Strange Loops

LOOKING INTO MUSIC

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by christian swinehart

Designed by Christian Swinehart
for Visual Systems (Dietmar Winkler)

RISD

Set in DTL Elzevir & Caspari
Visualized with 257 lines of python code

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I.I

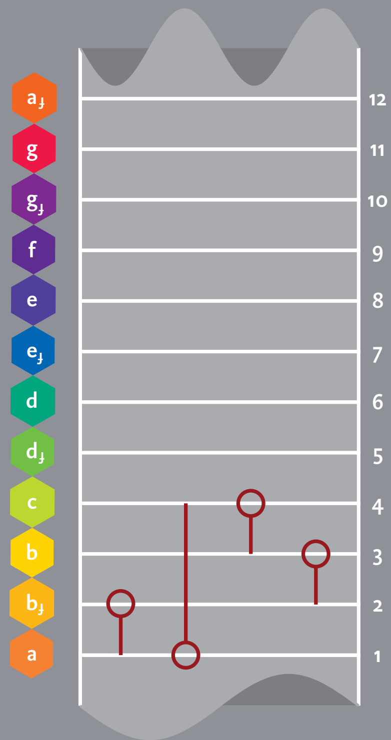
NOTATION SYSTEMS & THE SCALE *The Basics*

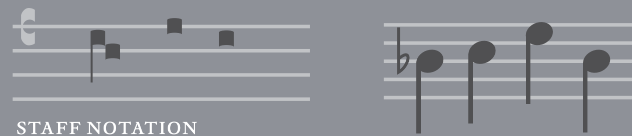
The cornerstone of most Western music systems is the diatonic, or 'twelve tone', scale.

The basic unit of pitch is the Octave, defined as a doubling in the frequency (or halving of the wavelength) of a given tone.

The space within the octave is divided into 12 half-steps, with each being assigned a unique name between A & G *such as* B *or* E*-flat.*

Typically these pitches are recorded using the 5-line staff notation, but this is not the only way to depict these values. They can also be represented spatially or as a function of hue or lightness.



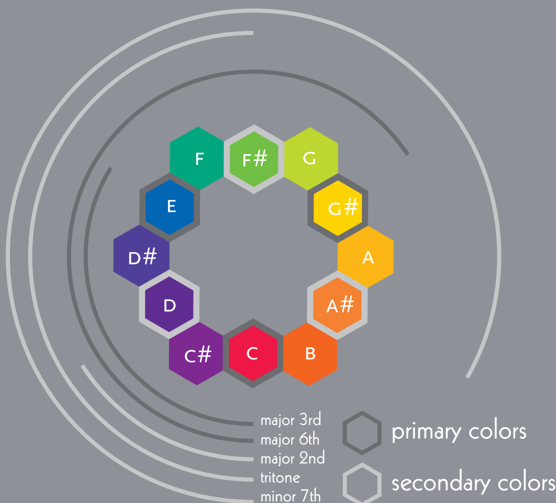


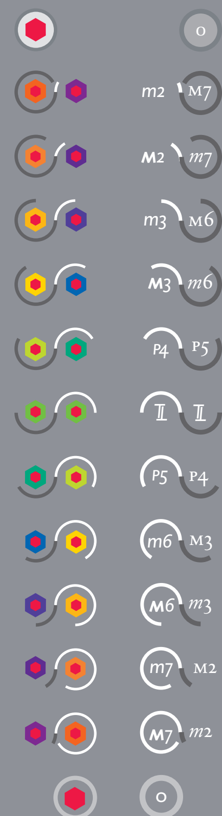
STAFF NOTATION
pitch via position and diacrtical marks

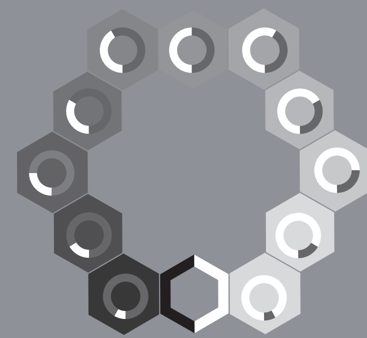
SPATIAL REPRESENTATION
position on page proportional to position on 12 tone scale

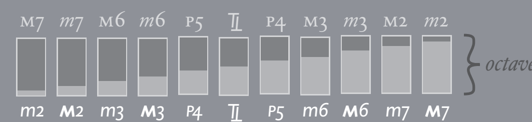
COLOR REPRESENTATION
lightness/hue proportional to position on scale

INTERVALS *The Space Between the Notes*









CORRESPONDENCE BETWEEN THE COLOR WHEEL AND THE OCTAVE

The twelve half steps in the octave and the twelve hues in the color wheel allow for a one to one mapping of colors to tones. as a result, color families have corresponding sets of intervals

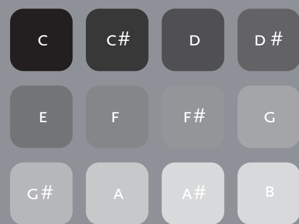
COMPLEMENTARY INTERVALS

Each interval between the tonic note and a second note in the octave has a complementary interval which would complete the octave. For instance stepping up by five half steps is a perfect fourth. Seven additional steps (a perfect fifth) above that we return to the tonic note, but one octave higher than before.

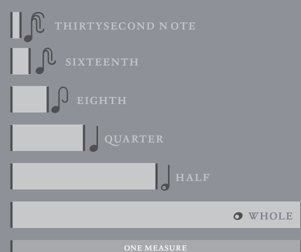
1.3

TIME & SEQEUENCE *Stringing Things Together*

PITCH



DURATION



A TRANSLATION

LITTLE FUGUE IN G MINOR · J.S. BACH

SPATIAL NOTE DURATION (SPACE = TIME)

Just as the pitches of the scale evenly divide the octave, notes of fractional durations divide the measure. Note lengths exist in a geometric progression with each shorter note being precisely half of its larger sibling

These lengths are typically noted symbolically through dots and tails. here the relative durations of different notes are shown as a function of width. note lengths exist in a geometric progression with each shorter note being active for precisely twice the period of its next largest sibling

AN ALTERNATIVE NOTATION SCHEME (SIZE & LIGHTNESS)

Notes on the staff offer a view of music that maps precisely onto its aural form, but in order to fit as much information into the smallest area, it is highly compressed, both in terms of tone and duration. Tonal compression occurs when two notes (say, a and a-flat) both share a line on the staff, distinguished only by a symbol. This breaks down the linear mapping between pitch and height on the staff. Though there is some reflection of duration in the horizontal spacing of the notes – particularly the way eighth and smaller notes have their tails joined to form note clusters – it is not strictly conserved.

The alternative scheme shown here is purely linear. Time is a function of horizontal space and pitch of lightness. Though functionally equivalent to the compressed staff notation, this encoding is a less preprocessed, more analog representation of the notes in the score.

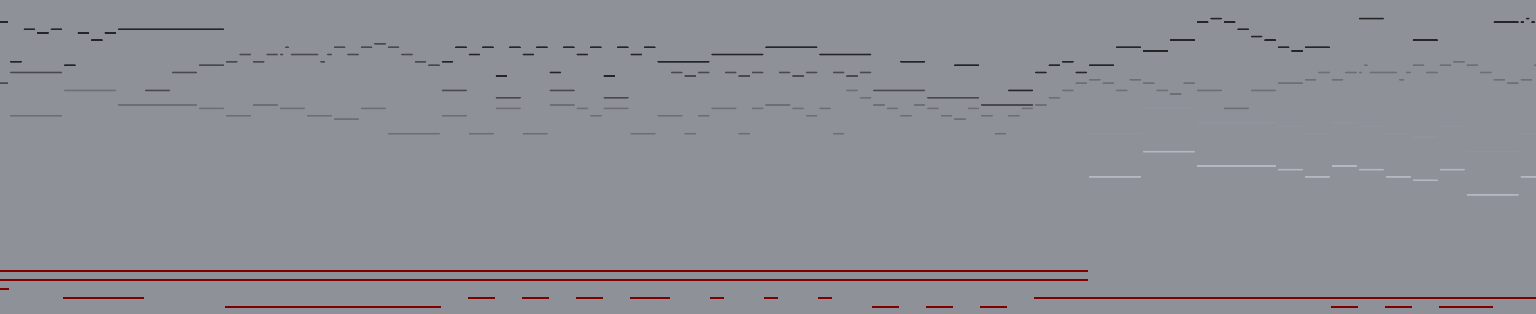
Three Ways of Looking at J.S.

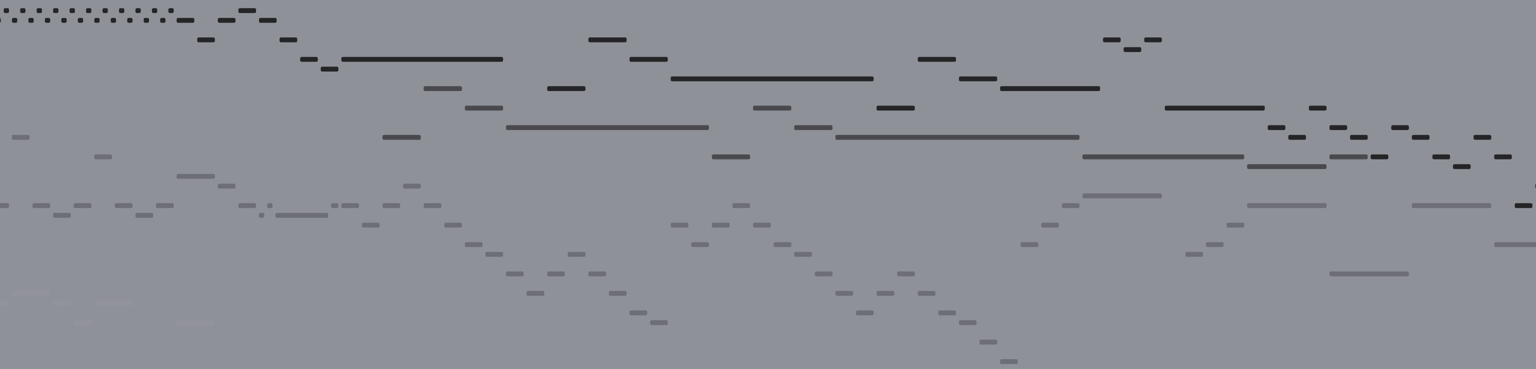
LITTLE FUGUE IN GREY BOX NOTATION

Further translation using the grey box scheme. Jumps of an octave (which would ordinarily be invisible) are marked with an inscribed square.

LITTLE FUGUE IN INTERVAL ARC NOTATION

Time of note onset is given by location of arc's origin. Size of interval is represented by arc length with up-intervals in white and down- in black.





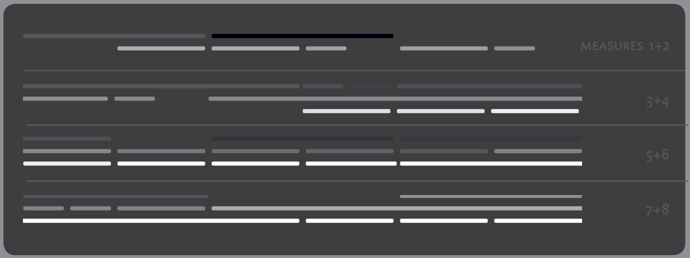
PIANO ROLL NOTATION

The greybox notation is similar to another analog notation used a century ago: the player piano roll. Since the 'reader' portion of the piano was purely mechanical, decoding pitch from colors would be impossible. Instead the piano roll notation encoded pitch by the bar's vertical position on the page.

Here the notes use the piano scheme for pitch while retaining the bar width to duration relationship from before. The colors now represent separate lines in the melody. The red lines below are the 'rests' during which a given melody line is otherwise silent.

J.S. BACH
JESU DER DU MEINE SEELE (BWV 78)

J.S. BACH
GOLDBERG VARIATIONS (V. 15)



SONG STRUCTURES REVEALED

Though our ears can immediately pick out pitches and harmonies, higher level patterns of song structure are less apparent. Looking at the score over time shows the amount of structural variety in different types of music. Each voice is plotted on its own line, stacked atop the other voices active at that moment. Subsequent measures of the song are plotted below.

What is noteworthy about the cantata (left) is its incredible regularity. The phrasing is nearly identical from one measure to the next, suggesting that the song is really about the chords formed by the voices. The piano piece (above) has a clear segregation of high and low pitches between the voices, illustrating that those 'voices' are really 'fingers' on the keyboard reaching the notes nearest to them.

A GRADUAL INTRODUCTION

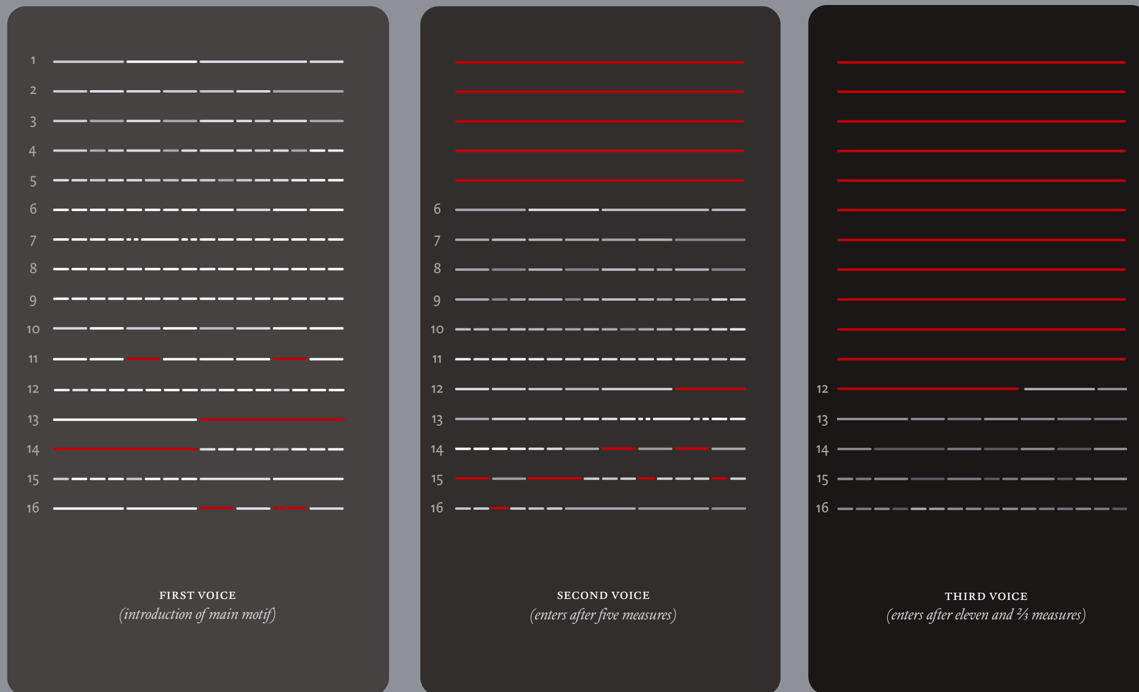
A general characteristic of fugues is the rigid protocol by which they begin. A single voice will begin the song with the motif that will form the basis for the variations to come. This is followed by the introduction of a second voice which enters imitating the main motif, but typically at a different starting pitch.

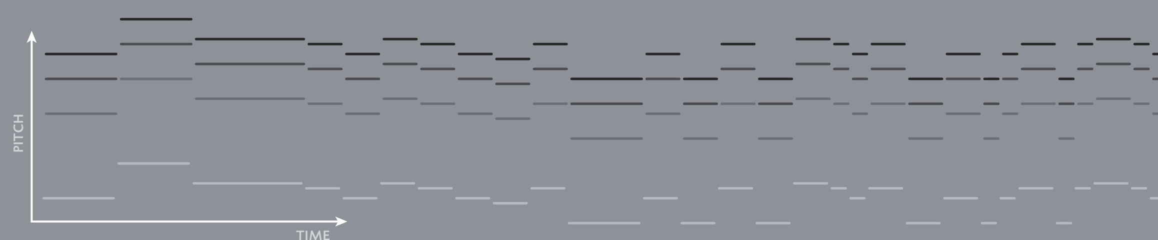
While this occurs, the first voice is still playing but has moved on to the 'countersubject' – a secondary motif designed to harmonize with the first. This pattern continues until all three, four, or more voices have entered the song.

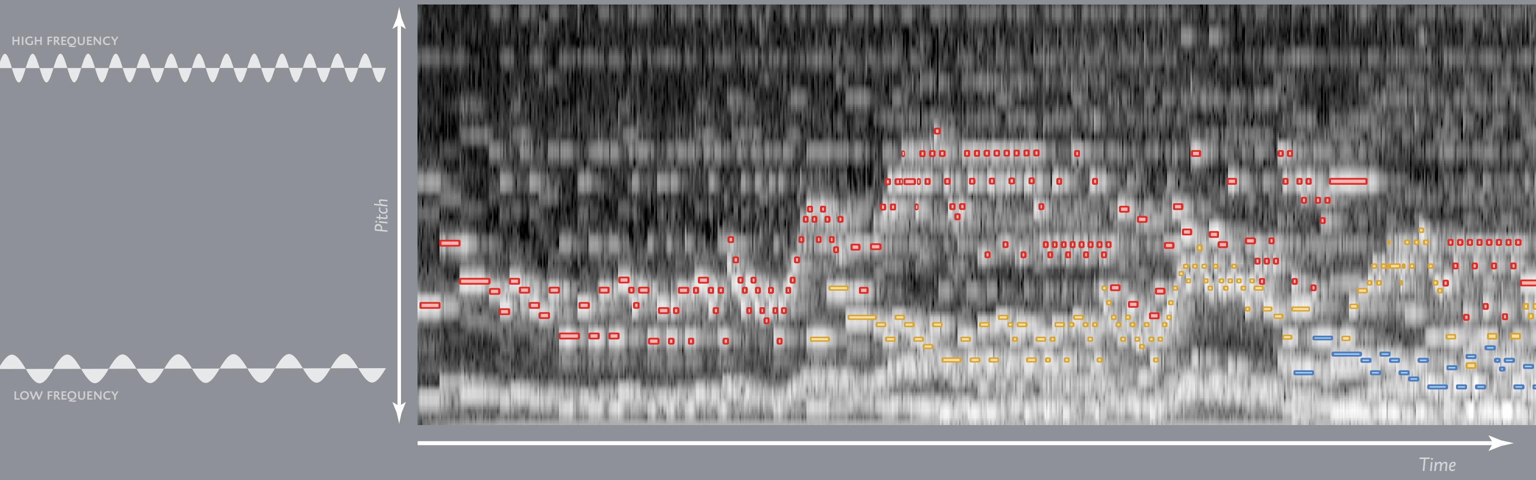
PARALLEL FORMS

Here the four voices have been aligned to begin simultaneously rather than being staggered, as they are in the score. The starting pitches vary, but the structure is clearly conserved across the voices.

J.S. BACH
THE LITTLE FUGUE IN G MINOR







INDUCTION/DEDUCTION

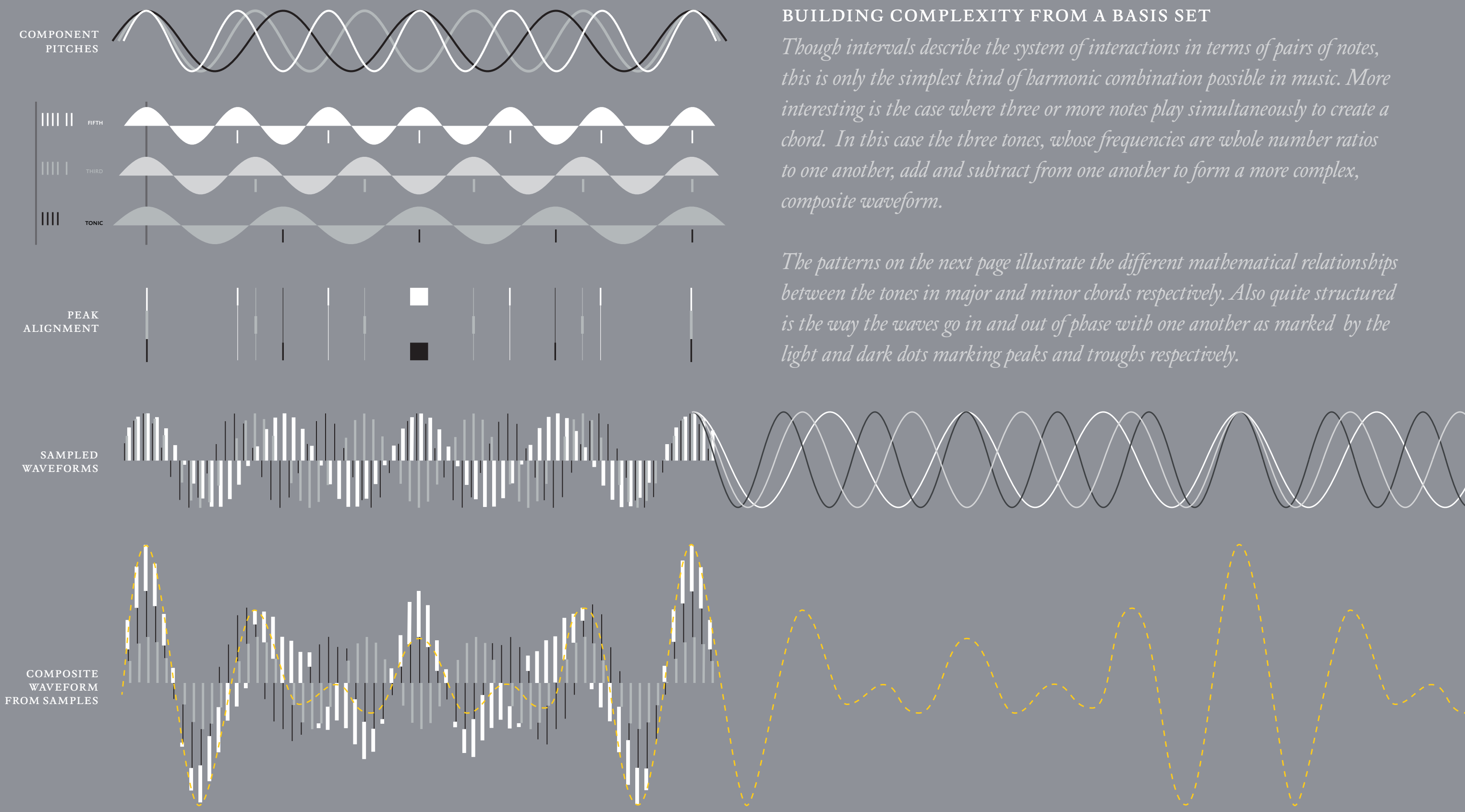
If the piano roll notation is truly more analog than traditional staff notation, it should be possible to see the correspondence between its representation of the score and the actual character of the music as it is performed. In the figure above this correspondence takes the form of overlaying the notation (red, yellow, and blue ovals) atop a spectrographic visualization of a recorded performance (the black and white image).

The two representations use identical axes, so the degree of agreement is perhaps unsurprising.

Time flows from left to right while the different pitches are represented on the vertical axis. When a note is played, the recording software will notice a large amount of volume in the frequency range corresponding to that pitch. The loudness of that frequency is represented through brightness. Thus the brightest spots in the image should correspond to notes in the score, and indeed comparing them to the overlayed bars show this is the case.

An interesting secondary observation is the presence of 'ghost' melody lines which appear both above and below the 'true' melody. These harmonics are a kind of echo in the frequency space and occur with a diminishing amplitude at each multiple of the original pitch.

Perfect Combinations



BUILDING COMPLEXITY FROM A BASIS SET

Though intervals describe the system of interactions in terms of pairs of notes, this is only the simplest kind of harmonic combination possible in music. More interesting is the case where three or more notes play simultaneously to create a chord. In this case the three tones, whose frequencies are whole number ratios to one another, add and subtract from one another to form a more complex, composite waveform.

The patterns on the next page illustrate the different mathematical relationships between the tones in major and minor chords respectively. Also quite structured is the way the waves go in and out of phase with one another as marked by the light and dark dots marking peaks and troughs respectively.

3.2

VECTOR MATH & HARMONY

Chords Compared