Prathusha Boppana
Jie Zhang
2270 Linear Algebra Project Report

Using Markov Chain to Compose Music Pieces

Markov chains contains the probability of transferring from one state to the next possible state in a sequence of events. When Markov chains are used in learning algorithms, it usually is the abstraction of the probabilistic data which can be used to infer how the next steps would be from the previous steps that just went through. Music composition is an interesting subject that can have Markov chains applied relatively easily as the a music piece can be easily seen as a sequences of state, with each state as a note, with its specific length played. Since the notes available are not infinite, the length options are not infinite either, even adding in the probability of multiple instruments, the categories of state should also be finite. Markov chains thus can be built from previous musical pieces of different genre and be the basis for learning algorithm to make probabilistic decisions and create new music pieces in the same genre.

Different orders of Markov chains would vary in terms of its accuracy in capturing the probability of transferring from one state to the next possible state. A first order chain means only to count the previous two state and the third following state and example the probability transition from the second to the third. An example of a first-order chain with states of the system as note or pitch values, and a probability vector for each note constructed, completing a transition probability matrix is shown below.

1st-order matrix			
Note	A	C♯	E♭
A	0.1	0.6	0.3
C♯	0.25	0.05	0.7
E♭	0.7	0.3	0

An algorithm would need to be constructed to produce output note values based on the transition matrix weightings above.

2nd-order matrix			
Notes	A	D	G
AA	0.18	0.6	0.22
AD	0.5	0.5	0

AG	0.15	0.75	0.1
DD	0	0	1
DA	0.25	0	0.75
DG	0.9	0.1	0
GG	0.4	0.4	0.2
GA	0.5	0.25	0.25
GD	1	0	0

A second-order Markov chain can be used by creating a table with the current state and the previous state, similar to the table above. Higher, nth-order Markov chains tend to "group" particular notes together, while creating various patterns and sequences. These higher-order chains offer sequences of notes with a sense of phrasal structure, rather than the random sequences produced by a first-order system.

Usually musical systems need to enforce specific control constraints that they generate on finite sequences, but control constraints are not compatible with Markov models, since they require these constraints to be induced repetitively without end and therefore violate the Markov hypothesis of limited memory. In order to overcome this limitation, we decided to restrict the sequence of notes produced.

Project Steps

1. Correct digital music form that can be processed to compose Markov chain matrix
2. Process Midi files using Java code
3. Setting up parameters for auto composing
4. Auto compose

References:

https://en.wikipedia.org/wiki/Markov_chain#Music