ImproViz: Visual Explorations of Jazz Improvisations

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ABSTRACT
ImproViz is a visualization technique for diagramming music that brings to light the signature patterns of a jazz musician's improvisational style. ImproViz consists of two parts: (1) *melodic landscapes* show the general contours of musical phrasing; and (2) *harmonic palettes* represent the musician's tendency to use a particular combination of notes in a given part of the song. Viewing the jazz standard *All Blues* through the lens of ImproViz illustrates the contrasting melodic and harmonic styles of three musicians. This analysis uncovers some surprises, such as how Miles Davis played musical ideas that contradicted his own composition. ImproViz offers jazz students a new way to study jazz theory and can also serve as a real-time improvisational aid, allowing a student to borrow the harmonic vocabulary of jazz masters.

Author Keywords
Information visualization, harmony, melody, jazz, music, improvisation, analysis.

ACM Classification Keywords
H5.5 Sound and music computing: Methodologies and techniques

INTRODUCTION
Jazz improvisation -- the art of spontaneously creating interesting melodies that fit the harmonic and rhythmic structure of a song -- can be difficult to learn. Sheet music typically provides nothing more than the melody and the chord changes, leaving the musician to figure out the rest. Some music instructors suggest that the best way to learn to improvise is to transcribe and then memorize famous jazz solos. This may be effective but it is very time consuming and labor intensive.

The goal of ImproViz is to create a way of visualizing jazz improvisations to discover melodic and harmonic patterns. Although ImproViz has not yet been implemented or evaluated with its target user base, it is intended that the target audience -- jazz students -- will benefit from its use in two ways: (1) increased understanding of jazz theory through visual solo analysis; and (2) improved improvisational skills by using ImproViz as a tool for real-time improvisation. In addition, ImproViz can be seen as a form of educational entertainment for music enthusiasts. Even people who cannot read musical notation can follow along with the melodic landscapes as they listen to a recording and simultaneously see and hear the musical patterns of their favorite jazz soloists.

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RELATED WORK
Stephen Malinowski's *Music Animation Machine* software application [3] provides an animated exploration through a musical composition. As the piece is played, colored bars stream across a computer screen, rising and falling with the notes played. The colors of the bars differentiate instruments or structural components of the piece. Separating simultaneous musical voices visually helps separate them aurally. This is particularly useful when listening to multi-voice compositions like a fugue or orchestral piece but less so for analyzing a single musical line or solo.

Martin Wattenberg's *The Shape of Song* software application [5,6] "draws musical patterns in the form of translucent arches, allowing users to see—literally—the shape of any composition... from the deep structures of Bach to the crystalline beauty of Philip Glass." Wattenberg's system generates visualizations for any MIDI file. *The Shape of Song* excels at showing the interconnectedness and repetition of motifs in a piece.

THE VISUALIZATION
ImproViz consists of two parts: (1) *melodic landscapes*, a representation of melodies played; and (2) *harmonic palettes*, a distribution of notes played per measure. ImproViz utilizes standard musical notation consisting of notes and five line staffs because it is very familiar to most music students. The visualization was created using Adobe Illustrator and was based on a book of transcriptions [4].

Selection of *All Blues* for Analysis
All Blues, a 1959 Miles Davis composition from the classic album *Kind of Blue* [1], was selected for analysis for several reasons. First, it is familiar to music lovers around the world. In fact, *Kind of Blue* is believed to be the most recognized jazz recording ever, having sold over five million copies worldwide [2]. Second, *All Blues* consists of 12 measures with chord changes in the 5^{th}, 7^{th}, 9^{th}, 10^{th} and 11^{th} measures, otherwise known as a 12 bar blues. The

techniques used to graph this common structure can be easily applied to any 12 bar blues. Third, each soloist played for the same amount of time: four choruses, or cycles through the 12 bar structure. This allows an even comparison of the soloists' melodic ideas and note selections over time.

Most importantly, the soloists had very distinct styles: Miles Davis with his cool, mysterious trumpet, Julian "Cannonball" Adderley with his funky alto sax riffs and John Coltrane on tenor sax playing his signature "sheets of sound," or continuous streams of notes. Bill Kirchner summed up their playing of *All Blues*:

> ... the solos are all remarkably diverse: Davis's (in open horn) strongly motivic, Adderley's soaringly blues-based, Coltrane's intense -- perhaps his most passionate playing on the album [2, p.16].

The challenge is how to visualize Davis' "motifs," Adderley's "soaring blues" and Coltrane's "intense passion" in a way that is accessible to musicians.

Melodic Landscapes

A *melodic landscape* is a contour map of the rising and falling pitches of a soloist that outlines the general characteristics of a performance but suppresses the detail of individual notes. Finished graphs resemble a mountainous landscape, hence the term *melodic landscapes*.

In standard musical notation the width of a measure is variable, based on the number of notes that must be displayed. In contrast, ImproViz uses a fixed width for all measures which normalizes the x axis (time). This allows melodic ideas to be viewed over a consistent representation of time to further shed light on patterns (see Figure 1).

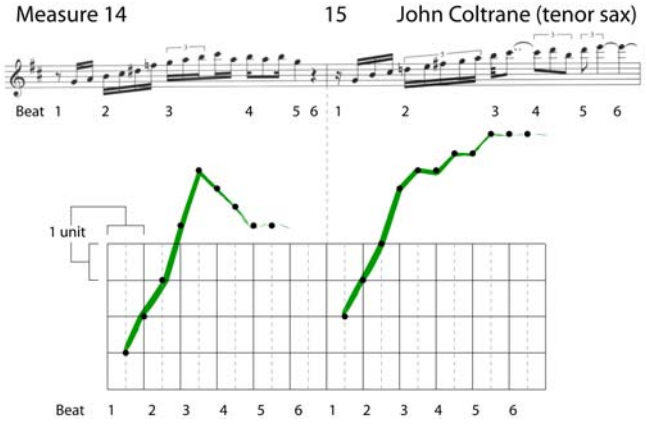

Figure 1. Bars 14-15 of Coltrane's solo as a transcription (top), and as a melodic landscape (bottom). The x-axis of time in the transcription is erratic, resulting in distortion. In the *melodic landscape*, a consistent representation of time corrects this.

Each chorus is presented as an unbroken set of 12 measures instead of wrapping some measures to the next line. This presents a cyclical view of the musical structure (12 bar blues) and facilitates vertical comparisons of musical ideas across choruses on a measure by measure basis.

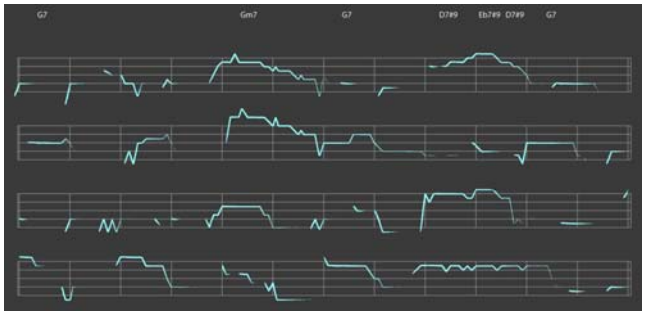

Figure 2. Cyclical view of all four choruses of Davis' solo. Davis punctuates long phrases with equally long silences, creating a sparse *musical landscape*. His solo is full of musical motifs like the sweeping phrase in bars 4-5 (chorus 1 and 2).

The graphing algorithm is: (1) Construct a five line musical staff. (2) Add vertical subdivisions for every half-beat, where the length of one beat is equal to the height between two staff lines. (3) Delineate 12 6-beat measures since *All Blues* has six beats per measure and 12 measures per chorus. (4) Plot a point at each half-beat for the note played -- ignore interstitial notes. (5) Connect the dots with a line, leaving gaps for rests (musical silences). (6) Apply a style to the line, such as the "watercolor" brushstroke effect in Adobe Illustrator.

Harmonic Palettes

A *harmonic palette* is a breakdown of the notes each musician played in every measure of the 12 bar blues. It illustrates a musician's tendency to use a particular combination of notes at a particular point in the song's structure. Notes are often characterized as being *colorful* so we can think of a jazz artist's choice of notes as a kind of color palette, hence the term *harmonic palette*. Ashley Kahn used these terms to describe Davis' style in the mid 1950s: "Color, timbre and even atmosphere began to play a more prominent role in Miles's musical palette" [2, p.37].

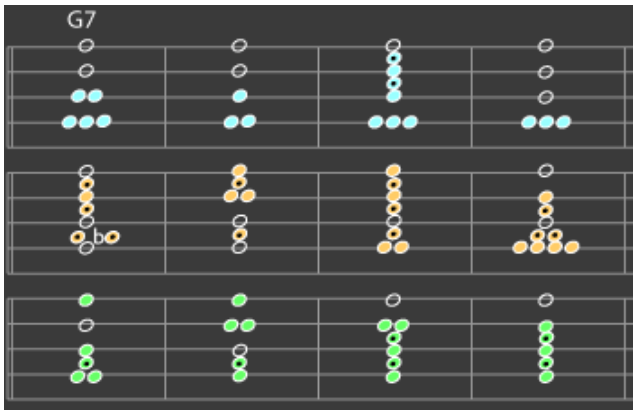

Figure 3. *Harmonic palettes* for Davis (top), Adderley (middle) and Coltrane (bottom). Filled circles: notes played in chord. Filled circles with dots: notes played outside the chord. Unfilled circles: notes from the chord left unplayed. The soloists emphasized different shades of the G7 chord in each of these measures even though the chord stayed the same. Davis chose notes sparingly, ignoring the 5th and 7th intervals and accenting the root of the chord (G) whereas Adderley played a wide selection of notes and refused to play the G until bars 3-4.

Each *harmonic palette* is vertically laid out starting with the tonic (root note) of the chord for that measure. The first bar is a G7 chord so the *harmonic palette* starts at G and builds up to the seventh of the chord, an F (see Figure 3). To allow notes to be stacked directly above the tonic, the vertical space between staffs was increased. Otherwise, notes would be staggered to the left or right of one another, falsely implying a sequence to the student.

The *harmonic palettes* also show the fundamental notes of chords (1st, 3rd, 5th and 7th intervals) that were *not* voiced by a soloist by using empty, unfilled note heads. Visualizing the absence of notes is just as informative as seeing the notes that were played. For example, in Figure 4 Davis played notes that were not part of the chord (filled note heads with black dots) and played none of the notes that were in the chord (unfilled note heads).

The algorithm for graphing harmonic palettes is:

(1) Transpose all instruments into the concert key of C (the tenor sax and trumpet are always written in B flat and the alto sax is written in E flat). Assign a color to each soloist.

(2) For each note *n*, measure *m*, and soloist *s*, add up the number of beats played across the *c* choruses:

$$b_{n,m,s} = \sum_{i=1}^{c} b_{n,m,s,i}$$

(3) Find $b_{n,m,s}$ with the highest value and divide it by 5 to derive *beats per note head* (BPNH). This serves as the timescale. The number 5 produced the best distribution of notes for *All Blues* which is in 6/4 time (6 beats per measure), but songs in 4/4 time (4 beats per measure) should be divided by a smaller number.

$$BPNH = \frac{\max(b_{n,m,s})}{5}$$

(4) To determine how many note heads to graph ($g_{n,m,s}$), for each measure, note and soloist, divide $b_{n,m,s}$ by BPNH.

$$g_{n,m,s} = \min\left(4, \left\lfloor \frac{b_{n,m,s}}{BPNH} \right\rfloor\right)$$

(5) Graph $g_{n,m,s}$ circular note heads using the soloist's color. If $g_{n,m,s} = 0,$ and the note is in the measure's chord, plot an empty circle. If the note is not in the measure's chord, place a dot in the center of the filled circle.

Davis tended to play fewer notes and held them for longer than Coltrane, who produced his trademark "sheets of sound." The algorithm above accounts for these differences by optimizing the timescale to show plenty of notes in each harmonic palette while maintaining proportionality across soloists. For example, in Figure 4, the timescale is two BPNH, so one note head equals two beats, two note heads equals four beats, and so on. In this way, a music student can quickly grasp which notes a soloist emphasized over others in a given measure.

Surprising Discoveries

Tenor saxophonist Jimmy Heath commented on the unusual harmonic structure of *All Blues*:

> When people play it [*All Blues*] other than in the Miles Davis band, a lot of people play it where they go from the G chord to C, a traditional blues. But when we played "All Blues," Miles would always say don't go the IV chord [C] on the second part of that. He wanted it to stay in a modal concept. So he'd go from G7 to a G minor sound, really playing that mode so that let his improvisation sound a little dissonant, and a little more sophisticated [2, p.142].

However, in Figure 4 we see that Davis did not play any of the notes in the G minor chord but instead plays an A minor triad (A, C, E). Why did he intentionally ignore his own chord changes? Meanwhile, Coltrane spent most of his time playing a C, the tonic of the chord Miles told his band not to play! Adderley was the only musician to voice the full G minor chord in the fifth bar.

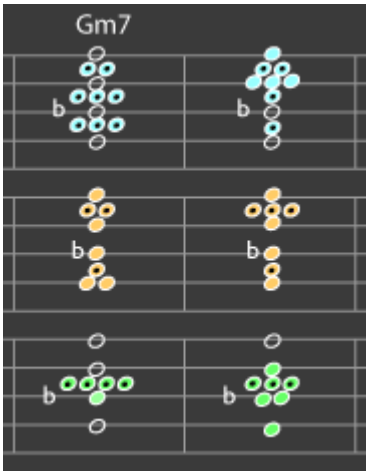

Figure 4. *Harmonic palettes* for the G minor chord (5th and 6th bars). In the fifth bar, Davis (top) played six beats of A and C, Adderley (middle) played four beats of G and E and Coltrane (bottom) played more than eight beats of C.

Composites

Composite melodic landscapes show a soloist's approach for improvising over the 12 bar structure by superimposing all four choruses on top of each other. The composites at the top of Figure 5 reveal how Davis held on to key notes for long periods of time with occasional embellishments, while Adderley soared up and down in huge bell curves and peppered his solo with zigzagging riffs.

Composite harmonic palettes show the combined distribution of notes played by two or more soloists (see Figure 5, bottom). Further composites can be made of any two soloists such as Davis plus Coltrane or Coltrane plus

Adderley. This flexibility holds exciting possibilities for a music student who wishes to borrow styles from multiple sources at once.

FUTURE DIRECTIONS

These ideas could be extended to allow students to view solo information for one or many soloists simultaneously. It could display beginner or advanced views of *harmonic palettes* showing basic and extended chord structures. Animation could also be an important aspect of this interface, allowing students to see exactly where they are in a song.

ImproViz could also be used as a form of self-evaluation. In the ideal scenario, ImproViz could be attached to a MIDI-enabled instrument that could translate the soloist's improvisation into visualizations in real time. This would allow students to see how successfully they are playing inside the chord changes of a tune and would provide feedback regarding their progress.

ACKNOWLEDGEMENTS

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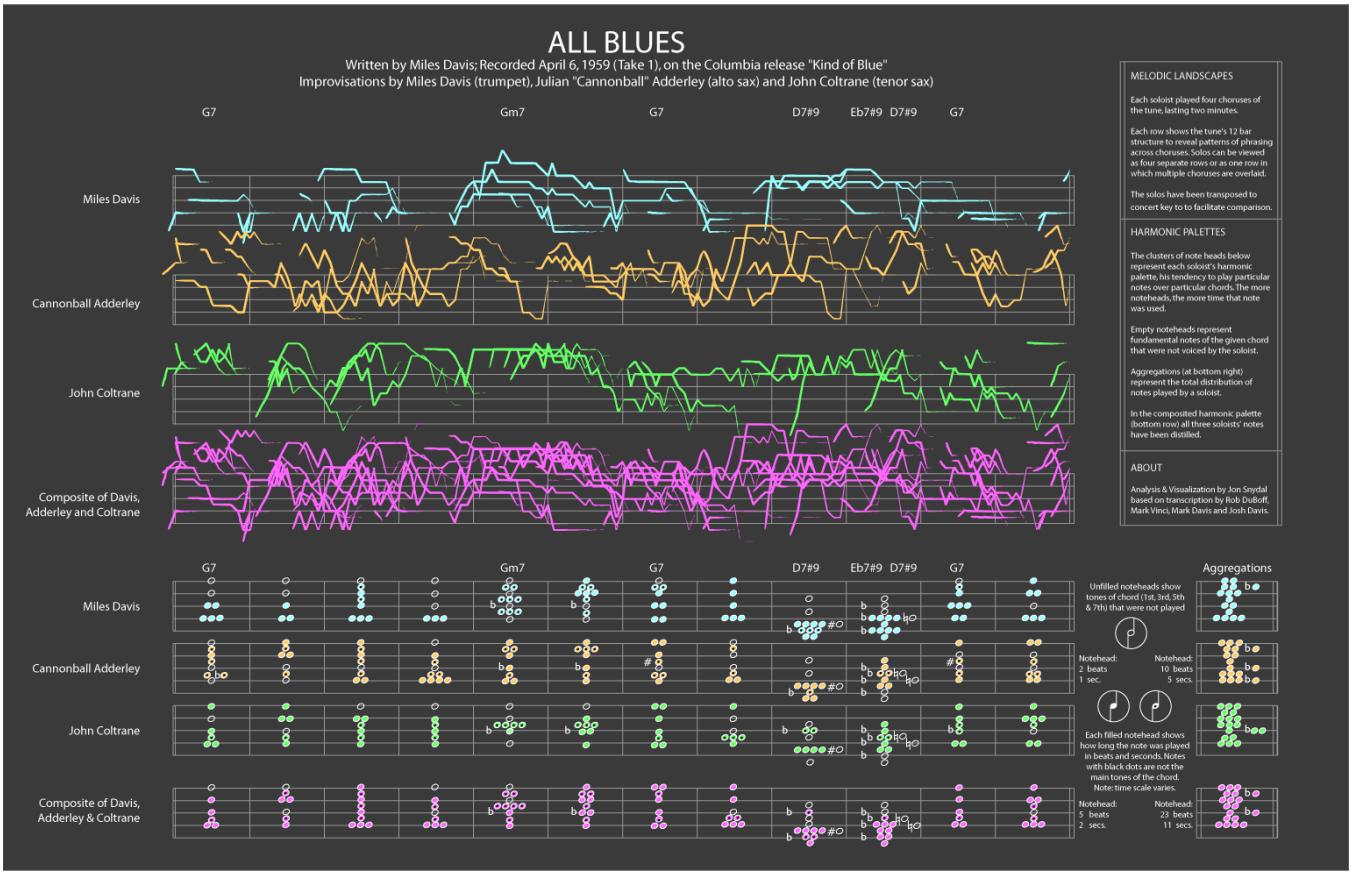

Figure 5. In this view of ImproViz, *composite melodic landscapes* (top) show the stylistic differences between the three solos. Davis played motifs at different intervals in bars 5-6 and 9-10. Adderley played like a roller coaster, taking the listener on a wild ride down and up scales. Although Coltrane played sweeping phrases filled with hundreds of notes, he hovered around particular notes in bars 5-6 on all four choruses, and launched each chorus in a grand ascent in bar 2. *Harmonic palettes* for the soloists appear below which illustrate their harmonic differences and similarities in each measure of the 12 bar blues.