenges of Human and AI collaboration in music conducting. To collect data, the research utilizes a combination of document study and an extensive review of existing literature, which includes peer-reviewed scholarly articles, documented technological developments, and various case reports. By synthesizing these diverse materials, the study systematically examines how AI influences musical creativity and performance, aiming to fill the current knowledge gap regarding the role of technology in this field. This structured analytical approach allows for a thorough exploration of the benefits and obstacles associated with AI integration, ensuring that the findings remain grounded in both established research and current industry practices.

Artificial Intelligence (AI)

This is a field in science and technology that develops systems that can accomplish tasks that require human intelligence, such as machine learning, machine reasoning, language processing, and recognition of patterns. It is the attempt to reproduce the cognitive abilities of humans using computer systems. According to PK (1984), "Artificial Intelligence is a branch of science and technology that creates intelligent machines and computer programs to perform various tasks which requires human intelligence. It is a system that mimic various functions which a human can do. AI uses external data like the big data in order to achieve excellent performance for the given tasks." It refers to the brain-like ability created by a machine in the fields of computer science and technology. It describes the potential of a machine or other systems to mimic the traits of a person's mind by simulating its intelligence. It is a system that simulates all the things a person can do. Artificial intelligence was created to replace humans in almost every field. It is automated cognition. It is the social and cognitive processes that gives a machine the ability to socially integrate into a society, to undertake competitive tasks that involve day to day interactions with the immediate society, exchanging ideas, providing help where necessary, etc. (PK, 1984., Abbas, 2021., Lai, 2021, Ahmed, 2023)

Types of Artificial Intelligence

In his work titled Three Types of Artificial Intelligence, Strelkova (2017) presents and explains three levels of Artificial Intelligence. They include the Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and the Artificial Super Intelligence (ASI).

(i) Artificial Narrow Intelligence (ANI): This is the initial level of artificial intelligence that is created to know everything about a given area. Its knowledge is narrow, since it does not have general knowledge, but is a master of a given area, i.e., the area it was programmed to know. As an example, there is an AI that has been built with expert knowledge in playing chess. It can defeat the world's best chess champion in chess, although that is the only thing it does.

(ii) Artificial General Intelligence (AGI): This type of AI is designed to surpass humans in intelligence. It is equipped with the ability to reason, find solutions to problems, think and plan, understand difficult issues, learn quickly, and also learn from experience.

(iii) Artificial Super Intelligence (ASI): This AI is believed to possess intelligence levels that reach and surpass the intelligence level of humans. It possesses an intellect that is very much smarter than humans, even the best brains in every field. This includes creativity, scientific discoveries, as well as social skills and general wisdom.

To gain further insight into the types of Artificial Intelligence, Dorr (2022), mentioned the three main types of Artificial Intelligence as presented by Strelkova. He also looked at types of Artificial intelligence from another perspective. He broke AI down into 4 categories, based on their thinking abilities. They include – "Reactive AI, Limited Memory AI, Theory of Mind AI, and Self-aware AI".

(i) Reactive AI: This is the oldest form of AI. It "concludes patterns in data by using statistical models and algorithms. Reactive machine-learning models analyze huge amounts of data to identify patterns and produce output". Examples are spam filters that analyze texts to determine if there is any repetition. This AI does not have a memory of what happened before.

(ii) Limited Memory AI: This came when there was a need to create an AI with the ability to learn from past experiences. Limited AI makes decisions like the reactive AI, but learns from its experiences and avoids repeating past mistakes. It stores large volumes of data and previous experiences, which are used as a reference for making future decisions.

(iii) Theory of Mind AI: This AI is still under development, and is only in existence conceptually. The goal of this AI is to understand the intents of the individual(s) it is interacting with, such as emotions, beliefs, needs, thoughts, and goals. It will be designed in a way that human feelings and thoughts would affect its behaviour.

(iv) Self-aware AI: This AI model will be seen as AI in human form. They will do everything humans can do and even better. They will be able to feel, develop emotions, cry, laugh, love, etc. This category of AI falls under the Artificial General Intelligence (AGI) and the Artificial Super Intelligence (ASI)

Music Conducting: A music conductor is a person who directs a musical performance using visible gestures. Although there may be other personnel – both musical and non-musical who contribute to the overall success of performances, the conductor's role extends beyond the stage performance. It is an important quality in a conductor to inspire the performers, through a series of rehearsals, until the actual performance. That is an aspect of the leadership quality of a conductor which can sometimes be given other names like good teaching ability, and ability to create enthusiasm in the players among others. This is so because rehearsals can be considered to be a class, where the conductor teaches the singers or instrumentalists how to sing or play the piece. (McElheran, 2004).

Beyond the leadership role of a conductor, there are other musical and extra-musical qualities expected of a conductor. These musical and extra-musical qualities have been enumerated by Ekwueme (2013) as follows:

(a) Musical qualities – A good ear, relative pitch, general musicianship, knowledge of choral literature, good knowledge of music theory, singing techniques, acoustics and vocal orchestration, keyboard facility, orchestral conducting, musical and aesthetic standard.
(b) Extra-musical qualities – Discipline, regularity in attendance, punctuality, personal self-control, hard work and mental alertness, clarity of instructions, friendly attitude, sense of humour, general education, physical and health education.

Igbi (2024) further submits that an effective conductor and ideal ensemble manager should, at a minimum, possess the following abilities:

(i) Effective utilization of the left hand for appropriate gestures.
(ii) Have an in-depth knowledge of the musical score.
(iii) Be conversant with and correctly apply beat patterns suitable for performed pieces.
(iv) Effectively interpret the music being performed, such that the intentions of the composers are well captured.
(v) Possess good musical and non-musical communication skills.
(vi) Have artistic discipline in keeping tempo and seamlessly changing it if need be.

(vii) Use appropriate teaching methods during rehearsals.

(viii) Possess psychological skills to understand individual needs and challenges of ensemble members.

(ix) Acquire technical versatility in music.

(x) Have a robust repertory to meet audience needs.

(xi) Innovation and spontaneity in making correct decisions.

(xii) Prudence and ability to manage ensemble finances.

(xiii) Be able to manage time in teaching songs.

(xiv) Proficiency on the piano or any other musical instrument.

(xv) Possess very good aural ability.

(xvi) Be approachable.

(xvii) Have the ability to handle pressure.

(xviii) Firmness in taking decisions.

(xix) Ability to work with ensemble members from different ethnic and family background.

Human–AI Collaboration: This describes the collaborative partnership between Artificial Intelligence and humans, where Artificial Intelligence provides humans with support for human activities or provides assistance in such a way that augments human creativity and productivity. This collaboration has continued to revolutionize disciplinary practices across industries. Every sphere of human existence has been affected in one way or the other by Artificial Intelligence. In the field of medicine, AI has been very helpful. It excels in interpreting medical images such as X-rays, MRIs, and CT scans. It helps detect diseases like cancer, helps in drug discovery and development, and AI has even grown to the extent of performing several successful surgeries.

The impact of AI in the field of education has been quite glaring. “The use of artificial intelligence (AI) in education has enabled personalized learning, revolutionizing the way students learn”. It plays a critical role in personalized learning by using machine learning algorithms to analyze data and identify patterns in students’ learning behaviour, preferences, and achievements. Chatbots, computer programmes, have been increasingly used in education as a

form of personalized support for students, automating administrative tasks, and offering new opportunities for engagement. (Yeruva, Choudhari, et al., 2022). Artificial intelligence (AI) can provide automated instant grading and assessment for students. This prompt and timely feedback saves the educators time and effort. (AlAli, Wardet, & Al-Qahtani, 2023).

In the field of music, AI has profoundly changed the landscape of musical practices in the areas of music creation, education, and performance. This is done by offering innovative tools for collaboration, analysis, and composition. It facilitates the generation of music through algorithms, helps artists with less stressful and more accurate editing, and provides help with production tasks, as well as creating personalized learning experiences via adaptive platforms. In the realm of performance, AI boosts interactions, provides simulation of instrumental sounds, and can, on many occasions, function as a virtual musician or conductor. Additionally, it enhances how audiences interact with content by providing music recommendations to listeners. In summary, AI is broadening the horizons of creative possibilities while at the same time, challenging conventional roles in the general music-making process.

AI and Human Collaboration in Music Conducting

A group of three AI powered Robots conducting different sections of an Orchestra at the same time.

An AI-powered robot in action, conducting the South Korean National Orchestra

AI and Human collaboration can be seen from two perspectives. Firstly, as shown in the images above, there have been attempts to substitute human conductors with AI-powered robots completely. This move has seen numerous experiments, where AI robots have been programmed to conduct orchestras. They have appeared in different forms and shapes, and have at each point performed to the best of their abilities. They have, however, not been able to match human performances in music conducting, especially in areas such as conveying emotion, intuitiveness, and making on-the-spot decisions. Maybe because the Artificial Super Intelligence (ASI) robots are yet to come to fruition. Secondly, AI has provided many tools which will not substitute humans, but can help in training and enhancing conducting practices for humans, thereby serving as partners, rather than as substitutes. There are so many ways in which AI can partner with humans to enhance conducting practices. These AI tools are presented below:

1. **Yamaha AI Project YOO**

   Current possibilities: This is a musically talented AI-powered tool that is primarily designed for ensemble playing. It can listen to a solo performer and provide real-time accompaniment. It can also create a simulation of an ensemble for conducting training and practice. This tool can also help a conductor, upcoming and established conductors alike, by analyzing the tempo, dynamics, and expression of pieces during rehearsals and even performances.

   More Potential Adaptation: YOO can be developed further and equipped with motion capture technologies like sensors and cameras, to be able to interpret gestures. It can also be equipped with the ability to read scores, to be able to follow a score in real-time, and to adjust its audio output to the interpretive decisions of the conductor.

2. **Semiconductor**: This is a web-based interface that provides a virtual orchestra that can be conducted by a human in real-time. It understands gestures that it sees through the webcam and interprets these gestures audibly. It is a good tool for upcoming conductors. One can practice conducting from the comfort of his/her home. It is pocket-friendly and does not provide the tension that will sometimes be there for a beginner facing a live human orchestra. It helps the beginner conductor develop and master the art of conducting, even without standing in front of a live human orchestra.
3. **Vocaloid**: This is an AI voice synthesizer, designed for creating virtual performances. In Vocaloid, one can simulate a vocal performance the way he or she wants it to be presented. It can serve as a very important tool for training conductors on directing vocal performances and interpreting vocal phrasing. These Vocaloid simulated performances can be used as a practice tool for young conductors. Just like the semiconductor, it can help the beginner conductor develop and master the art of conducting, even without standing in front of a live human orchestra.
4. **Klangio AI**: This is an AI tool that specializes in music transcription. It converts music from audio formats into sheet music. Since score reading and interpretation is a part of the process of conducting, this tool becomes a handy one for a music conductor/choral director, especially to help transcribe works that only exist in audio formats.

Challenges of AI and Human Collaboration

While the possibilities of human and AI collaboration are exciting, there are also several challenges/limitations. These challenges are presented in two sections. First, challenges of outrightly substituting human conductors with AI-powered robots, and secondly, challenges of implementing AI tools that assist humans in the conducting process. Below are some of the key challenges of substituting humans with AI-powered robots in music conducting:

1. Emotional Expression: There have been different attempts to completely substitute humans with AI robots on the conducting stage. These experiments, however, have presented numerous limitations. While the AI robots may be able to beat time, cue in and cut off, process dynamics, tempo, and basic musical structure, it has struggled to convey emotions. It is important to note that music conducting is not just about technical precision, but also the ability to convey the emotions accompanying the music. AI lacks the emotional intelligence that humans have, and which humans bring to performances, such as shaping dynamics and setting the mood of the piece.
2. Ability to adapt to Performance Dynamics: The conductor's role in a live performance goes beyond just conducting the score. They are involved in live interactions with the musicians, responding to their every energy. AI tools are not yet fully capable of providing such a response, especially in cases of unexpected change in timing and expression. AI-powered robots may struggle to adjust to a real-time shift in ensemble performance, especially in cases of spontaneous or unplanned changes.
3. Lack of intuition: A very important aspect of conducting is the ability to make quick decisions on the spur of the moment, to address unforeseen occurrences. While AI is smart and intelligent, it does not possess the intuitive ability to do that. For example, a conductor may decide to conduct a piece without following the dynamics as written in the score. This means that the audience may not get the same output if a particular person conducts the same piece of music several times. An AI-powered robot may, however,

conduct the same piece the same way, no matter how many times it is repeated, except its programming is altered.

4. Reliability and Technical Issues: AI systems are susceptible to technical failures in the form of software bugs and hardware malfunctions during performance. This can pose a serious challenge, especially since timing is very important in performance. Technical instability could have a significant negative impact on the performers and the performance itself. There can also be possibilities of a direct cyber-attack on the robots with an aim to disrupting live performances.
5. Cost Implication: In developing countries, choral groups and orchestras may not be able to afford it. It therefore poses its challenge, even if it is considered.

Having outlined challenges of substituting humans with AI robots in music conducting, the following are some challenges of AI and human collaboration in music conducting:

1. Lack of Advanced Technological Gadgets: Many AI tools require high-end computer gadgets to operate. They sometimes require high model sensors and reliable internet connections to function properly. This may be a limitation to some conductors as they may not have the financial strength to purchase such gadgets. Tools like the YOO by Yamaha may not run accurately and be itch-free because of low hardware and network instability.
2. Cost of Acquisition and Maintenance: Many commercial AI tools are expensive to purchase. Not every conductor will be able to afford it. This poses a challenge, especially in developing countries, with meager resources and upcoming conductors.
3. Lack of Digital Literacy: The integration of AI tools generally needs a certain level of digital literacy. If this skill is not there, using these tools becomes difficult.
4. Lack of local technical support: Most AI tools are created in the Western world, and local support may not be available in other regions. As a result of this, end users might find it difficult to get help when it is needed or troubleshoot problems specific to them or their environment.
5. Understanding Indigenous Music: These tools may not comprehend the intricacies and complexities that are characteristic of African music. In this case, they may not be able to

help a conductor who wants to grow his skill in the understanding and conducting of African music.

Prospects of AI and Human Collaboration in Music Conducting

The incorporation of Artificial Intelligence (AI) tools into the domain of music conducting presents exciting and transformative prospects that can potentially reshape traditional music conducting practices. Though still in the formative stages, the collaboration of AI-powered systems and Human conductors presents exciting and promising directions for the future of music conducting.

- Artificial Intelligence (AI) has the potential to become a valuable co-teacher in music institutions where conducting is studied. Through AI software, upcoming conductors will be able to receive real-time feedback on their emotional expressions, accuracy of gestures as well and timing. Virtual orchestral simulations, powered by AI, can create a good learning tool, where conducting students can rehearse with a digitally responsive orchestra. This can accelerate their learning without the challenges of a physical orchestra.
- Artificial Intelligence (AI) can help with score interpretation and preparation. It can help analyze historical performances, trends in interpretation, and orchestral styles. AI tools can offer assistance with phrasing, dynamics and variations in tempo.
- In the wake of the emergence of the Artificial Super Intelligence (ASI), humans will have a near-perfect alternative. This becomes a welcome innovation and can provide alternatives if, for any reason, a conductor does not show up for a performance. It remains to be seen if these Artificial super-intelligence systems will have the ability to completely replace humans.

Recommendations

Based on the discussions above, the following are recommendations to guide the further adoption and integration of Artificial Intelligence in Music Conducting:

Music institutions should include the teaching and learning of AI systems and information technology in their curricula. This will prepare conductors for the future, where they may not be able to function without the use of AI tools.

Software developers should collaborate with musicians to provide tools that address specific areas in music practice. This partnership will ensure that AI tools are designed and equipped with pedagogical and musical sensitivity.

Music educators and conductors must ensure that the Human element is preserved in music conducting. This becomes very important in an era where Artificial Intelligence is taking over everything. The emotion, leadership, and intuition in musical performances are very important components that give more life to a performance. Artificial Intelligence should continue to play a supportive role, and not outrightly substitute Humans.

Teachers and conductors who use AI tools should be able to provide feedback to developers. This continuous feedback can ensure that these tools align with the goals they were created.

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