Stochastic Simulation

IT-461

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201301143

Markov Chains: Applications in Music

Markov Chains are a sequence of random numbers, where the current random number only depends on one previous state. In the domain of music, it can be used to predict the notes of a song, given that it has had a song to work on before. In essence, it allows for some amount of machine learning probabilistic modeling of music.
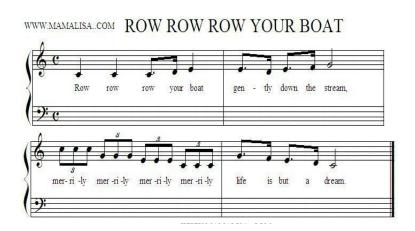
$$\Pr(X_{n+1} = x \mid X_1 = x_1, X_2 = x_2, \ldots, X_n = x_n) = \Pr(X_{n+1} = x \mid X_n = x_n)$$

With the notes of the input song, we can construct an adjacency matrix for a Markov Chain by calculating the probabilities of the occurrence of a note, depending on its previous note. The output is a clear, noiseless melody which is similar to the one given as the input.

The Input Sample : We can take an input sample of *Row row row your boat* poem to create an adjacency matrix for the successive notes and timings of the notes, which constitutes of the Markov Chains.The Markov Chain then outputs a melody based on these probabilities of playing one note, given the previous note. This leads us to produce a melody.

The Adjacency Matrix of note timings :

	1	2	4	8	16
1	0	0	0	0	0
2	0	0	0	0	1
4	0	0	1	2	0
8	0	2	1	7	0
16	0	0	0	1	11

The adjacency matrix for Notes:

	a	a#	b	c	c#	d	d#	e	f	f#	g	g#
a	0	0	0	0	0	0	0	0	0	0	0	0
a#	0	0	0	0	0	0	0	0	0	0	0	0
b	0	0	0	0	0	0	0	0	0	0	0	0
c	0	0	0	6	0	1	0	0	0	0	2	0
c#	0	0	0	0	0	0	0	0	0	0	0	0
d	0	0	0	1	0	0	0	2	0	0	0	0
d#	0	0	0	0	0	0	0	0	0	0	0	0
e	0	0	0	0	0	2	0	3	1	0	0	0
f	0	0	0	0	0	0	0	1	0	0	1	0
f#	0	0	0	0	0	0	0	0	0	0	0	0
g	0	0	0	1	0	0	0	1	1	0	0	0
g#	0	0	0	0	0	0	0	0	0	0	0	0

Algorithm: The initial note is provided to the system (C, 4), later we look into the row of note C, and generate a random value below the sum of the values in the row (Ex. for row C, the max is 9). The value generated is later checked using the probability distribution and the next note is formed. A similar approach is simultaneously done for the timings of the notes, as they are independent matrices. The output thus generated is a Markov chain generated using probability of the given input sample. The output melody sounds similar to that of inputs. We have tried the experiment for poems *Row row row your boat*, and *Twinkle twinkle little star*, and also *Vande Maatram*. The applications of generating tunes can be seen in Remixes, Malls- automatic piano players, completing the music notes given a small sequence, and also comparing similarity between tunes.

References:
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