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Markov Processes as Musical Improvisation

Abstract:

This project was a simple demonstration of how Markov Processes could be used to produce variations in well-known musical sequences that still resembled the original sequencing despite being put through what is essentially a random number generation process.

Bach Matrices and JFugue

STATE MATRIX

T/F	E	F	G	D	C	EQ	DI	DH	DQ	CI	CH
E	2	2	0	2	0	0	0	1	0	0	1
F	2	0	2	0	0	0	0	0	0	0	0
G	0	2	2	0	0	0	0	0	0	0	0
D	2	0	0	0	2	0	0	0	0	0	0
C	0	0	0	2	2	0	0	0	0	0	0
EQ	1	0	0	0	0	0	0	0	0	0	0
DI	0	0	0	0	0	1	0	0	0	0	0
DH	0	0	0	0	0	0	1	0	0	0	0
DQ	1	0	0	0	0	0	0	0	0	0	0
CI	0	0	0	0	0	0	0	0	1	0	0
CH	0	0	0	0	0	0	0	0	0	1	0

PROBABILITY MATRIX

T/F	E	F	G	D	C	EQ	DI	DH	DQ	CI	CH
E	.25	.25	0	.25	0	0	0	.125	0	0	.125
F	.5	0	.5	0	0	0	0	0	0	0	0
G	0	.5	.5	0	0	0	0	0	0	0	0
D	.5	0	0	0	.5	0	0	0	0	0	0
C	0	0	0	.5	.5	0	0	0	0	0	0
EQ	1	0	0	0	0	0	0	0	0	0	0
DI	0	0	0	0	0	1	0	0	0	0	0
DH	0	0	0	0	0	0	1	0	0	0	0
DQ	1	0	0	0	0	0	0	0	0	0	0
CI	0	0	0	0	0	0	0	0	1	0	0
CH	0	0	0	0	0	0	0	0	0	1	0

DISTRIBUTION MATRIX

T/F	E	F	G	D	C	EQ	DI	DH	DQ	CI	CH
E	.25	.5	.5	.75	.75	.75	.75	.875	.875	.875	1
F	.5	.5	1	1	1	1	1	1	1	1	1
G	0	.5	1	1	1	1	1	1	1	1	1
D	.5	.5	.5	.5	1	1	1	1	1	1	1
C	0	0	0	.5	1	1	1	1	1	1	1
EQ	1	1	1	1	1	1	1	1	1	1	1
DI	0	0	0	0	0	1	1	1	1	1	1
DH	0	0	0	0	0	0	1	1	1	1	1
DQ	1	1	1	1	1	1	1	1	1	1	1
CI	0	0	0	0	0	0	0	0	1	1	1
CH	0	0	0	0	0	0	0	0	0	1	1

JFugue Notation : D C C D E F E DH DI EQ E E D C D C D C C D E E E E E F G G F G

Turk Matrices and JFugue

STATE MATRIX

T/F	C	G	EH	CH	D	FH	DH	E
C	2	0	0	1	0	0	0	1
G	1	0	0	0	2	0	0	0
EH	0	1	0	0	0	0	0	0
CH	0	0	1	1	1	0	0	0
D	1	0	0	1	5	0	0	1
FH	0	1	0	0	0	0	0	0
DH	0	0	0	0	0	1	0	0
E	0	1	0	0	0	0	1	3

PROBABILITY MATRIX

T/F	C	G	EH	CH	D	FH	DH	E
C	.5	0	0	.25	0	0	0	.25
G	.33	0	0	0	.66	0	0	0
EH	0	1	0	0	0	0	0	0
CH	0	0	.33	.33	.33	0	0	0
D	.125	0	0	.125	.625	0	0	.125
FH	0	1	0	0	0	0	0	0
DH	0	0	0	0	0	1	0	0
E	0	.2	0	0	0	0	.2	.6

DISTRIBUTION MATRIX

T/F	C	G	EH	CH	D	FH	DH	E
C	.5	.5	.5	.75	.75	.75	.75	1
G	.33	.33	.33	.33	1	1	1	1
EH	0	1	1	1	1	1	1	1
CH	0	0	.33	.66	1	1	1	1
D	.125	.125	.125	.25	.875	.875	.875	1
FH	0	1	1	1	1	1	1	1
DH	0	0	0	0	0	1	1	1
E	0	.2	.2	.2	.2	.2	.4	1

JFugue Notation:

C E DH FH G C C CH CH CH CH EH G C C C CH CH D D D D D D C CH

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COG 356

This particular assignment worked with two tunes: Turk's "March" and Beethoven's "Ode to Joy". The tracks are both snippets from classical music. There are a few pertinent differences to consider. "Ode to Joy" is, in simple terms, a rising track, where the feeling of the song is that of an increase, or a rise towards some musical climax. "March" is a more level track, conveying a sense of level headedness reminiscent of a marching parade. This assignment primarily focused on producing and working with Markov Processes through the creation of State Transition Matrices based off of a JFugue notation of these two tracks. For both tracks, a State Transition Probability Matrix was created. This matrix is meant to display the odds of a note in the track being any given note, based only on the current note, or 'state'. In my view, these matrices do not capture the essence of these musical tracks. The real tracks, as produced as an orchestra, are sweeping, complex pieces of music with detailed and deliberate choices as to where to place notes, and why those notes are played at specific times. The matrices, being random representations, do not capture the artistic essence of the tracks from an aesthetic perspective. Remarkably, despite the randomness applied, the matrix-generated JFugue notes do sound similar to the original tracks on a purely mechanical level. On a stripped-down, note-to-note

basis, these small correlations take the form of recognizable musical motifs. That is where the similarities end.

A Markov Process is a process wherein a random sequence of events happen independent of the past. The next iteration of a Markov Process is based only on the present state, not the previous one, or any of the ones before that. Markov processes are generally used for modeling semi-random real world events, such as the length of lines at amusement parks, economic systems and exchange rates, and epidemic modeling. To generate these two models, a Markov Process was initiated. This was done, manually, by first constructing a state transition matrix, where the amount of times one note was followed by a different note was counted. Next, a probability matrix was formed, out of the odds of a given note being followed by another given note. Finally, a distribution matrix was produced, where the distribution of these odds was calculated. This final matrix was then used to manually compute an algorithm, where a random number was applied to the matrix from a given note, and if the cell's value was higher than that random number, then whatever note's column held the cell, that note would be the next starting point for the next randomly generated number. This produced a series of notes from a Markov Process in JFugue form, which were then converted into MIDI format, which was then made into MP3 files. JFugue can be said to be a knowledge representation because it contains conventions such as note type, length, and pitch that allow a machine to render a JFugue sequence into a playable notation. This also means it is an executable representation.

Improvisation can be said to be the production of something randomly, or based off of little or none previous information. This is, in my view, similar to that of a Markov Process, although a Markov Process is purely M-Mode thinking and human activity is I-Mode. From a computational point of view, the process used to develop these melodies was improvisational,

but from a human perspective, it was the opposite: a set of numbers that inevitably produced a result. Since the numbers being generated are being generated by a machine, and not a human, I would argue that this is not a true representation of improvisation, although it is certainly adjacent.