

Musical Notation & Representation

Music 253/CS 275a

Stanford University

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8 Jan 2015

Representing Music

Two main categories:

- For **Performance** (used as memory aid and for non-aural transmission)

Usually not a complete representation (some discretion left to performer)

- Usually written, but also Guidonian hand is a spatial representation of music for education and memorization.

- For **Analysis**

Usually highlights a specific aspect of the music (reductive)

- Graphical representations (visualizations)
- Digital representations (computational analysis)

- Also:
- Literal representation of sound (analog/digital audio recordings)

Not a direct representation of the cognitive level of music
(extracting musically meaningful information from audio files using computers is difficult)

- Sonification: reverse process on converting data into sound.

Oldest Known Music Notation



2 double columns, each of 7 ruled lines with numbers in Old Babylonian cuneiform tablature notation, with headings, "intonation" and "incantation", respectively.

Two ascending heptatonic scales to be played on a 4-stringed lute tuned in ascending fifths.

MS 5105

Old Babylonian cuneiform musical notation. Babylonia, 2000-1700 BC



And in modern transcription

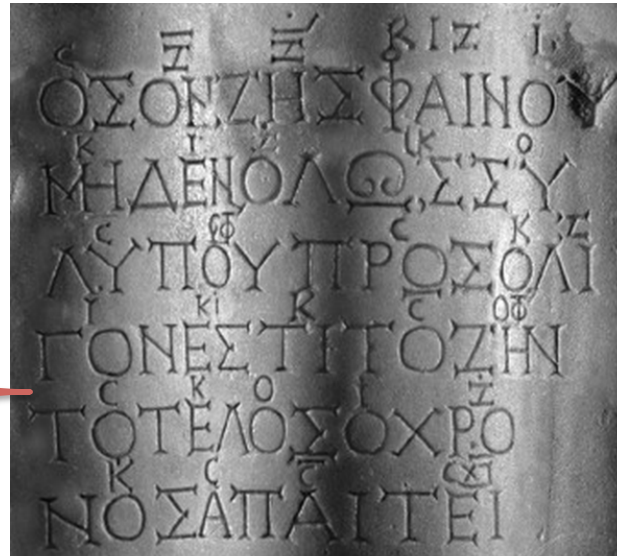
http://www.schoyencollection.com/music_files/ms5105.jpg

<http://www.schoyencollection.com/music.html>

Music Notation in Ancient Greece

Oldest complete notated song (~1st century AD)

Seikilos epitaph



Σ $\bar{\Sigma}$ $\dot{\Sigma}$ ΚΙΖ $\dot{\Gamma}$
 Ὅ σον ζῆς φαί νου

$\bar{\kappa}$ Ι $\dot{\Sigma}$ $\dot{\Gamma}\bar{\kappa}$ Ο $\bar{\Sigma}$ $\bar{\text{ΟΦ}}$
 μη δέν ὄ λως σὺ λυ ποῦ

Σ Κ Ζ Ι $\dot{\kappa}\dot{\Gamma}$ $\bar{\Sigma}$ $\bar{\text{ΟΦ}}$
 πρὸς ὀ λί γον ἐς τὶ τὸ ζῆν

Σ Κ Ο Ι $\dot{\Sigma}$ $\dot{\kappa}$ $\bar{\Sigma}$ $\bar{\Sigma}$ $\bar{\text{Χ}}$
 τὸ τέ λος ὀ χρό νος ἀπ αι τεῖ.

Music Notation in Ancient Greece

C $\bar{Z}$ $\dot{\bar{Z}}$ K I Z $\dot{\bar{I}}$

Ὁ σον ζῆς φαί νου
While you live, shine

$\bar{K}$ I $\dot{Z}$ $\dot{\bar{I}}\bar{K}$ O $\bar{C}$ $\bar{O}\Phi$

μη δέν ὅ λως σὺ λυ ποῦ
Have no grief at all

C K Z $\dot{I}$ $\dot{K}\dot{I}$ $\bar{C}$ $\bar{O}\Phi$

πρὸς ὀ λί γον ἐσ τὶ τὸ ζῆν
Life exists only for a short while

C K O $\dot{I}$ $\dot{Z}$ $\dot{K}$ C $\bar{C}$ $\bar{C}\dot{X}\bar{\Gamma}$

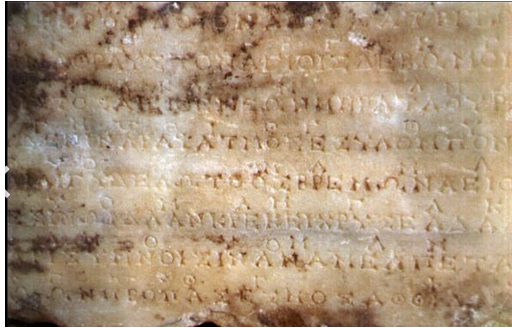
τὸ τέ λος ὁ χρό νος ἀπ αι τεῖ.
And time demands its toll



http://en.wikipedia.org/wiki/Seikilos_epitaph

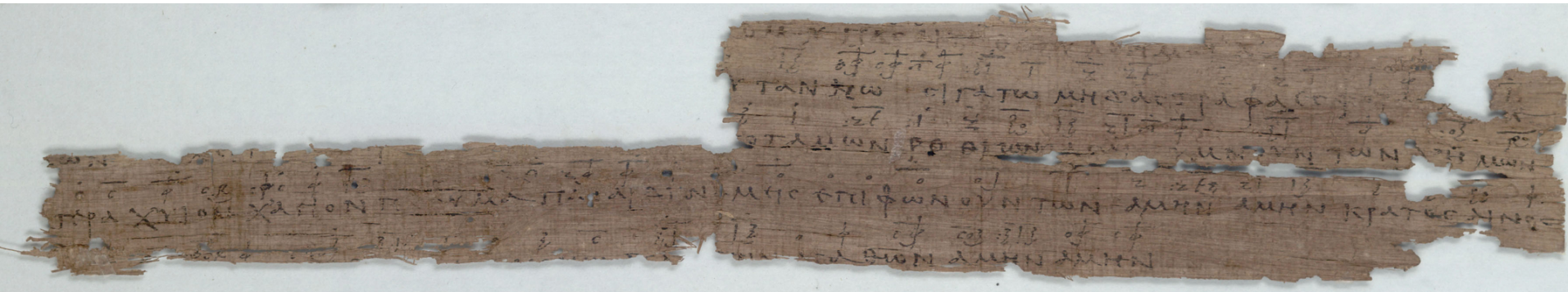
Performed on a *hydraulis*: https://www.youtube.com/watch?v=P4_iWkP24Ww#t=7

Music Notation in Ancient Greece



2nd century BC
Earliest surviving composition
with a known composer
(Athenios son of Athenios)

http://en.wikipedia.org/wiki/Delphic_Hymns



http://en.wikipedia.org/wiki/Oxyrhynchus_hymn

3rd century AD

http://en.wikipedia.org/wiki/Music_of_ancient_Greece

Tonic Sol-Fa

The Lamb.

WILLIAM BLAKE.

GEORGE HENSCHEL.

VOICE.

Lit - tle lamb, who made thee? Dost thou know who

KEY C. { | m .m :m .s | s :r | m .s :d^l .l }

PIANO.

The image shows a musical score for the song 'The Lamb' by William Blake, set to music by George Henschel. The score is for voice and piano. The voice part is written on a single staff with a treble clef and a 2/4 time signature. The piano part is written on a grand staff with both treble and bass clefs and a 2/4 time signature. The lyrics are 'Lit - tle lamb, who made thee? Dost thou know who'. Below the lyrics is a Tonic Sol-Fa notation: KEY C. { | m .m :m .s | s :r | m .s :d^l .l }. The notation uses letters m, s, r, d, and l to represent musical notes, with dots and colons indicating rhythm and pitch. The score is on aged, yellowed paper with a vertical crease down the middle.

Byzantine Music Notation

(10th – 15th centuries)

interval notation



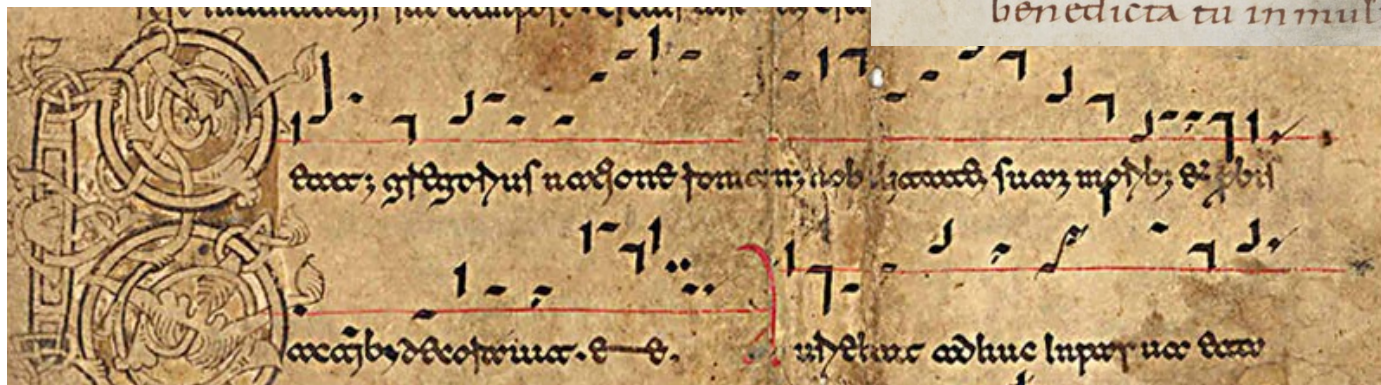
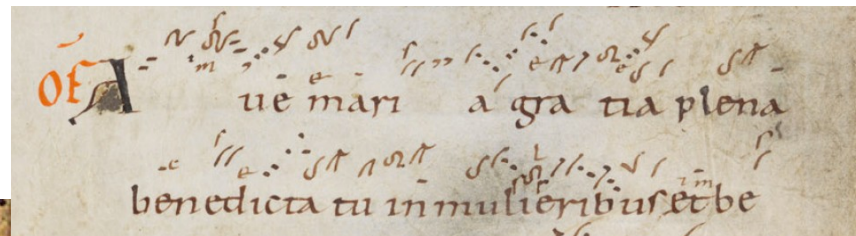
Romania, 1823

http://en.wikipedia.org/wiki/Musical_notation#Byzantine_Empire



http://www.musicportal.gr/byzantine_music_system/?lang=en

Gregorian Chant



http://www.schoyencollection.com/music_files/ms1681.jpg



Messine notation

Modern chant notation

St. Gall notation

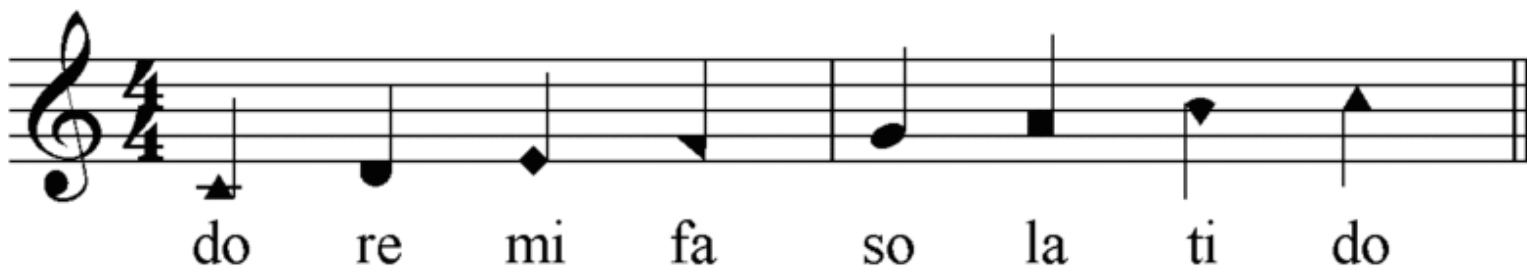
<http://euouae.com/category/transcription/>

http://en.wikipedia.org/wiki/Gregorian_chant

<http://en.wikipedia.org/wiki/Neume>



Shape Notes



16

STAR IN THE EAST 10, 11.

Baptist Harmony, p. 35

Two systems of musical notation for 'STAR IN THE EAST'. Each system consists of three staves (treble, alto, and bass clefs). The lyrics are written below the staves. The first system includes the lyrics: 'Hail the blest morn, see the great Mediator, Down from the regions of glory descend! } Caeuus. Brightest and best of the sons of the morning!'. The second system includes the lyrics: 'Shepherds, go worship the babe in the manger, Lo, for his guard the bright angels attend. }

Two systems of musical notation for 'STAR IN THE EAST'. Each system consists of three staves (treble, alto, and bass clefs). The lyrics are written below the staves. The first system includes the lyrics: 'Dawn on our darkness, and lend us thine aid; Star in the east, the ho - ri - zon a - dorn'g, Guide where our infant Re - deemer was laid. The second system includes the lyrics: '2 Cold on his cradle the dew-drops are shining; Low lies his bed, with the beasts of the stall; Angels adore him, in slumbers reclining, Wise men and shepherds before him do fall. Brightest and best. &c. 3 Say, shall we yield him, in costly devotion, Odours of Eden, and offerings divine, Gems from the mountain, and pearls from the ocean, Myrrh from the forest, and gold from the mine? Brightest and best. &c. 4 Vainly we offer each ample oblation, Vainly with gold we his favour secure, Richer by far is the heart's adoration: Dearer to God are the prayers of the poor Brightest and best. &c.

2 Cold on his cradle the dew-drops are shining;
Low lies his bed, with the beasts of the stall;
Angels adore him, in slumbers reclining,
Wise men and shepherds before him do fall.
Brightest and best. &c.

3 Say, shall we yield him, in costly devotion,
Odours of Eden, and offerings divine,
Gems from the mountain, and pearls from the ocean,
Myrrh from the forest, and gold from the mine?
Brightest and best. &c.

4 Vainly we offer each ample oblation,
Vainly with gold we his favour secure,
Richer by far is the heart's adoration:
Dearer to God are the prayers of the poor
Brightest and best. &c.

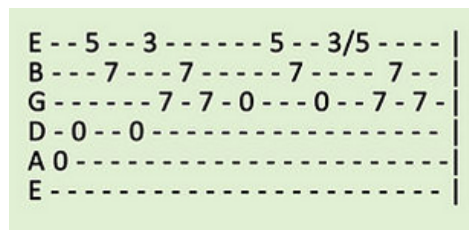
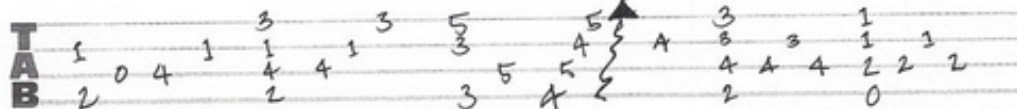
A musical staff in treble clef showing shape notes for the melody 'fa so la fa so la mi'. The notes are represented by different shapes: a downward-pointing triangle for 'fa', a circle for 'so', a square for 'la', an upward-pointing triangle for 'fa', a circle for 'so', a square for 'la', and a diamond for 'mi'.

Tablature

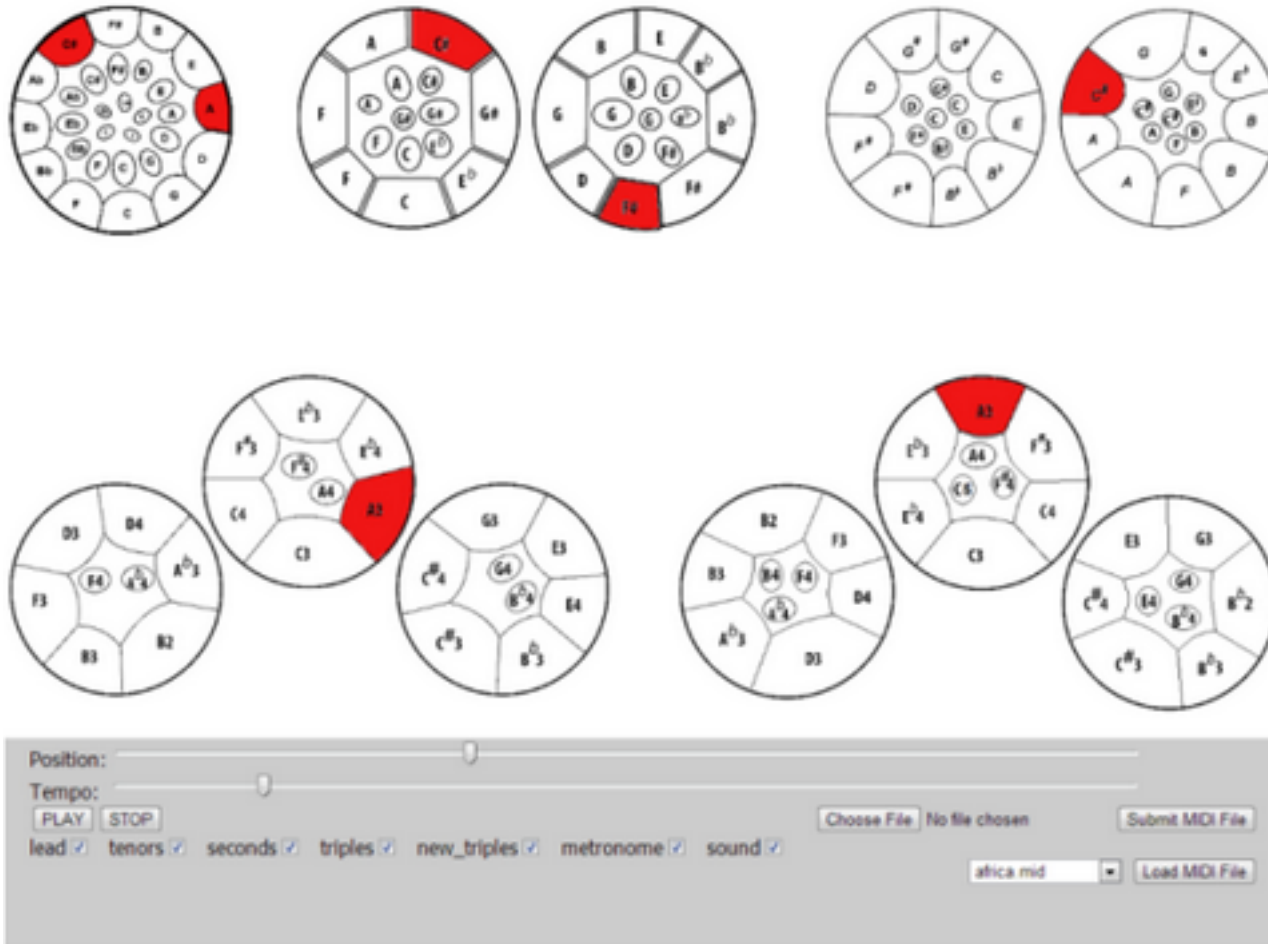
Indicates *how* to play the pitches, not an abstracted/neutral concept of pitch.



lute



Steel Drum Tablature



— Jonathan Potter, Cardinal Calypso

Koto Tablature

Yamada school notation (Tokyo)

テ - ン | トン シャン | シヤ シヤ | コ ロ ン トン | トン コ ロ | リン シヤッ
 五 二 | 参 〆 〆 | 〇 〆 〆 | ハ 七 六 七 | 〆 五 四 | 参 〆 〆

“Rokudan no shirabe”

by Kengyō Yatsuhashi (1614–1685)



Digital representation:

**koto	**kuchi	**kern
*M4/4	*M4/4	*M4/4
=1-	=1-	=1-
{5+i	te	{2d
-	n	.
3	ton	4A
1s	shan	4d: 4G:
=2	=2	=2
0}	.	4r}
{3 sb	sha	{8A: 8A#:
3 sc	sha	8A: 8A#:
8 .	koo	8.a
7	ro	16g
6	rin	8d#
7 o	chin	16gH
.	.	16ah
=3	=3	=3
1c	ton	4d
5 . .	koo	8.d
4	ro	16A#
3}	rin	4A}
{1s	shan	{4d: 4G:
=4	=4	=4

Ikuta school notation (Kyoto)

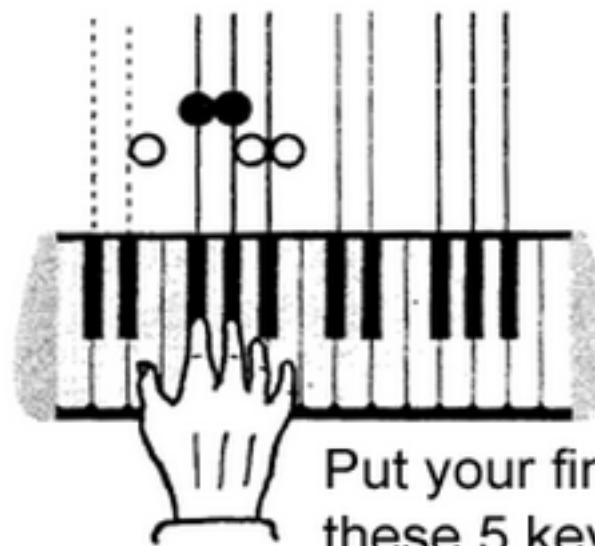
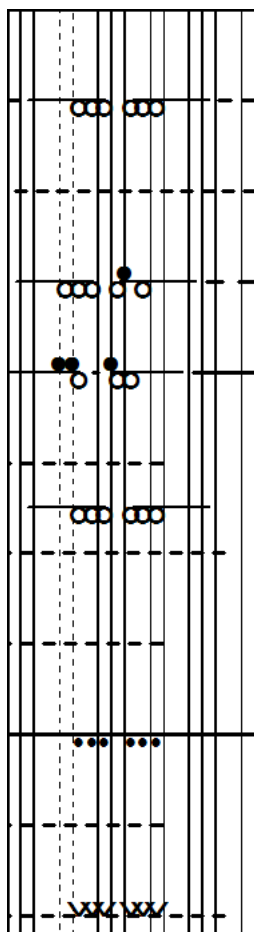
テ 五
 五 〇
 ン
 ト 三
 ン
 シ 二
 ン
 一 〇
 ヤ
 シ 三 四 二
 シ 二 三
 コ ハ
 ロ 二
 リ 六
 ナ 七
 ト 一 三
 ン
 シ 五
 ン
 ト 三
 ン
 シ 二
 ン



Piano Tablature

Klavarskribo

“Keyboard script” in Esperanto



Put your fingers above
these 5 keys

<https://www.youtube.com/watch?v=MlolvxunihA&t=659>

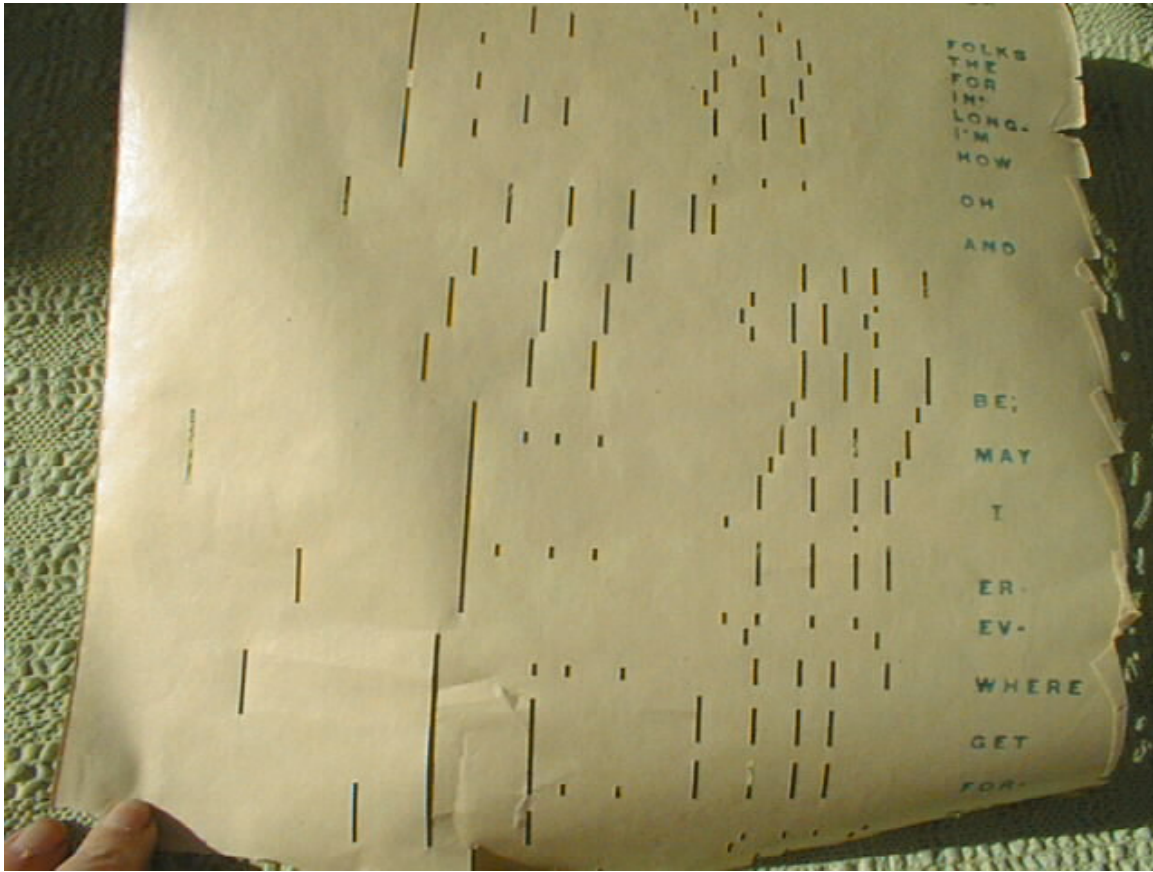
<http://evanlenz.net/blog/2007/11/02/re-discovering-klavarskribo/>

<http://en.wikipedia.org/wiki/Klavarskribo>

<http://www.klavarskribo.nl/en>

Piano Rolls

Mechanical Representation of music



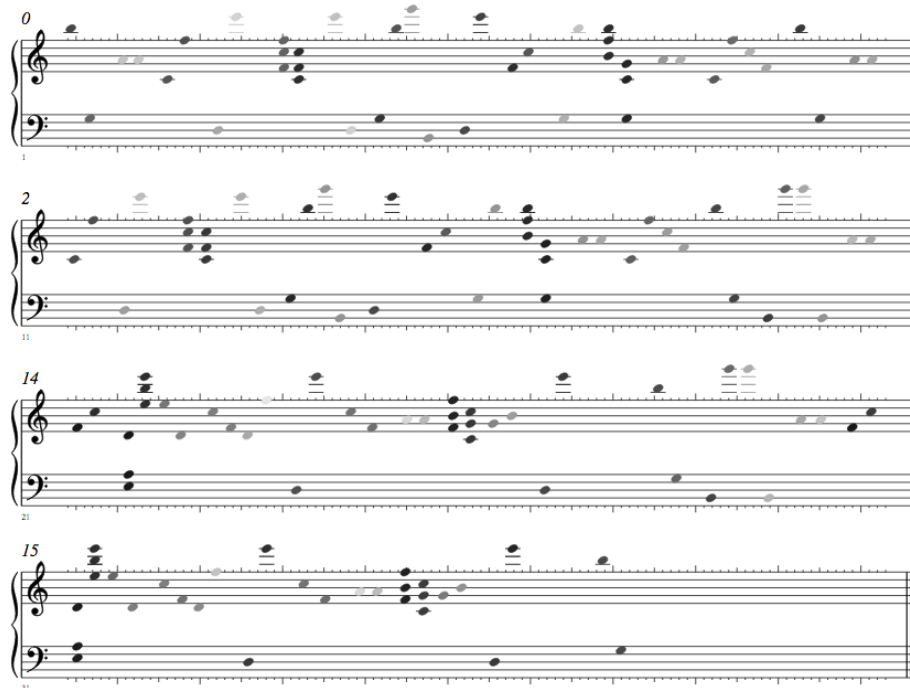
http://en.wikipedia.org/wiki/Piano_roll

<https://www.youtube.com/watch?v=GjpPesy7kIA>

Performance Data Visualization

Webern Piano Variations, mvmt. 2, (Op. 27)

Anderszewski 1996



Gould 1954



<http://dl.acm.org/citation.cfm?id=2597179>

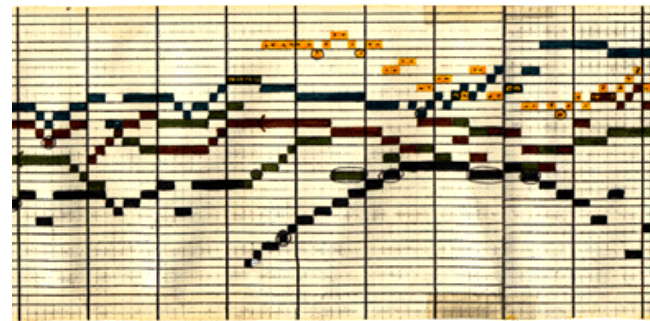
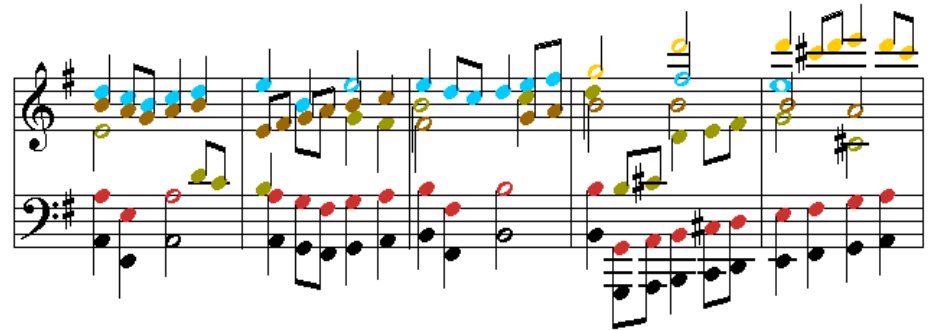
<http://mazurka.org.uk/webern/notation/Anderszewski1996>

<http://mazurka.org.uk/webern/notation/Gould1954>

Music Animation Machine

<http://www.musanim.com>

Stephen Malinowski



<https://www.youtube.com/channel/UC2zb5cQbLabj3U9l3tke1pg>

<https://www.youtube.com/playlist?list=PLMOarqHv8B7P1BuvL2iGqkjS1xNrvTiuX>

Music Animation Machine

Bach, Toccata and Fugue in D minor, organ

https://www.youtube.com/watch?v=ipzR9bhei_o

How are musical
Dimensions mapped
In each visualization?

Mozart, Symphony No. 40 in G minor

<https://www.youtube.com/watch?v=xvtoqE33iZg>

Beethoven, Fur Elise

<https://www.youtube.com/watch?v=o0VwTw1eZ1k>

Beethoven, String Quartet No. 16, 1st mvt. (opus 135)

<https://www.youtube.com/watch?v=Lj4kLPgX5QM>

Paganini, Caprice No. 5 (solo violin)

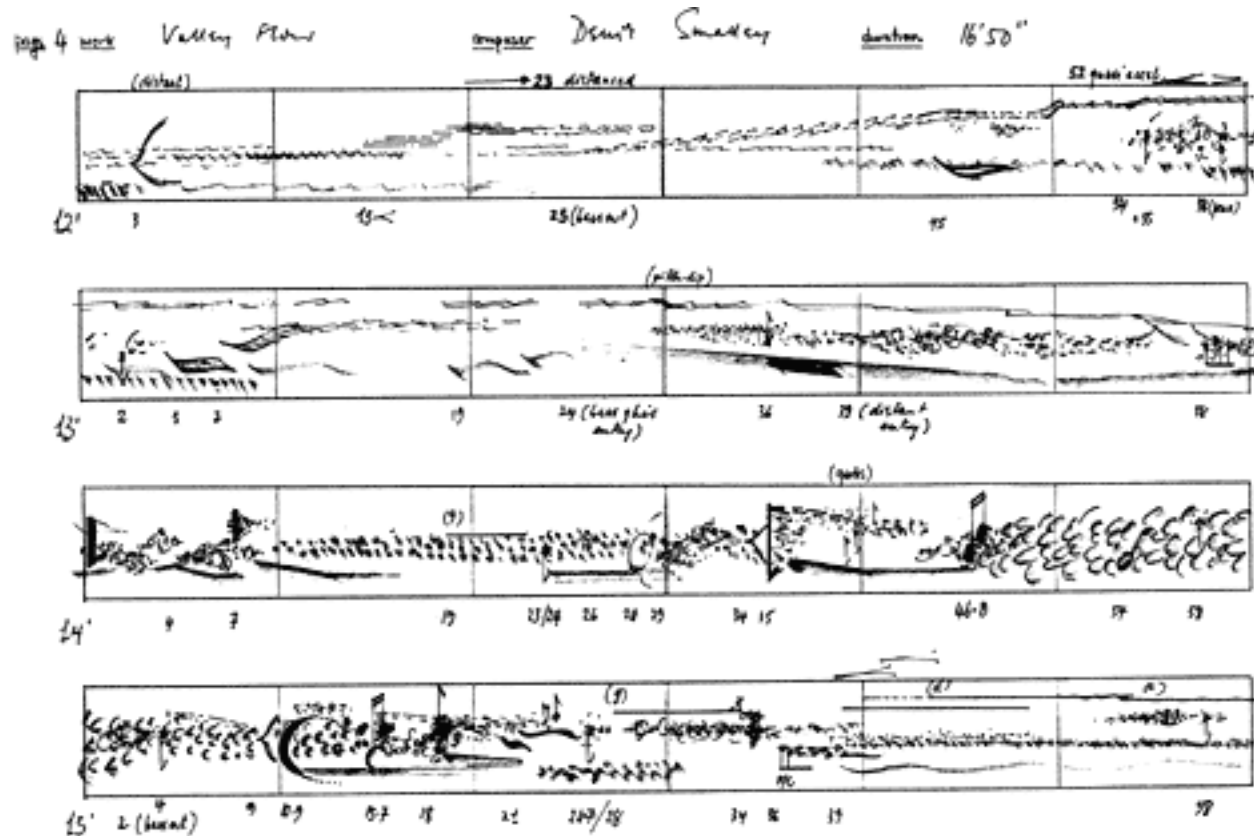
<https://www.youtube.com/watch?v=xhc1PsokFOw>

Debussy, First Arabesque

<https://www.youtube.com/watch?v=Yt1jfX5C1u0>

Textural Notation

Analytic notation of electro-acoustic music

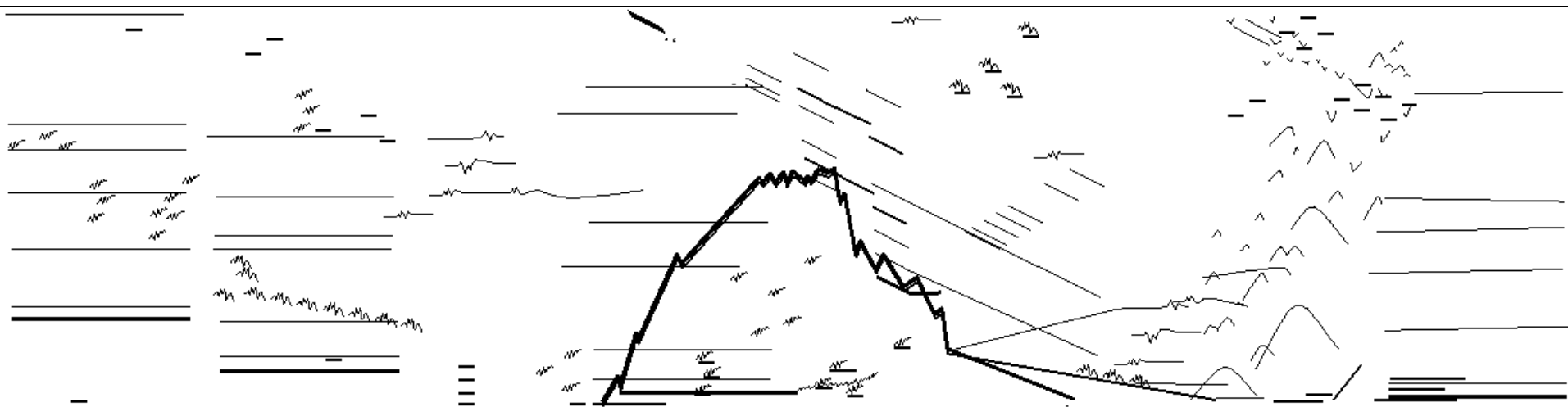


line2sine

Sonification of vector graphics

<http://sig.sapp.org/projects/all/line2sine/line2sine/examples>

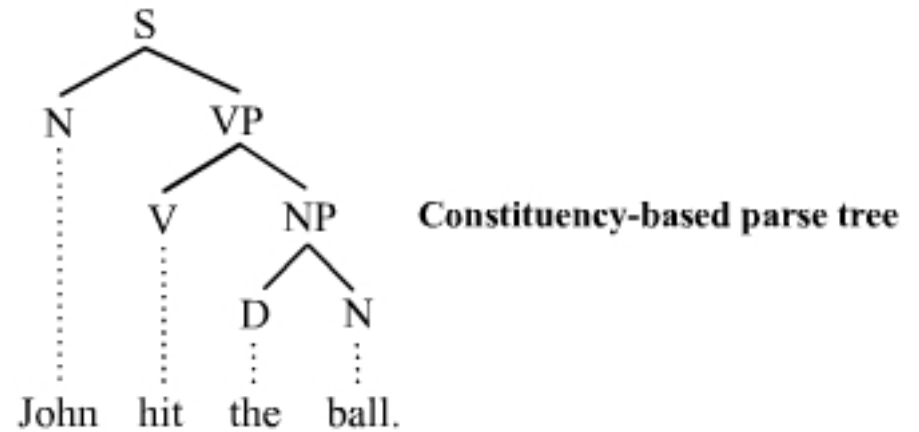
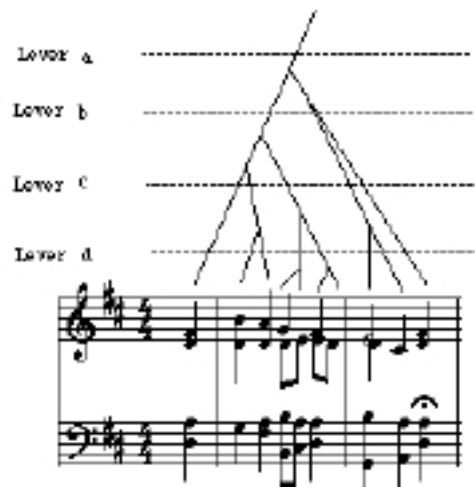
Example 6:



See the music of Iannis Xenakis

http://en.wikipedia.org/wiki/Iannis_Xenakis

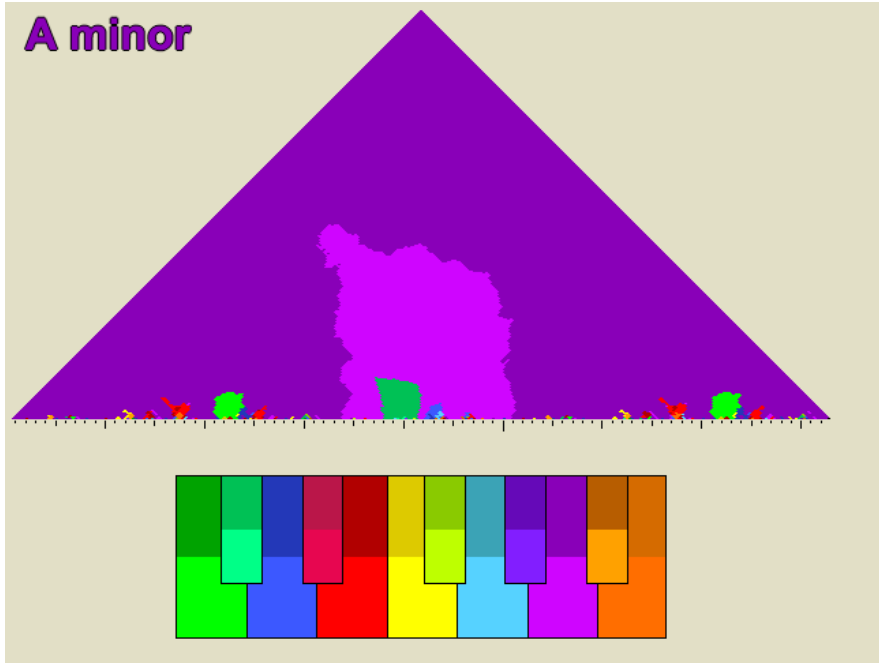
GTTM



http://en.wikipedia.org/wiki/Parse_tree

Keyscapes

Graphical display of harmonic structure



Chopin mazurka in A minor Op. 67, No. 4

<https://www.youtube.com/watch?v=AcxZRI6aews>

A major: 1:18

A minor: 2:10

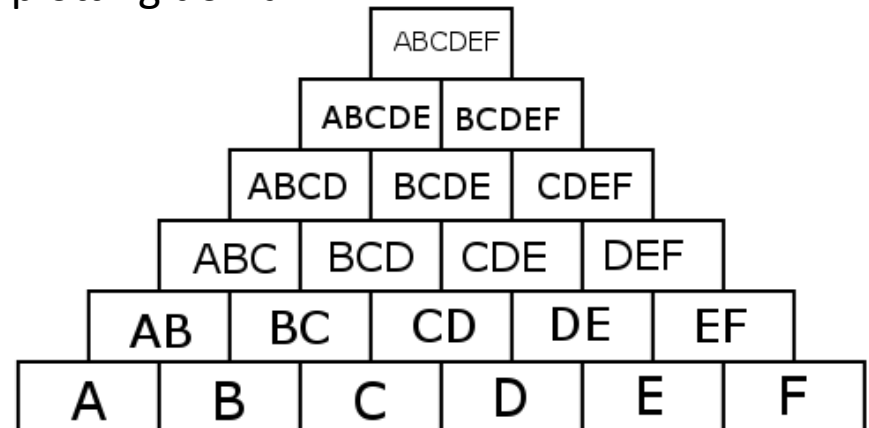
Landscape:

background
large-scale structures
middleground
small-scale structures
foreground
surface features



An Orchard c1896 Henri Rousseau

Scape plotting domain:



Computational Key Identification



<http://extras.humdrum.org/man/keycor>

Computational Key Identification



Pearson correlation:

$$r(x, y) = \frac{\sum_n (x_n - \bar{x})(y_n - \bar{y})}{\sqrt{\sum_n (x_n - \bar{x})^2 \sum_n (y_n - \bar{y})^2}}$$

Krumhansl-Schmuckler
key-finding algorithm:

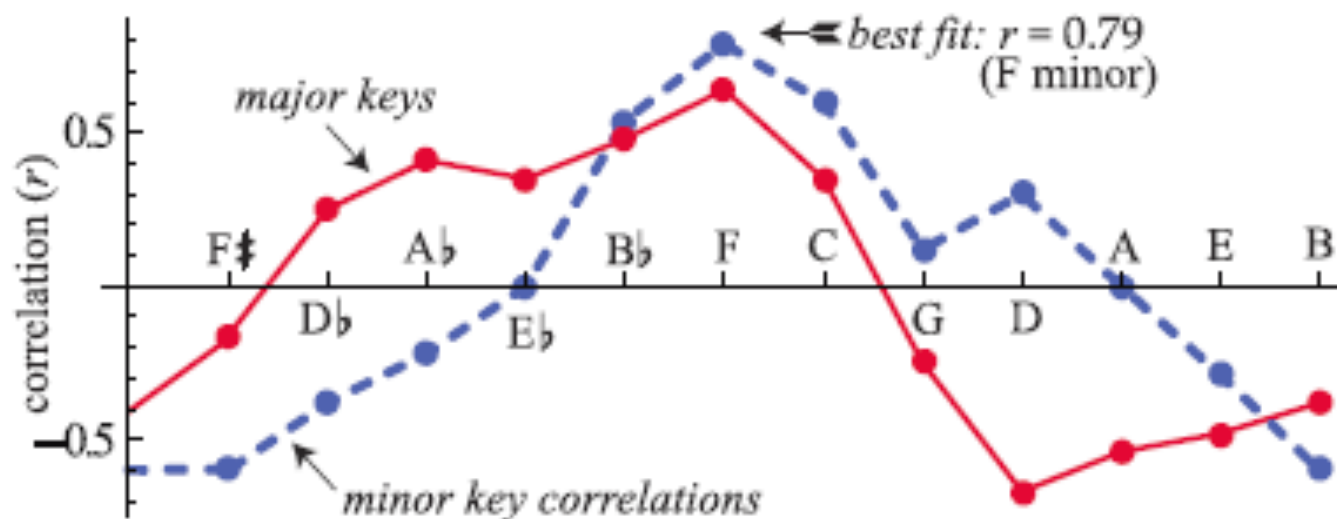
$$\text{key}_k = \arg \max_k r(x, y_k)$$

Computational Key Identification



pitch-class counts
(duration weighted):

C: 8 ♪	D $\sharp$ /E $\flat$: 0	F $\sharp$ /G $\flat$: 0	A: 0
C $\sharp$ /D $\flat$: 0	E: 2 ♪	G: 5 ♪	A $\sharp$ /B $\flat$: 5 ♪
D: 0	F: 11 ♪	G $\sharp$ /A $\flat$: 7 ♪	B: 2 ♪



pitch-class histogram: $x = (8, 0, 0, 0, 2, 11, 0, 5, 7, 0, 5, 2)$
 major key prototype: $y_M = (2, 0, 1, 0, 1, 1, 0, 2, 0, 1, 0, 1)$
 minor key prototype: $y_m = (2, 0, 1, 1, 0, 1, 0, 2, 1, 0, 1, 0)$

Computational Key Identification

KS algorithm:

$$\text{key}_k = \arg \max_k r(x, y_k)$$

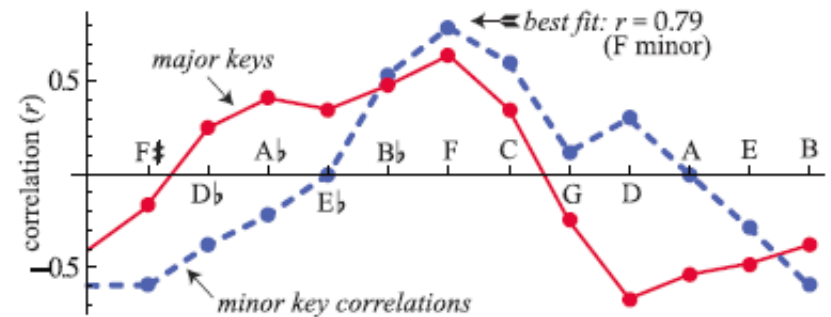
$$\text{key}_k = \arg \max_k \frac{1}{N} \sum_n z_{x,n} z_{y_k,n}$$

“z-scores”

dot product

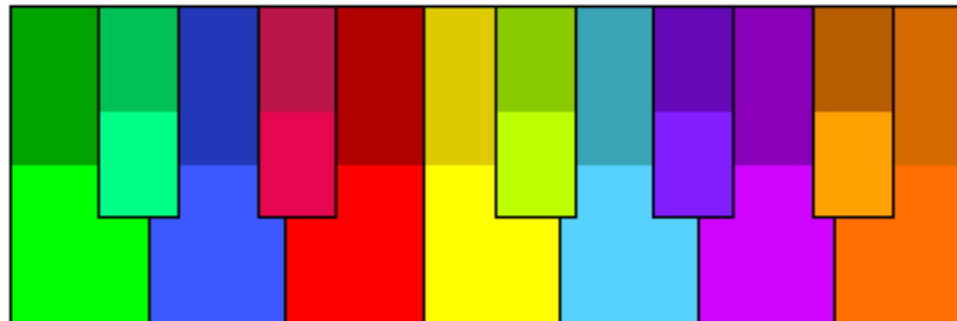
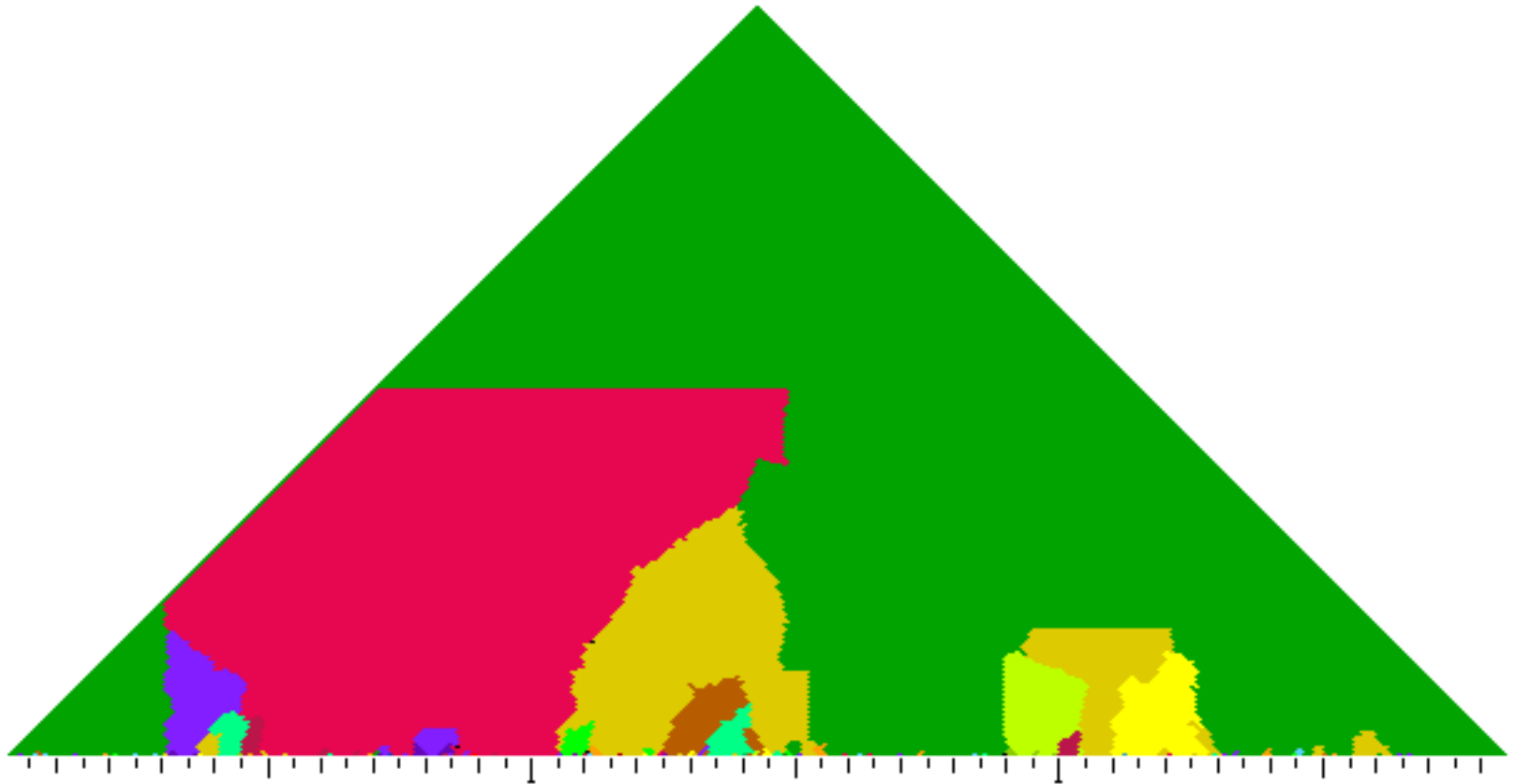
$$X_k = \sum_n x_n e^{-\frac{2\pi j}{N} kn}$$

DFT:



“Key spectrum”

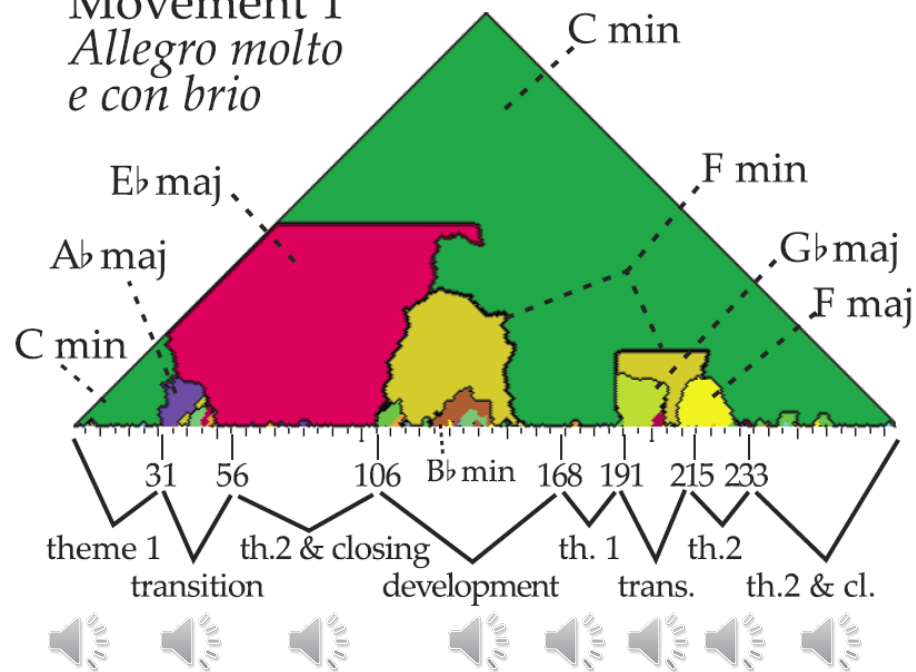
Beethoven Piano Sonata #5 mvmt 1



Sonata No. 5 Internal Key Structure

Theme 1 (C minor):

Movement 1
*Allegro molto
e con brio*



Theme 2 (E♭ major):



Theme 2 (F major):



Theme 2 (C minor):



No. 5:

Movement 1
*Allegro molto
e con brio*

Movement 2
Adagio molto

Movement 3
*Finale
Prestissimo*

th.1 th.2 & closing th.1 th.2 th.1' th.2 th.1'' th.1 th.2 & closing dev. th.1 th.2 closing coda

31 56 106 168 191 215 233 24 46 71 91 17 47 58 74 83 104

C min E♭ maj A♭ maj C min F min G♭ maj F maj E♭ maj C min F min C maj D♭ maj C maj

B♭ min

th.2 & closing development trans. th.2 & cl.

Figure 1 consists of two triangular diagrams, each representing a different movement of the film 'The Piano'. The left triangle is for 'Movement 1: Maestoso. Allegro con brio ed appassionato'. The right triangle is for 'Movement 2: Arietta Adagio molto semplice cantabile'. Both triangles are divided into colored regions representing different musical styles: green for 'C min', purple for 'A♭ maj', yellow for 'G maj', orange for 'F min', brown for 'B♭ min', and blue for 'F maj'. The triangles are plotted on a horizontal axis with time markers in minutes. Below the triangles, a series of musical style icons (represented by small triangles) are aligned with the time markers, showing the sequence of styles throughout the score.

Movement 1
Maestoso. Allegro con brio ed appassionato

Movement 2
Arietta Adagio molto semplice cantabile

Time markers (minutes): 19, 36, 50, 72, 91, 101, 117, 147, 19, 37, 55, 74, 112, 141, 171.

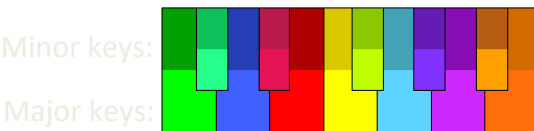
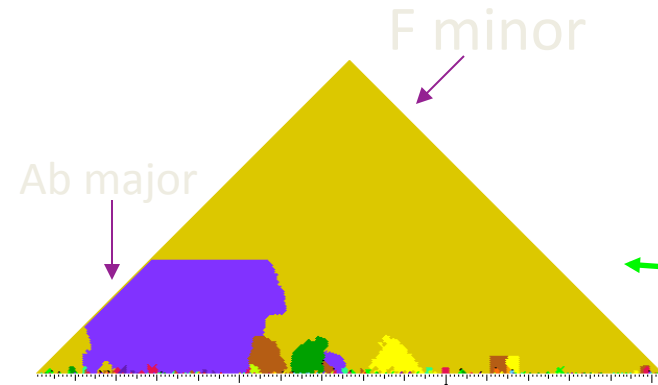
Labels for Movement 1: C min, A♭ maj, (G maj), F min, B♭ min, C maj, F maj.

Labels for Movement 2: C maj, F min, C min, A min, G maj, (B♭ maj), A min.

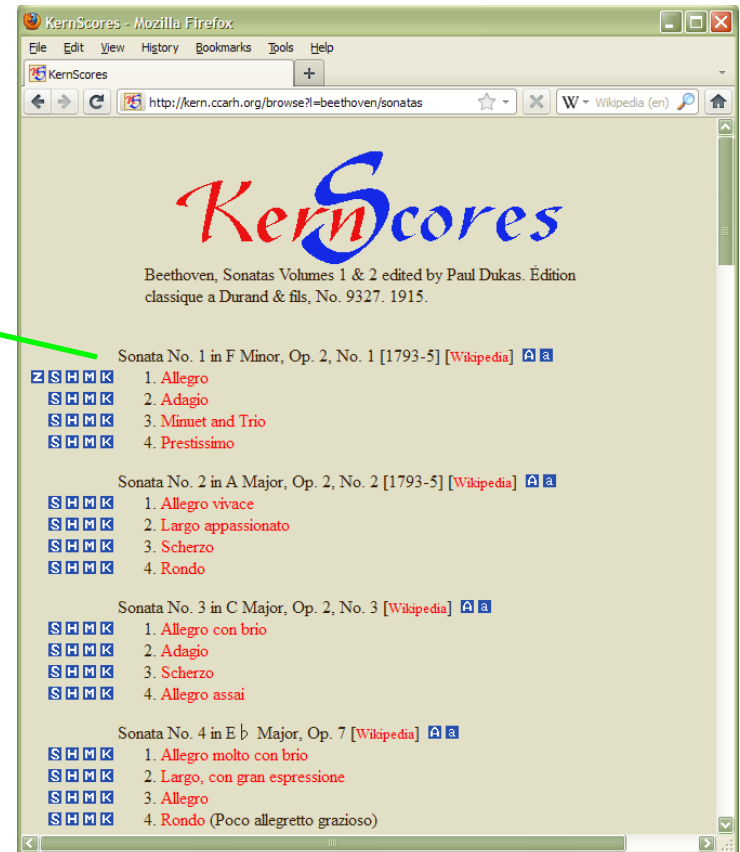
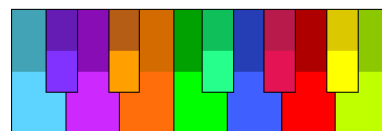
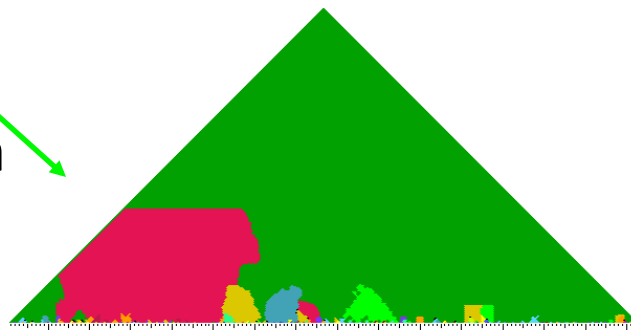
Section labels: Maestoso, th.1, trans., th.2, devel., th.1, trans., th.2, coda, theme, var.1, var.2, var.3, var.4, interlude, var.5, var.6 (coda).

Online Keyscape Plot Generation

<http://kern.ccarh.org/browse?l=beethoven/sonatas>



Transposition
(tonic on C)



→ 2nd theme in relative major
which recapitulates in C minor

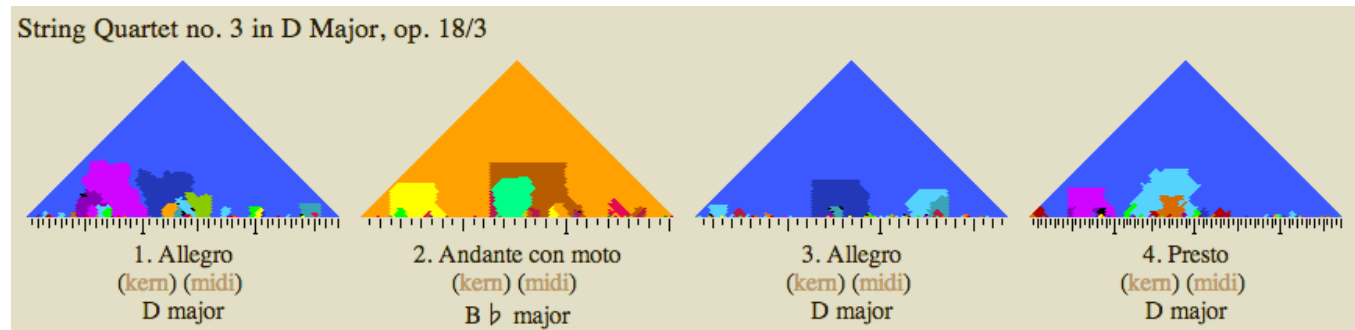
More Info

C++ implementation of KS algorithm and keyscape generator:

- <http://extras.humdrum.org/man/keycor>
- <http://extras.humdrum.org/man/mkeyscope>

See bottom of last link for latest keyscape galleries, such as Beethoven string quartets:

<http://extras.humdrum.org/man/mkeyscope/beet-quartet>



~5000 keyscales of MIDI files:

<https://ccrma.stanford.edu/~craig/keyscape/class>

Form Visualization/Analysis

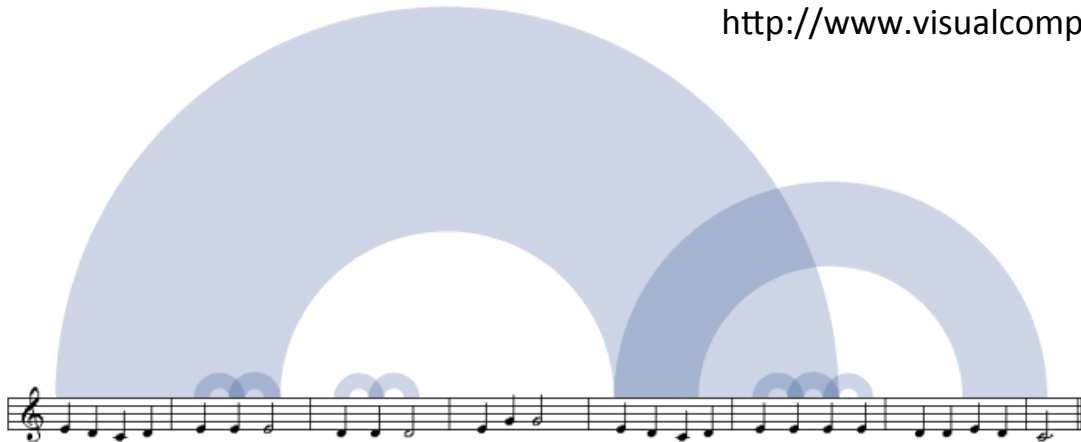
<http://www.bewitched.com/song.html>

<http://hint.fm/papers/arc-diagrams.pdf>

Martin Wattenberg



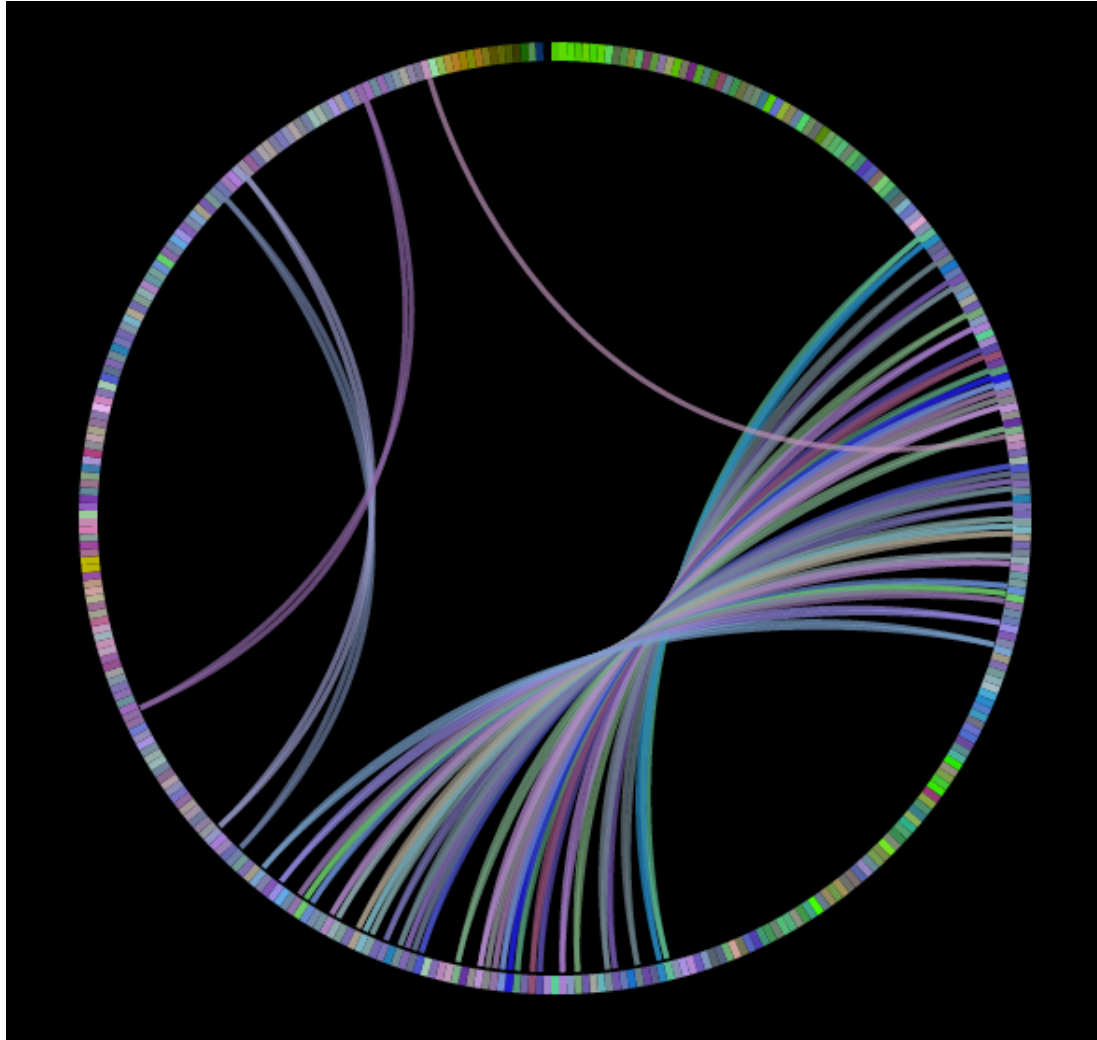
<http://www.visualcomplexity.com/vc/index.cfm?method=Arc%20Diagrams>



Infinite Jukebox

<http://labs.echonest.com/Uploader/index.html?trid=TRORQWV13762CDDF4C>

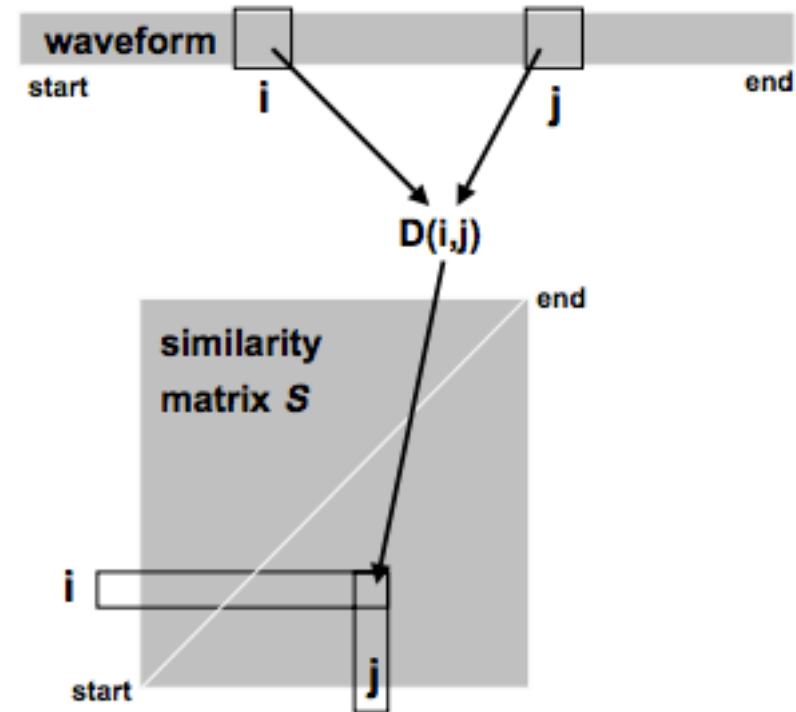
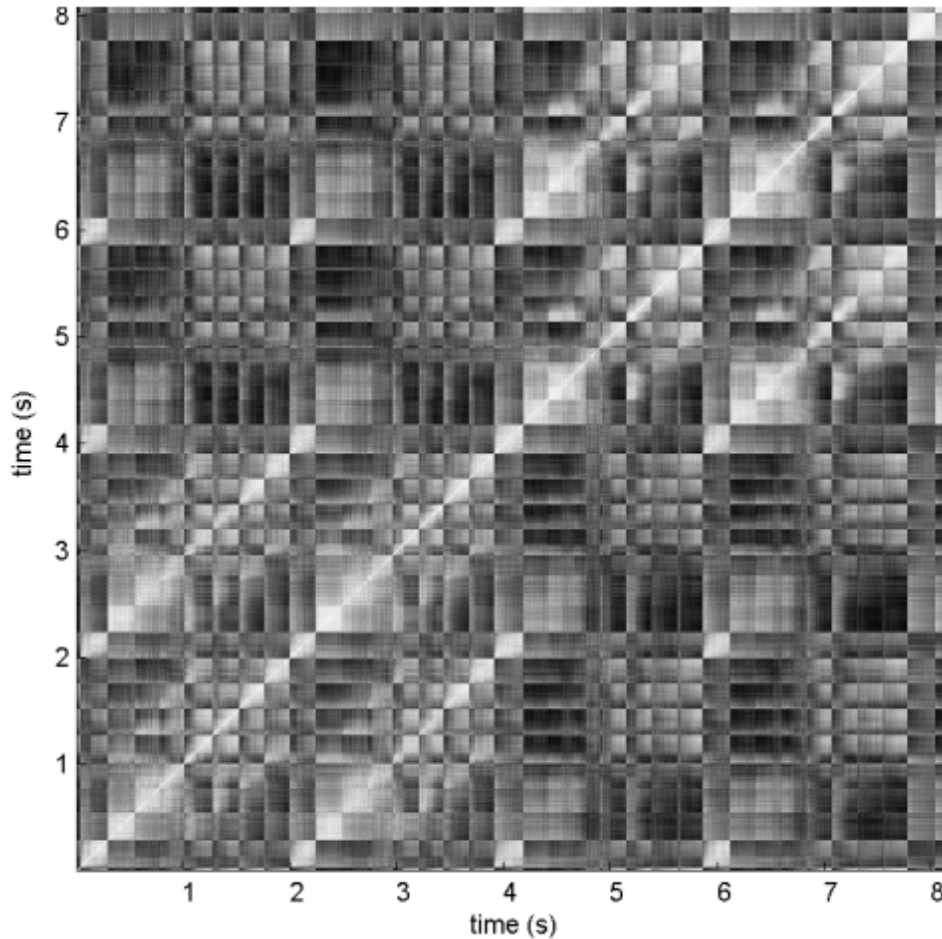
Paul Lamere



Similarity Matrix

Jonathan Foote

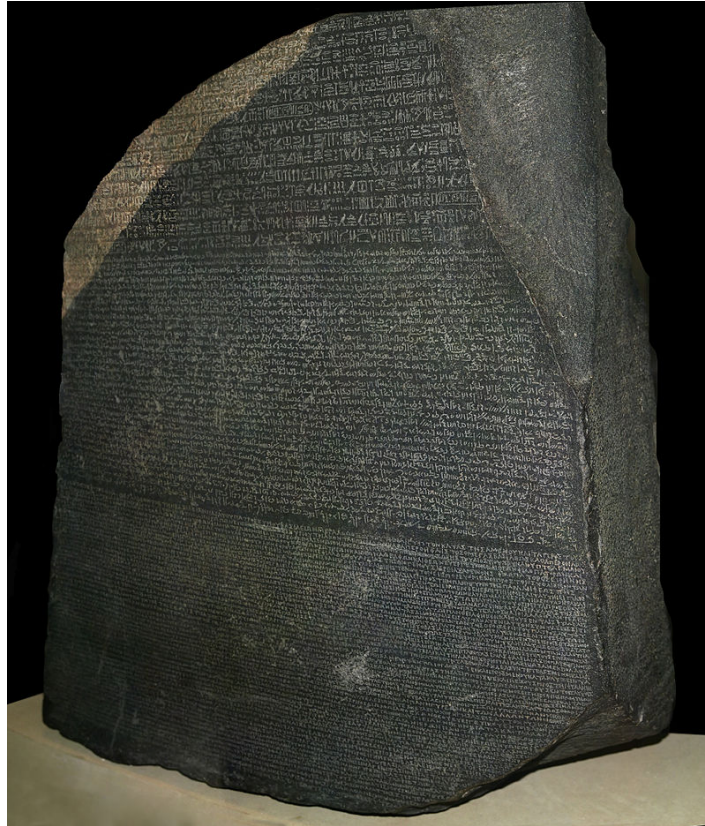
<http://www.fxpall.com/publications/visualizing-musical-structure-and-rhythm-via-self-similarity.pdf>



J.S. Bach WTC 1: Prelude #1 in C major

Rosetta Stone of Digital Representations

Various Digital representations of music (mostly ASCII), encoding this melody:



Rosetta Stone of Digital Representations



Braille

○* ○* *○ ○* ○* ○○ ○* ** ○○ *○ ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** **
○* ○○ *○ ○* ○* ** ○○ ○* ○○ ○* ○* ○* ** ** ○○ ○○ ** *○ *○ ○○ ○* ** ** ○* *○ **
*○ *○ *○ ** ○○ ○* ○* ○○ *○ *○ *○ ** ** ○* *○ ** ** ** ○* *○ **

○○ ** ○○ ○* ** ** ○* ○* *○
○* ○* ○○ *○ ○* *○ ** *○ **
○* ○○ *○ ** ** ○* ** ** **

Rosetta Stone of Digital Representations



Plaine & Easie

G-2 bB 2/4 {8.C3DC}{8CC}/{6CF}4F6-F/{FA}4A6-C/{8.C6A}{CBAG}/

Rosetta Stone of Digital Representations



ABC

X:1

T:Example

M:2/4

K:F

L:1/16

c3 d/2 c/2 c2 c2 | c f f4 z f |

f a a4 z c' | c'3 a c'bag |

Rosetta Stone of Digital Representations



DARMS

```
!G !K1- !M2:4  
6E.( 7T(( 6))) 6E( 6) /  
6S(( 9)) 9Q RS 9S /  
9S( 11) 11Q RS 13S /  
13E.( 11S) 13S(( 12 11 10)) /
```

Rosetta Stone of Digital Representations



Guido Music Notation

```
[ \clef<"g2"> \key<-1> \meter<"2/4">  
      c2/8. d/32 c c/8 c  
  \bar<2> c/16 f f/4 _/16 f  
  \bar<3> f a a/4 _/16 c3  
  \bar<4> c/8. a2/16 c3 b&2 a g  
]
```

Rosetta Stone of Digital Representations



SCORE (User Input)

```
TR/K1F/2 4/C5/D/C/C/C/M/C/F/F/R/F/M/F/A/A/R/C6/M/C/A5/C6/B5/A/G/M/MI;  
E./32/32/E/E/S/S/Q/S/S/S/S/Q/S/S/E./S/S/S/S/S;  
;  
1 3/4 5/6 7/10 11/14 15/16 19;  
;
```

Rosetta Stone of Digital Representations



MuseData

Part_1

Group memberships: score

score: part 1 of 1

\$ Q:8 K:-1 T:2/4 C:4

S

```
C5      6      1 e.    d  [  
D5      1      1 t     d  =[[  
C5      1      1 t     d  ]]]  
C5      4      1 e     d  [  
C5      4      1 e     d  ]
```

measure 2

```
C5      2      1 s     d  [[  
F5      2      1 s     d  ]]  
F5      8      1 q     d  
rest    2      1 s  
F5      2      1 s     d
```

measure 3

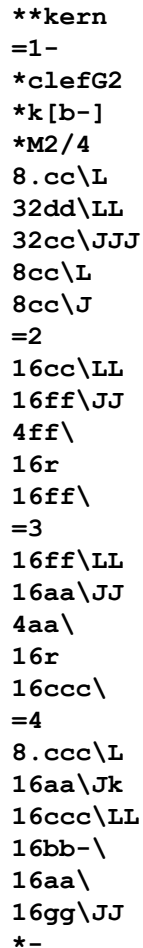
```
F5      2      1 s     d  [[  
A5      2      1 s     d  ]]  
A5      8      1 q     d  
rest    2      1 s  
C6      2      1 s     d
```

measure 4

```
C6      6      1 e.    d  [  
A5      2      1 s     d  ]\  
C6      2      1 s     d  [[  
Bf5     2      1 s     d  ==  
A5      2      1 s     d  ==  
G5      2      1 s     d  ]]
```

/END

Humdrum



Rosetta Stone of Digital Representations



Humdrum

```
**kern
=1-
*clefG2
*k[b-]
*M2/4
8.cc\L
32dd\LL
32cc\JJJ
8cc\L
8cc\J
=2
16cc\LL
16ff\JJ
4ff\
16r
16ff\
=3
16ff\LL
16aa\JJ
4aa\
16r
16ccc\
=4
8.ccc\L
16aa\Jk
16ccc\LL
16bb-\
16aa\
16gg\JJ
*-
```

Humdrum
**koto

```
**koto
5.|
5||h
5|
5|
=
5||
7||
7
0||
7||
=
7||
9||#
9#
0||
A||
=
A|.
9||#
A||
9||##
9||#
8||
=
*-
```

|| 5. 5 5 5 | 5 7 7 0 7 | 7 9 9 0 A | A. 9 A 9 9 8 |

Rosetta Stone of Digital Representations



Melisma

Info keysig 1 flat

Note	0	750	72
Note	750	875	74
Note	875	1000	72
Note	1000	1500	72
Note	1500	2000	72
Note	2000	2250	72
Note	2250	2500	77
Note	2500	3500	77
Note	3750	4000	77
Note	4000	4250	77
Note	4250	4500	81
Note	4500	5500	81
Note	5750	6000	84
Note	6000	6750	84
Note	6750	7000	81
Note	7000	7250	84
Note	7250	7500	82
Note	7500	7750	81
Note	7750	8000	79

Rosetta Stone of Digital Representations



SKINI

```
// Measure number 1 =0  
// Keysig 1 flat
```

NoteOn	0	1	72	64
NoteOff	0.75	1	72	64
NoteOn	0	1	74	64
NoteOff	0.125	1	74	64
NoteOn	0	1	72	64
NoteOff	0.125	1	72	64
NoteOn	0	1	72	64
NoteOff	0.5	1	72	64
NoteOn	0	1	72	64
NoteOff	0.5	1	72	64

```
// Measure number 2 =2
```

NoteOn	0	1	72	64
NoteOff	0.25	1	72	64
NoteOn	0	1	77	64
NoteOff	0.25	1	77	64
NoteOn	0	1	77	64
NoteOff	1	1	77	64
NoteOn	0.25	1	77	64
NoteOff	0.25	1	77	64

```
// Measure number 3 =4
```

NoteOn	0	1	77	64
NoteOff	0.25	1	77	64
NoteOn	0	1	81	64
NoteOff	0.25	1	81	64
NoteOn	0	1	81	64
NoteOff	1	1	81	64
NoteOn	0.25	1	84	64
NoteOff	0.25	1	84	64

```
// Measure number 4 =6
```

NoteOn	0	1	84	64
NoteOff	0.75	1	84	64
NoteOn	0	1	81	64
NoteOff	0.25	1	81	64
NoteOn	0	1	84	64
NoteOff	0.25	1	84	64
NoteOn	0	1	82	64
NoteOff	0.25	1	82	64
NoteOn	0	1	81	64
NoteOff	0.25	1	81	64
NoteOn	0	1	79	64
NoteOff	0.25	1	79	64

Rosetta Stone of Digital Representations



Allegro

1	1	72	64	0	0.75
2	1	74	64	0.75	0.125
3	1	72	64	0.875	0.125
4	1	72	64	1	0.5
5	1	72	64	1.5	0.5
6	1	72	64	2	0.25
7	1	77	64	2.25	0.25
8	1	77	64	2.5	1
9	1	77	64	3.75	0.25
10	1	77	64	4	0.25
11	1	81	64	4.25	0.25
12	1	81	64	4.5	1
13	1	84	64	5.75	0.25
14	1	84	64	6	0.75
15	1	81	64	6.75	0.25
16	1	84	64	7	0.25
17	1	82	64	7.25	0.25
18	1	81	64	7.5	0.25
19	1	79	64	7.75	0.25

Rosetta Stone of Digital Representations



NoteArray

%bar	%mdur	%bdur	%beat	%b40
1	2	1	0	202
1	2	1	0.75	208
1	2	1	0.875	202
1	2	1	1	202
1	2	1	1.5	202
2	2	1	0	202
2	2	1	0.25	219
2	2	1	0.5	219
2	2	1	1.5	0
2	2	1	1.75	219
3	2	1	0	219
3	2	1	0.25	231
3	2	1	0.5	231
3	2	1	1.5	0
3	2	1	1.75	242
4	2	1	0	242
4	2	1	0.75	231
4	2	1	1	242
4	2	1	1.25	236
4	2	1	1.5	231
4	2	1	1.75	225

Rosetta Stone of Digital Representations



CMN

```
(cmn  
  staff  
  treble  
  f-major  
  (meter 2 4)
```

```
(bar 1)  (c5 e.) (d5 ) (c5 ) (c5 e) (c5 e)  
(bar 2)  (c5 s) (f5 s) (f5 q) sixteenth-rest (f5 s)  
(bar 3)  (f5 s) (a5 s) (a5 q) sixteenth-rest (c6 s)  
(bar 4)  (c6 e.) (a5 s) (c6 s) (bf5 s) (a5 s) (g5 s)  
)
```

Rosetta Stone of Digital Representations



Director Musices

mono-track

```
:trackname "track 1"  
(bar 1 n ("C5" 3/16) meter (2 4))  
(n ("D5" 1/32))  
(n ("C5" 1/32))  
(n ("C5" 1/8))  
(n ("C5" 1/8))  
(bar 2 n ("C5" 1/16))  
(n ("F5" 1/16))  
(n ("F5" 1/4))  
(n (nil 1/16) rest t)  
(n ("F5" 1/16))  
(bar 3 n ("F5" 1/16))  
(n ("A5" 1/16))  
(n ("A5" 1/4))  
(n (nil 1/16) rest t)  
(n ("C6" 1/16))  
(bar 4 n ("C6" 3/16))  
(n ("A5" 1/16))  
(n ("C6" 1/16))  
(n ("Bb5" 1/16))  
(n ("A5" 1/16))  
(n ("G5" 1/16))
```

Rosetta Stone of Digital Representations



ENP

```
(:begin :score
  (:begin :part1
    :staff :treble-staff
    :key-signature :f-major
    :time-signature (2 4)
    (:begin :voicel
      (:begin :measure1
        (1 (
          (6 ((1 :notes (72) :stem-direction :down)))
          (1 ((1 :notes (74) :stem-direction :down)))
          (1 ((1 :notes (72) :stem-direction :down)))
        ))
        (1 (
          (1 ((1 :notes (72) :stem-direction :down)))
          (1 ((1 :notes (72) :stem-direction :down)))
        ))
      ))
    (:begin :measure2
      (2 (
        (1 ((1 :notes (72) :stem-direction :down)))
        (1 ((1 :notes (77) :stem-direction :down)))
        (4 ((1 :notes (77) :stem-direction :down)))
        (1 (-1))
        (1 ((1 :notes (77) :stem-direction :down)))
      ))
    )
  )
)
```

```
(:begin :measure3
  (2 (
    (1 ((1 :notes (77) :stem-direction :down)))
    (1 ((1 :notes (81) :stem-direction :down)))
    (4 ((1 :notes (81) :stem-direction :down)))
    (1 (-1))
    (1 ((1 :notes (84) :stem-direction :down)))
  ))
)
(:begin :measure4
  (1 (
    (3 ((1 :notes (84) :stem-direction :down)))
    (1 ((1 :notes (81) :stem-direction :down)))
  ))
  (1 (
    (1 ((1 :notes (84) :stem-direction :down)))
    (1 ((1 :notes (82) :stem-direction :down)))
    (1 ((1 :notes (81) :stem-direction :down)))
    (1 ((1 :notes (79) :stem-direction :down)))
  ))
)
) ; end :voicel
) ; end :part1
) ; end :score
```

Rosetta Stone of Digital Representations



Lilypond

```
\version "2.3.25"
\header {
  crossRefNumber = "1"
  footnotes = ""
  tagline = "Lily was here 2.4.1 -- automatically
converted from ABC"
  title = "Example"
}
voicedefault = {
\set Score.defaultBarType = "empty"
\time 2/4   c8.    d32    c32    c8      c8      \bar "|"
c16
f16    f4    r16    f16    \bar "|"    f16    a16    a4
r16
c16    \bar "|"    c8.    a16    c16    b16    a16    g16
\bar "|"
}
\score{
  <<
    \context Staff="default" { \voicedefault }
  >>
}
```

header

score

staff 1

music

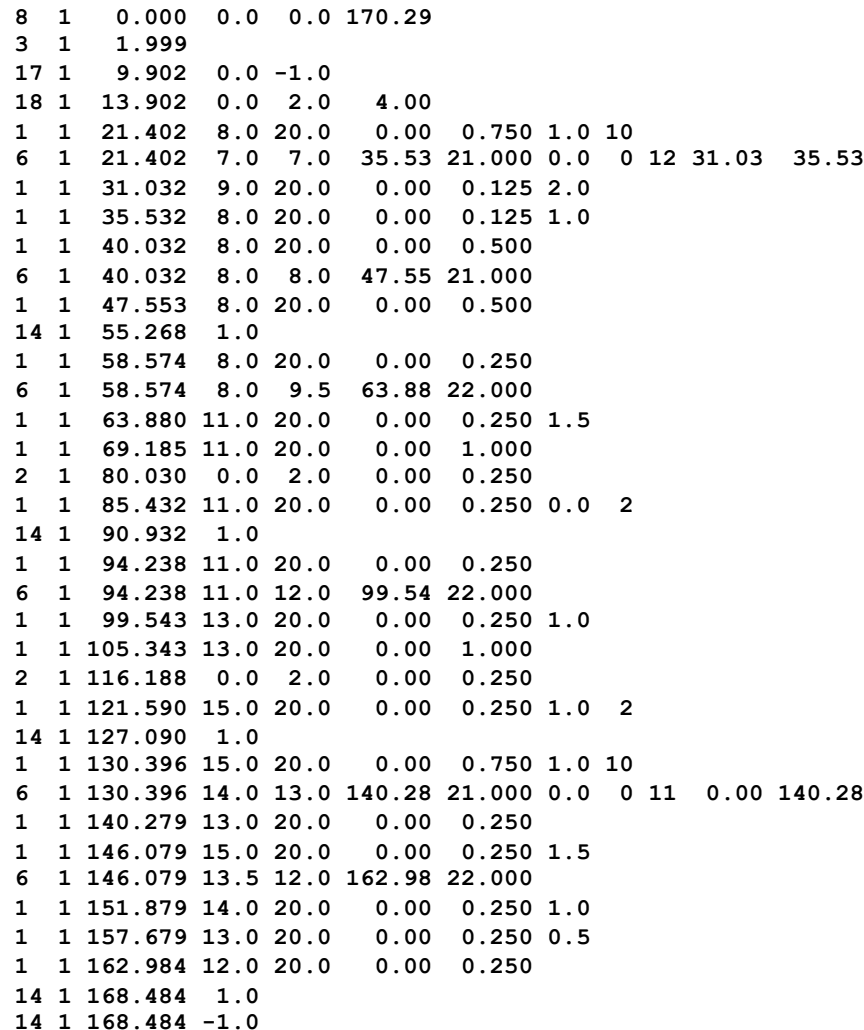
bar

bar

bar

bar

SCORE PMX



Rosetta Stone of Digital Representations



MEI

```
<measure n="1" xml:id="m_sc_2" left="invis">
  <staff n="1">
    <layer n="1">
      <beam>
        <note xml:id="n_sc_6_0" pname="c" oct="5" dur="8" dots="1"/>
        <note xml:id="n_sc_7_0" pname="d" oct="5" dur="32"/>
        <note xml:id="n_sc_8_0" pname="c" oct="5" dur="32"/>
      </beam>
      <beam>
        <note xml:id="n_sc_9_0" pname="c" oct="5" dur="8"/>
        <note xml:id="n_sc_10_0" pname="c" oct="5" dur="8"/>
      </beam>
    </layer>
  </staff>
</measure>
<measure n="2" xml:id="m_sc_11">
  <staff n="1">
    <layer n="1">
      <beam>
        <note xml:id="n_sc_12_0" pname="c" oct="5" dur="16"/>
        <note xml:id="n_sc_13_0" pname="f" oct="5" dur="16"/>
      </beam>
      <note xml:id="n_sc_14_0" pname="f" oct="5" dur="4"/>
      <rest xml:id="n_sc_15_0" dur="16"/>
      <note xml:id="n_sc_16_0" pname="f" oct="5" dur="16"/>
    </layer>
  </staff>
</measure>
```


MusicXML

MusicXML

```
<note>
  <pitch>
    <step>A</step>
    <octave>5</octave>
  </pitch>
  <duration>2</duration>
  <voice>1</voice>
  <type>16th</type>
  <stem>down</stem>
  <beam number="1">continue</beam>
  <beam number="2">continue</beam>
  <notations/>
</note>
<note>
  <pitch>
    <step>G</step>
    <octave>5</octave>
  </pitch>
  <duration>2</duration>
  <voice>1</voice>
  <type>16th</type>
  <stem>down</stem>
  <beam number="1">end</beam>
  <beam number="2">end</beam>
  <notations/>
</note>
</measure>
```

Rosetta Stone of Digital Representations



Standard MIDI File

4d	54	68	64	00	00	00	06	00	01	00	02	00	60	4d	54	72	6b	00	00
00	3c	00	ff	01	18	50	72	6f	64	75	63	65	64	20	75	73	69	6e	67
20	53	68	61	72	70	45	79	65	32	00	ff	59	02	00	00	00	ff	59	02
ff	00	00	ff	51	03	0f	42	40	00	ff	58	04	02	02	18	08	86	00	ff
2f	00	4d	54	72	6b	00	00	00	a9	00	c0	00	00	b0	07	50	00	ff	59
02	ff	00	00	90	48	40	48	80	48	40	00	90	4a	40	0c	80	4a	40	00
90	48	40	0c	80	48	40	00	90	48	40	30	80	48	40	00	90	48	40	30
80	48	40	00	90	48	40	18	80	48	40	00	90	4d	40	18	80	4d	40	00
90	4d	40	60	80	4d	40	18	90	4d	40	18	80	4d	40	00	90	4d	40	18
80	4d	40	00	90	51	40	18	80	51	40	00	90	51	40	60	80	51	40	18
90	54	40	18	80	54	40	00	90	54	40	48	80	54	40	00	90	51	40	18
80	51	40	00	90	54	40	18	80	54	40	00	90	52	40	18	80	52	40	00
90	51	40	18	80	51	40	00	90	4f	40	18	80	4f	40	00	ff	2f	00	