Markov Based Quality Metrics For Generating Structured Music With Optimization Techniques

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This research examines different ways in which low order Markov models can be used to build quality assessment metrics for an optimization algorithm that generates music. The metrics are used as the objective function of the algorithm which evaluates how good a solution or musical fragment fits the chosen style. A first order Markov model is built from a corpus of bagana music, a traditional lyre from Ethiopia [7], in order to capture the style of this type of music. Different metrics are then implemented in a variable neighbourhood search algorithm (VNS) that generates bagana music. It is often only possible to get rich statistics for low order models due to the size of many datasets. Unfortunately, these models do not handle structure very well, and often produce very repetitive output. Therefore, in this research, we also propose a method to enforce structure and repetition within the generated music, thus handling a type of long-term dependency with a first order model.

We chose to work with music for bagana because cycles and repetition play an important role. In a first part of this research a method is described for representing and efficiently evaluating this structure with long-range dependencies provided by an existing template piece, while still employing a Markov model to evaluate the music.

In previous research, the authors generated counterpoint with a VNS algorithm using an objective function based on rules from music theory [5]. For most styles of music however, formal rules are not available. Therefore, different ways are examined in which machine learned models such as Markov models can be used to construct quality metrics. An overview of the different metrics implemented in this research is given below.

High probability sequences Cross-entropy is used as a measure for high probability sequences, whereby minimal cross-entropy corresponds to a maximum likelihood sequence according to the Markov model. This metric is also used by Farbood and Schoner [4] and Lo and Lucas [6].

Minimal distance between transition matrix (TM) of model and solution Based on Davismoon and Eccles [3], an evaluation metric was evaluated that tries to match the transition matrices of both the original model and the newly generated piece by minimizing the Euclidean distance between them. This will ensure that they have an equal distribution of probabilities after each possible note.

Delta cross-entropy In order to optimize towards a cross-entropy value that actually occurs within the corpus, this metric optimizes towards the average cross-entropy value of the dataset.

Information contour is an additional constraint that describes the movement of information between two successive events. Since high probability sequences often sound uninteresting and repetitive [6], this metric might correct this by enforcing diversity within a piece.

Unwords are significantly rare patterns [1]. They are the shortest sequence of notes (i.e., not contained within a longer unword) that never occur in the corpus, yet whose absence from the corpus is surprising given their letter statistics [2].

The metrics above are implemented in the objective function of a VNS that generates bagana music. The results are very promising and clearly indicate that high-probability sequences on their own are not sufficient. Yet combined with extra constraints such as information contour, a bagana expert described the generated music as "very good". The musical fragments generated with the TM distance metric were also among the better ones according to the bagana expert.

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