Creativity in machines: Music composition using artificial intelligence

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Abstract— In this paper we propose a framework to take the next step towards making creative machines. Taking cue from Turing's Mind Paper (1950) to more recent studies by Riedl in ''The Lovelace 2.0 test of artificial creativity and intelligence' we try to examine a very creative area of human creativity – music. We have summarized the different works published on artificial intelligence and machine learning implemented for algorithmic music composition. Comparison of different algorithms-techniques including key features, advantages, disadvantages, common issues, trade-off and future aspects are discussed in detail. We then propose our own framework of how machines can be made to learn creativity.

1. Introduction

The Lovelace 2.0 test can be act as a test of intelligence in the case of creative artefacts that require human level intelligence. One such artefact is musical composition that requires human intelligence, emotional intelligence, knowledge of musical theory, setting the music to tell a story. If we take this artefact as use case for research and analyse how the approach of different researchers has been and then as we propose, what kind of big data should be collected and used to train the deep learning models that can generate creative compositions.

Algorithmic composition is a process to create music using computer algorithms. We can define algorithms as a formal set of rules/instruction, in a proper sequence which tend to solve a particular problem. In composition, algorithms are used to combine different musical parts into a whole composition [1]. Alpern in 1995 [2] defined music composition as the process of using some formal processes for music generation with minimal or no human intervention.

The ideas of using formal instruction set to generate music is from the time of the ancient Greeks. Even Pythagoras (around 500 B.C.) believed that the fundamental laws of nature have direct relation with music and harmony.

"The word music had a much wider meaning to the Greeks than it has to us. In the teachings of Pythagoras and his followers, music was inseparable from numbers, which were thought to be the key to the whole spiritual and physical universe. So the system of musical sounds and rhythms, being ordered by numbers exemplified the harmony of the cosmos and corresponded to it" (Grount, 1996) [3].

2. The Review

Here we briefly review the recent work in algorithmic composition from an implementation perspective as well as theoretically. In coming sub-sections we will discuss the implemented AI methods which includes:

- Translational Models
- Mathematical Models
- Knowledge-Based Systems
- Grammars
- Evo-Devo Approach
- Hybrid Systems

All these methods are classified based on the different AI methods, their structure and the way these algorithms process the data. Some of these models can be partially overlapping types.

For e.g. Markov chains used in Mathematical models is very similar to the type-3 grammars (Noam Chomsky, 1957). Evo-Dvo approach is also a combination of Evolutionary methods combined with the developmental process.

In each sub-section discussion reflecting the amount of research-work done in that particular domain is summarized.

2.1 Translational Models

To generate music from this approach, it involves translating information from an already existing non-musical data-source to new musical sound. The translation can either be rules based or random (stochastic). e.g. the translation of text into music [5] in which text is used to extract sentiment and those sentiment can be used and as an input to music composition.

Another e.g. is translating an image into new sound, In a jpeg image treating horizontal pixels line as a value of sound with constant pitch.

2.2 Mathematical Models

Mathematical models are based on random events (stochastic processes) [6] and mathematical equations. Stochastic process is the most common way to compose music through the knowledge of mathematics. In stochastic methods multiple pieces of music is generated via the result of non-deterministic methods.

Stochastic methods are used in combination of other decision-making algorithms like Markov chains and Gussian Distributions. e.g. composer generated by Ames and Domino [7], Composer was able to generate music of different genres, e.g. standard jazz, latin jazz, rock, and ragtime.

Natural phenomena is also used to compose music, chaotic models already being used to generate composition from harmonic as well as in-harmonic natural phenomena. E.g. Harley [8], Pressing [9] and Chapel [10]. Chapel has also used fractals (basically complex patterns that are self -similar) models for algorithmic composition.

Another example of deterministic compositions is the use of all-interval series for computer-aided music generation.[11]

Main issues with stochastic process is that it requires other algorithms to generate probabilities, which involves analysing multiple music pieces for same type of music composition.

2.3 Knowledge Based Systems

Knowledge based systems (K-B-S) are programs that uses already provided/Incorporated knowledge base within the program to solve a set of problems. Knowledge based systems are based on pre-defined or pre-set of values that is used to generate new music pieces of the same genre and style.

The use of KBS systems in music composition is very common, as in KBS systems we can model well defined domain of music pieces and can also introduce set of explicit structures and rules-set for music composition [12]. In [13] able model a KBS which is able to execute the classification and addition of the non-harmonic tones by applying knowledge of KBS. Zimermann [14], Ramalho and Ganascia [15], tried for composing intension-mood based music.

As KSB systems generally tend to have a knowledge based on their own, but time and data required to generate such knowledge base is very large and complex. Other issue come in the categorization of the training data, as most times music experts segregate music files based on their domain and most probably they do not have any programming knowledge. So lack of flexibility between experts and programmers can also lead less efficient system.

2.4 Grammars

Like computers have their own grammar (Theory of Computation), music can also be explained and examined as a language with a distinctive set of grammar. Different properties can be defined for music using it's grammar set, and can be helpful for music composition.

Compositions can be constructed by first developing a grammar for music, which is then used for generation of comprehensible musical pieces. Musical grammar generally uses rules like harmony and rhythm for macro-level composing rather than single nodes.

Yaser [16] implemented music composition tools using genetic algorithm, and the

production of music is enhanced by integrating formal grammar rules (descriptive and prescriptive rules for analyzing sequences of different symbols). Johnson [17] also used grammars to generate and interpret jazz chord progression and bass.

Problems with grammars-based composers are:

- Parsing of musical string can be computationally expensive.
- Problems may arise due to the representational power of such a generated grammar is weak, can lead to non-efficient composers generating domain specific music.
- Improvisation as grammar are of hierarchical structure but music is not, increase ambiguity in system.

2.5 Evo-Devo Approach

In Evo-Devo (evolutionary developmental biology) approach includes, evolutionary methods (a generic population based optimization algorithm) with developmental processes. Evo-devo approach is used in generation and optimization of complex structures including music composition. Music structures is generated by iterative processing of few simple-composition into a complex composed music piece. Some examples of this approach are [18] and [19].

In [18] Melomics (an evolutionary method) which generates music pieces by continuous stimulated evolution. The melomics approach encodes each theme in a genome, and the complete data set of music pieces undergo evo-devo dynamics.

Problems faced in this approach is that it Involves formation of clusters required high computation setup to carry out the research.

2.6 Hybrid Systems

Hybrid system involves usage of a combinational of AI/ML algorithm. As programs results based on single algorithmic model succeed very rarely. Because of that different type of algorithms are often used together to combine the strength of each algorithms and diminishes the weakness of each other.

[21] come up with corpus-based hybrid method for music analysis and composition, which also includes statistical, connectionist and evolutionary component. Composer is developed by utilizing power-law matrices of music critics, then trained on a large music corpus and then using an evolutionary music composer that utilizes provided music critics for fitness function.

The main disadvantage of using hybrid systems is their exponential growing complexity and the need of resources required for running such algorithms to test the model on dataset.

3. Ideas for Future Work

In this section we discuss a new framework PALASH 1.0 which proposes to use a big data lake of human experiences, learning and reaction to listening music to train the deep learning models. These models can be used in conjunction with Grammars approach.

In all the discussed composers, the big negative point is that the music generated by the composers is meaningless. Computational models were able to generate tones based on genre and sentimental inputs. But as human tend to describe their emotions, feelings, mood, nature etc, these all objective were all missing till now.

Composer aided model tend to have some reference to an abstract or emotion but fully generated music piece from composers lack that abstract or reference.

Ideas which we like to incorporate in these models are:

- Addition of a human or a bot voice which are co-relate words into meaningful sentences and can collaborate with composers music, with right voice-to-word tuning so that the generated music will have meaningful reference to emotions and feelings. This could be achieved by text sentiment and training AI on different voice sentences with correct emotion mapped to each sentences.
- We will also need to developed and integrate musical cognition (how human interact with music) within the model to generate flexible, dynamic, and more closely human simulated music behaviour.

- The performance of each music piece is also an important factor which should not be treated as irrelevant in the context of algorithmic composition.

If we consider the journey of a student of music, he starts with learning the basic rules of music theory. Placing the right music structures together to play already composed pieces is the next step. Till now, tonal errors can be identified and all this body of knowledge is proposed to be used as one of the inputs to the data lake.

The next step is to incorporate human emotions into the music structures. This can be captured in two ways. The first one is to capture the reaction of different body parameters like heart beast, breathing, blood pressure, eyelid movements and other measurable parameters. This requires a huge computational effort as years of data has to be encapsulated together.

The final step would be to link the emotions to the different music structures. The deep learning models will have to be trained on this huge data set.

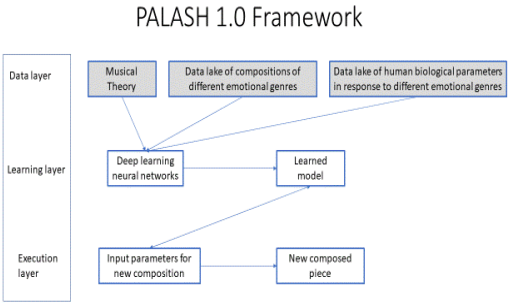

Fig 1. PALASH 1.0 framework for creative composition of music by machines

The challenges in this framework need to be addressed as collecting the data for creating the data lake as well as the computational power required for the learning models. But then, we are attempting to emulate a creative human brain.

The final test would be to pass the Lovelace 2.0 test when a referee listener is presented with two compositions, one from an human composer (has to be a new piece) and one generated by a machine using the proposed framework.

Conclusion:

In this paper we have provided a critical review on different AI methodologies and approaches for algorithmic compositions. Composers developed on a single AI technique are tend to perform below expectation in comparison with the hybrid architecture.

Blending different models requires a deep sense of understanding of the algorithms, and are very complex. But results generated by such algorithms comparatively perform much better.

If evolution algorithms are also Incorporated with the hybrid Composers, then the integrated system will easily tend to evolve over time and data and further yield great result.

Infusing human emotional intelligence into music composition requires diverse data collection and the actual working model of the same is being developed by the authors.

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Lalit Kumar is an associate consultant with Gazelle Information Technologies, New Delhi. He holds a bachelor's in technology with special interests in AI and using AI for practical applications. He has built practical solutions for businesses to predict incidents in the supply chain using various algorithms.

Palash Goyal is currently a student of class XI at Mount Carmel School, Sector 23, Dwarka, New Delhi. He started coding at an early age and is currently working on Python, Automation and Image Processing. It was his personal experience at one of his previous schools, that led to the birth of this idea last year, which he converted to reality with the help of other authors.

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