Analyzing and composing music with algorithms and machine learning

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August 14, 2018

Outline

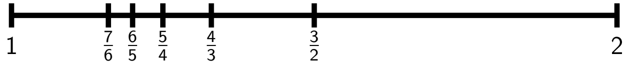
Tuning

Pythagorean tuning

Pythagorean fractions:

$$f = \frac{i+1}{i}; \;\; i = 1, 2, ..., n$$

The Pythagorean string separation:



Equal temperment and 12-TET

Name	12-TET	Pythagorean scale
Unison (C)	$2^{\frac{0}{12}} = 1$	$\frac{1}{1} = 1$
Minor second ($C\sharp/D\flat$)	$2^{\frac{1}{12}} \approx 1.05946$	$\frac{16}{15} \approx 1.06666$
Major second (D)	$2^{\frac{2}{12}} \approx 1.12246$	$\frac{9}{8} = 1.125$
Minor third ($D\sharp/E\flat$)	$2^{\frac{3}{12}} \approx 1.18920$	$\frac{6}{5} = 1.2$
Major third (E)	$2^{\frac{4}{12}} \approx 1.25992$	$\frac{5}{4} = 1.25$
Perfect fourth (F)	$2^{\frac{5}{12}} \approx 1.33484$	$\frac{4}{3} \approx 1.33333$
Tritone ($F\sharp/G\flat$)	$2^{\frac{6}{12}} \approx 1.41421$	$\frac{7}{5} = 1.4$*
Perfect fifth (G)	$2^{\frac{7}{12}} \approx 1.49830$	$\frac{3}{2} = 1.5$
Minor sixth ($G\sharp/A\flat$)	$2^{\frac{8}{12}} \approx 1.58740$	$\frac{8}{5} = 1.6$*
Major sixth (A)	$2^{\frac{9}{12}} \approx 1.68179$	$\frac{5}{3} \approx 1.66666$*
Minor seventh ($A\sharp/B\flat$)	$2^{\frac{10}{12}} \approx 1.78179$	$\frac{16}{9} \approx 1.77777$*
Major seventh (B)	$2^{\frac{11}{12}} \approx 1.88774$	$\frac{15}{8} = 1.875$*
Octave (C)	$2^{\frac{12}{12}} = 2$	$\frac{2}{1} = 2$

Note: the values with * can't be represented like Pythagorean fractions with decent accuracy but the human ear can't differentiate this (in the most cases)

MIDI

MIDI is an acronym to “Musical Instrument Digital Interface”.
It:

- Developed by MIDI Manufacturers Association
- Targets compact representation
- Splited into chunks

This makes MIDI a perfect way to store musical data in form of notes that enables easy manipulation

Header chunk

- Contains data about the file
- Always one

(M)(T)(h)(d) (0)(0)(0)(6) (0)(f) (n)(n) (d)(d)

f - the file type
nn - the number of track chunks
dd - the way of division of the time

Track chunks

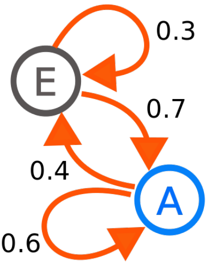
Each track chunk is built up by events (messages). Each event has delta time and data bytes. The most important events are:

- NOTE_ON - start playing a note
- NOTE_OFF - stop playing a note

The events described above have common structure:
(type;channel) (note number) (velocity)

$$note\ number = 69 + 12\log_2 \frac{f}{440}\ where\ f\ is\ the\ frequency$$

Markov chains



Markov chain diagram

Andrey Markov

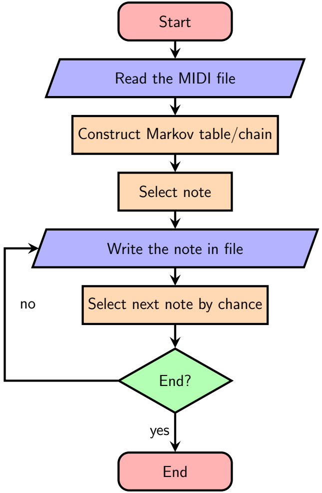
Markov chains

	Next event		
	A	B	C
A	33%	22%	45%
B	81%	9%	10%
C	30%	60%	10%

		Next event		
		A	B	C
A	A	16%	16%	68%
A	B	100%	0%	0%
A	C	12%	75%	13%
B	A	37%	25%	38%
B	B	0%	0%	100%
B	C	100%	0%	0%
C	A	33%	33%	34%
C	B	83%	17%	0%
C	C	100%	0%	0%

Example Markov chains for the string "AABAACBABACBABACCACAACBAAACBACBBCABAACBA"

Common block diagram



Diffrences between the algorithms

- First algorithm - uses only the pitch of the previous note for constructing Markov chain table
- Second algorithm - uses the pitch and the length of the previous note for constructing Markov chain table
- Third algorithm - uses only the pitch of the previous two notes for constructing Markov chain table

Results

Questions

Thank you for the attention!