FRACTAL MODELING OF CARNATIC RHYTHM SEQUENCE: CASE-STUDY ON A GENERATIVE MODEL

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EXTENDED ABSTRACT

Nature is full of irregular patterns and complicated phenomena. Despite their complicated appearances, 'self similarity', i.e. the similarity between the whole and a small portion of a system, can be observed in many configurations and phenomena upon closer investigation. Geometry with such scale-invariant features has been categorized and designated as 'fractal' in literature. Many geometries existing in nature are fractal, e.g. a mountain's profile and the shape of snowflakes. Music, whose origin may be attributed to imitating the harmony of nature's sound, also demonstrates a fractal property like many other naturally occurring fluctuations do. Fractal rhythms, in specific, involve complex dynamics of self-organizing that are visible are various levels of analysis by zooming-in or zooming-out, and tracing the pattern changes over time. Most music that we actually listen to is $\frac{1}{f}$ noise. It has the right combination of pattern and unexpectedness, and is pleasing to the human ear. Following are a few scholarly works that have used fractal analysis to show (un)predictability of musical sequences [1, 5, 6, 8]. Surprisingly, while rhythm is quite regular, it turns out that it is not as predictable as we might have expected. Because music has a beat and is based on repetition, it has been said that 'what' the next musical event will be is not always easy to guess, but 'when' it is likely to happen can be easily predicted. Using a large collection of music that spans centuries, researchers found that musical rhythm obeys a $\frac{1}{f}$ pattern, with different types of music being able to fit to this power law, though varying in the exponent.

The realm of music information retrieval (MIR), on the other hand, is broadly categorized into two complementary and seemingly mutually exclusive approaches, namely analysis and synthesis. Computational models for generative music have been a recent trend in AI based technology developments. Literature in non-Eurogenetic music constitute some of the earlier examples in the area of culture-specific music technologies. One early study [2] from our research group had the goal to develop expert systems that can reliably generate music in this style of Indian classical music, envisioning a contribution on two levels: (i) the creation of tools for lay audiences to interact with musical styles beyond the Western ones; and (ii) the automatic generation of unlimited amounts of data for training machine learning algorithms. However, an entirely data-driven strategy often falls short of capturing the naturally occurring rhythmic grouping. Guedes et al. [2, 4] had proposed dictionary based and stroke-grouping based approaches to generate novel sequences in the 8-beat cycle of Aditala. Authors used an n-gram approach for modeling Carnatic percussion generation. More recently an attempt of incorporating arithmetic partitioning, as conceived by performers, was made [3] to get rid of the drawback of the former model being failure to capture long-term structure and grammar of this particular idiom and being only successful in capturing local and short-term phrasing. The authors aimed to overcome these issues by introducing a new data-driven approach of modeling the tala cycle based on a set of arithmetic partitions that capture reliably the rhythmic structure of the tala, which led to developing an application that improves the generation of Carnatic rhythms and enhances the interaction of the user by adopting data visualization techniques during the generation. Other literature on computational models on rhythm in Indian music has covered aspects of analysis [7] which is essential to understand the top-down performance aspect, and thereafter can be imparted as knowledge constraints to the generative model.

The aim of our current study is to analyze rhythmic patterns at different time-scales and search for possible fractal geometry in the rhythmic progression. This would, additionally, help understand the mental 'schema' a performer uses while performing familiar, yet not memorized, rhythm sequences. We provide a brief background for the rhythmic framework of Carnatic music which is based on the tala that provides a structure for repetition, grouping and improvisation. The tala consists of a fixed time length cycle called avartana which is further divided into equidistant basic time units called aksharas (strokes). The concept of groupings is a fundamental building-block of Carnatic rhythm. There are certain rules that are followed by percussionists that allow this rhythmic generation to be more musically aesthetic, rather than just a series of groupings. Our approach is to analyze the data by computing self-similarity matrices with different empirical tuning of hyperparameters and look for interesting fractal patterns which could be explained via musicologically plausible hypotheses.

The data collection procedure for the current study was different from mainstream MIR task oriented dataset creation in the sense that the content was recorded with an intention of demonstrating the strategies that performers use which are hardly available in musicology texts. We believe that such a case-study has the potential of bridging the gap between theory and practice, thereby help generative music to "sound more natural". A professional Carnatic percussionist Akshay Anantapadmanabhan, who acts as a consultant to MaSC [1] and is also a co-author, was consulted for ideation of the hypotheses. Further he recorded demonstrative pieces, both compositions and shorter excerpts, with Mridangam and Kanjira, as applicable. The recordings were made in a studio environment with three microphones in the presence of metronome. The konokkol (vocables of the aksharas) of the same were also recorded.

Finally, an open ended question that still remains is what do we actually mean by a machine-generated music to "sound more natural" – it may be dynamic accent, more intuitive grouping, or even a better language model. As the qualitative evaluation of CAMel [2] involves expert listening, we believe, adding the proposed knowledge constraints would add to the naturalness, hence acceptability, of the generated sequences.

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