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InfoSys 247

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ImproViz: Visualizing Jazz Improvisations

ImproViz is available at: http://www.offhanddesigns.com/jon/docs/improViz.pdf

This paper is available at: http://www.offhanddesigns.com/jon/docs/improVizBrief.pdf

The Problem

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.

Project Goals

The goal of ImproViz is to create a way of visualizing jazz improvisations to discover melodic and harmonic patterns. The target audience, a jazz student, will benefit from ImproViz 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.

These goals require balancing how much information to display. As an analytical tool, enough detail must be provided to allow for meaningful comparisons between musicians' improvisational styles. As an improvisational aid, information presented to the user must be distilled down to the most relevant details so that the student is not overwhelmed.

Related Work

There seems to be a dearth of research in the area of visual jazz analysis, but I did come across several interesting techniques for visualizing music and dance.

Stephen Malinowski's Music Animation Machine 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. Visually separating simultaneous musical voices 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.

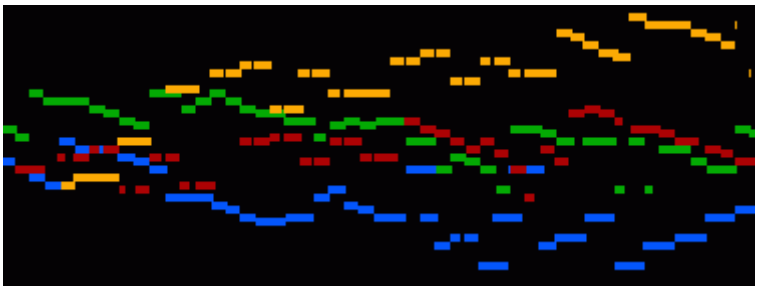

Figure 1: Malinowski's Music Animation Machine depicting a fugue.

Edward Tufte provides several examples of music visualizations in his book *Envisioning Information*. The juxtaposition of an electrocardiogram with musical notation (Tufte 59) is a subtle reminder that musical notation is very similar to a histogram. Malinowski used a histogram to represent music, although it appears to be unusable as a playing aid for musicians. Albert Zorn's choreographic notation (Tufte 117) provides a sophisticated yet whimsical representation of a dancer's movement. Zorn's flowing brushstrokes suggest the fluid, natural movements of a dancer and demonstrate that beauty and utility are not opposites.

David Franz used Markov chains, a mathematical technique for deriving probable future states, to analyze John Coltrane's improvisations on *Giant Steps*. First-order Markov chains showed what notes Coltrane was likely to play after playing a particular note. Second- and third-order Markov chains revealed Coltrane's tendencies in building runs of up to four notes. However, it would be impractical to present this much detail to a musician as guidelines for improvisation. It would be more useful to represent the distribution of notes that a musician played in a given measure. A student could use these note distributions as a basis for new improvisations.

The Visualization

ImproViz consists of two parts: a representation of melodies played and a distribution of notes played per measure. I relied heavily on standard musical notation consisting of notes and five bar staffs because it is quite robust and would be most familiar to the music student.

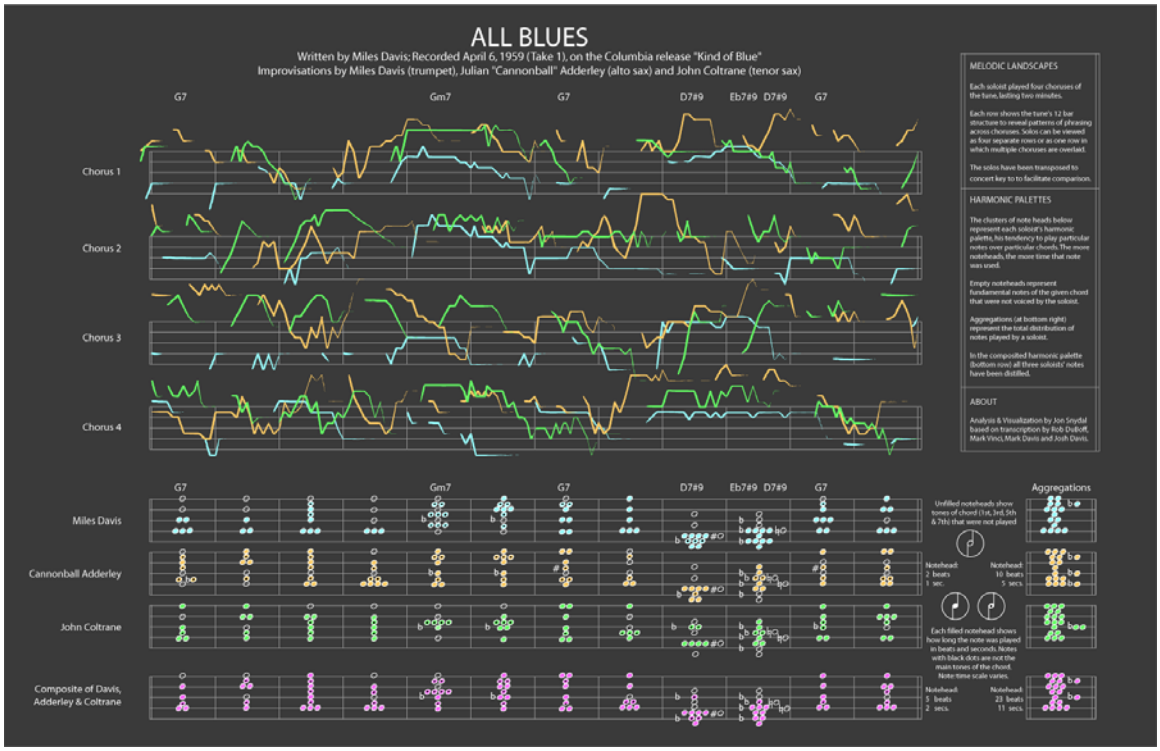

Figure 2: Full view of ImproViz, showing the complete solos and note selections of Davis, Adderley and Coltrane on *All Blues*.

Selection of *All Blues* for Analysis

I chose to analyze *All Blues*, a 1959 Miles Davis composition from the classic album *Kind of Blue*. *All Blues* is a 12 bar blues in the key of G, one of the most common jazz structures. Each soloist played four choruses, or runs through the 12 bar structure. It was convenient that each solo was the same length (approximately two minutes) because the resulting analyses of note distributions are proportional to one another.

The soloists were Miles Davis on trumpet, Julian "Cannonball" Adderley on alto saxophone and John Coltrane on tenor saxophone. 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. (*Kind of Blue* 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

Using Adobe Illustrator and a book of transcriptions, I graphed each musical phrase into rising and falling brushstrokes. Inspired by Zorn's choreographic notation, I chose a special brushstroke that fades away rather than straight lines because it captures more of the passionate, human spirit of the music. Finished graphs came to resemble a mountainous landscape, hence the term *melodic landscapes*.

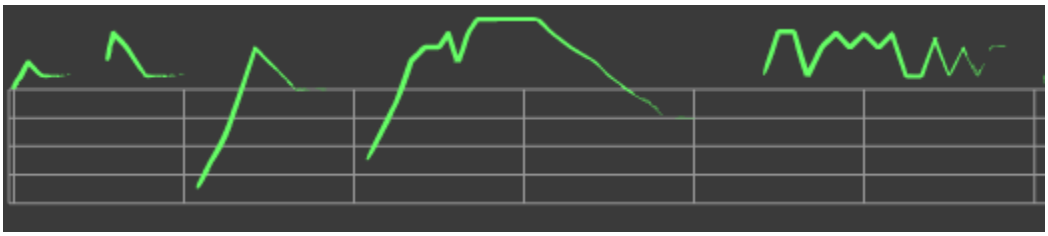

Figure 3: Brushstrokes rise and fall to represent Coltrane's improvisations in bars 13-18.

The goal was to create an abstract, high-level view of melodic phrases, so 16th notes (very short) were generalized into eighth notes (longer), and notes with accidentals (flats or sharps) were not differentiated. I used 45 degree angled brushstrokes to represent a major third interval, one of the most frequently used intervals in jazz. Intervals greater than a major third have more aggressive angles.

Each chorus is presented as an unbroken set of 12 measures instead of wrapping some measures to the next line. This preserves a holistic view of the musical structure (12 bar blues) and facilitates vertical comparisons of musical ideas across choruses on a measure by measure basis. 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 of time. This allows us to view melodic ideas over a consistent view of time to further shed light on patterns.

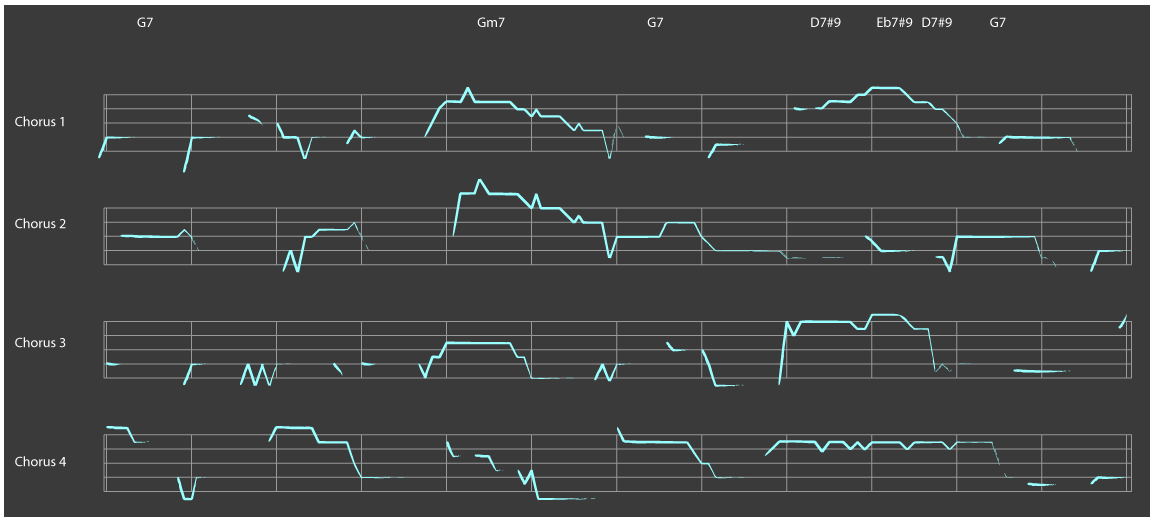

Figure 4: Linear view of all four choruses of Davis' solo, with chord changes at top.

A solo can be viewed as a linear story that reads from top left to bottom right (Figure 4). Alternatively, all four rows can be overlaid to create a composite view of all four choruses at once (Figure 5). This technique illustrates how Miles Davis used the same motifs (melodic ideas) in different choruses.

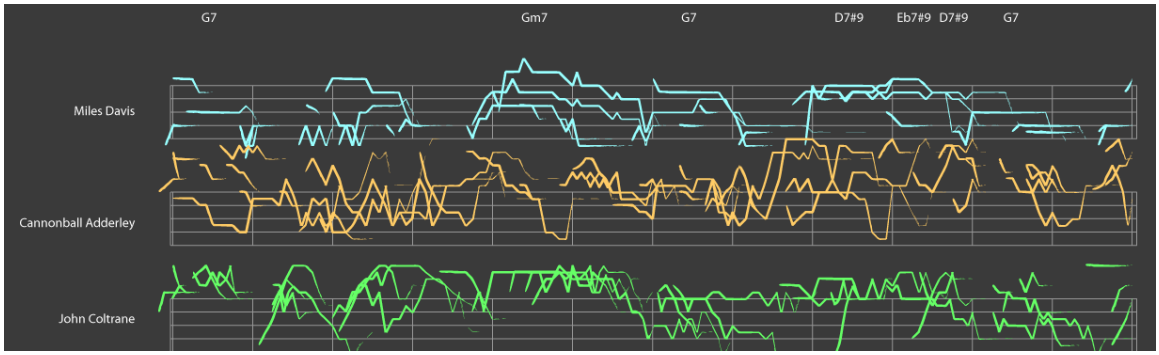

Figure 5: Composite overlays of Davis', Adderley's and Coltrane's solos. Davis' "motivic" style comes through clearly (esp. in 5th measure), as does Adderley's "soaring" style. Coltrane plays similar phrases in bars 5-6 on all four choruses.

Overlaying the three solos on top of one another in a linear fashion (Figure 6) shows how one musician echoed another and outlines major trends in melodic buildup and resolution. It allows the jazz student to grasp how each soloist developed musical ideas by showing the general contours of musical phrases. 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.

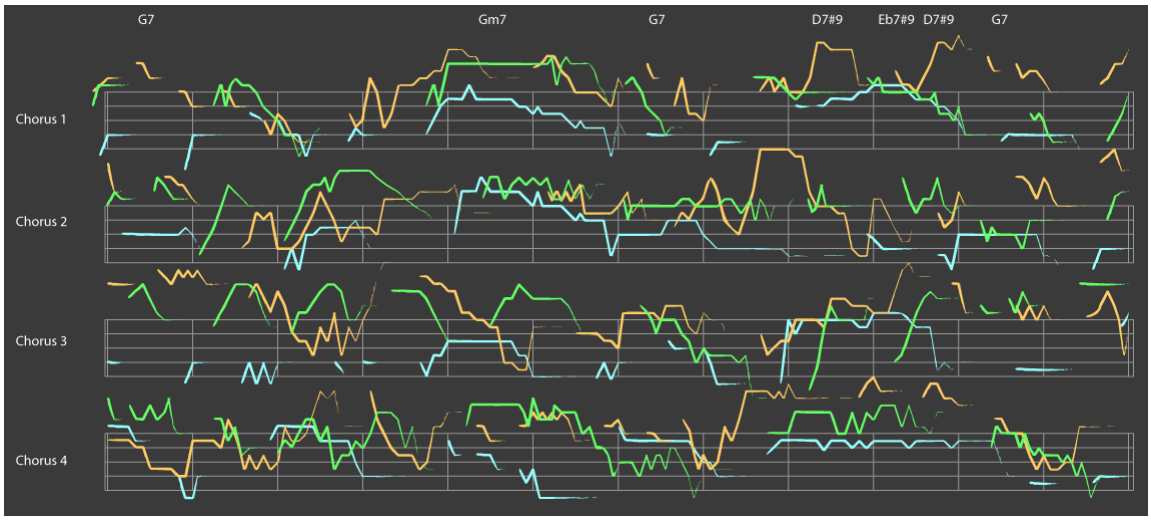

Figure 6: A linear overlay of complete solos by Davis (blue), Adderley (orange) and Coltrane (green).

Harmonic Palettes

ImproViz also shows a breakdown of the notes each musician played in every measure of the 12 bar blues. I call these note distributions *harmonic palettes* because they represent the musician's tendency to use a particular combination of notes. 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. 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" (Kahn, 37).

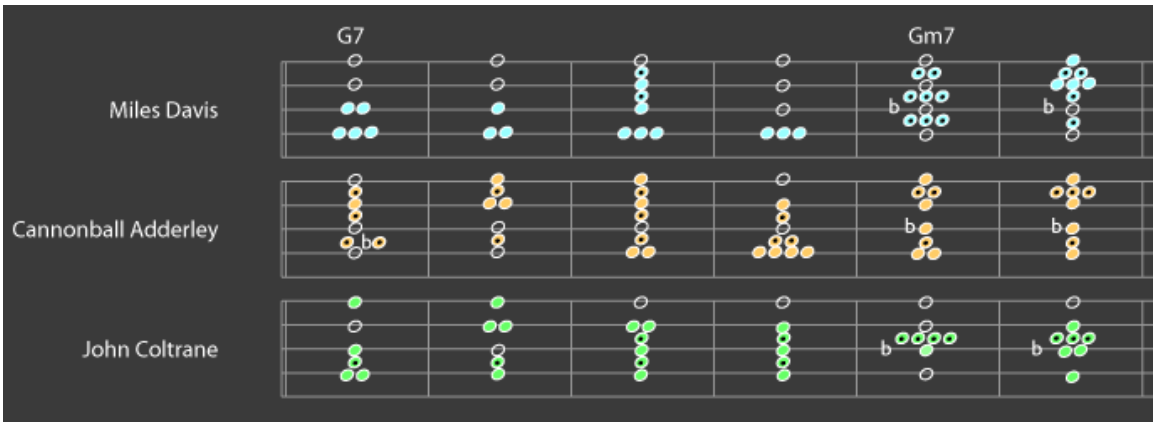

Figure 7: Harmonic palettes for Davis, Adderley and Coltrane for the first six measures. Miles' spare choice of notes and emphasis of the tonic (G) in the first 4 measures contrasts with Adderley's wide selection of notes (including an unusual A flat) and refusal to play the tonic until measures 3-4.

I used a straightforward technique to calculate the distribution of notes for each measure. First, I added up the duration (number of beats) that a given note was played in all four choruses of the first measure (i.e., the 1st, 13th, 25th and 37th measures). I did this for every note in all 12 measures and then repeated the whole process for all three solos, keeping the data separated by soloist. Next, I transposed the data into the key of C (the neutral concert key), because the tenor sax and trumpet were written in B flat and the alto sax was written in E flat.

All this information needed to be distilled into small bits that could be used by a jazz soloist. Also, note distributions needed to be proportional across all three soloists so that harmonic comparisons could be made more accurately. This was tricky because Davis tended to play fewer notes and held them for longer than Coltrane, who produced his trademark sheets of sound, or continuous streams of notes.

After much experimentation, I settled on a simple algorithm for graphing harmonic palettes that consists of three steps:

1. Find the measure with the highest duration spent on a single note (fifth bar of Coltrane's solo, 13 beats on C).
2. Calculate *N* by dividing that value (13) by five and rounding down (2).
3. For every note that was played for *N* beats (2) in each measure, graph 1 note head.

Thus, in this example 2 beats = 1 note head; 4 beats = 2 note heads; 6 beats = 3 note heads; and > 8 beats = 4 note heads. When the dataset is larger, *N* becomes a larger value so that the data is always reduced to an even, uncluttered distribution of note heads.

Each harmonic palette is built vertically up from the tonic (root) 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. 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, suggesting an implied 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 noteheads. Visualizing the absence of notes turned out to be just as informative as seeing the notes that were played.

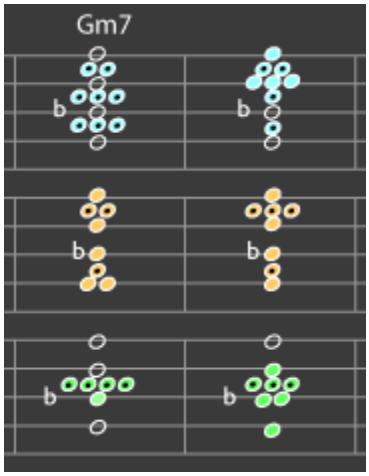

Figure 8: Harmonic palettes for the G minor chord (5th and 6th measures) for Davis (blue), Adderley (orange) and Coltrane (green). Hollow noteheads are major tones of the chord that were not voiced, filled noteheads are tones played, and filled noteheads with black dots are tones that were played but are not major tones of the chord.

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 little more sophisticated (Kahn, 142).

However, in Figure 8 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.

Aggregations

The same algorithm described above can be used to analyze all the notes a musician used in the course of a solo. Aggregate views for each soloist appear at the bottom right of ImproViz. The timescale has changed from 2BPN (beats per note head) to 10BPN to account for the increased duration (12 bars to 48).

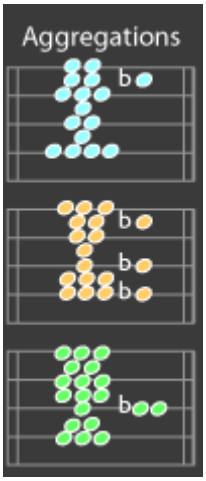

Figure 9: Aggregations (total note distributions) for Davis (blue), Adderley (orange) and Coltrane (green).

Aggregate views facilitate side-by-side comparisons of the overall harmonic choices of the soloists:

- Davis played E flats but never played a B flat
- Adderley played B flats, E flats and G flats.
- Coltrane played a lot of B flats but never played A flats

Composites

We can also create composite harmonic palettes of all three soloists. In the twelve bar view, the timescale is changed from 2BPN to 5BPN to accommodate the enlarged dataset.

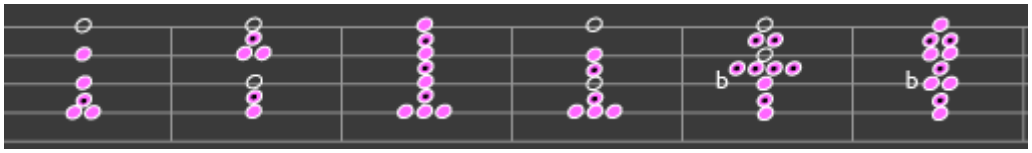

Figure 10: Composite harmonic palettes of all three soloists for first six measures.

Further composites could 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 Plans and Opportunities

ImproViz could be expanded into a working computer program for use by a jazz student. It could have the following features:

- view solo information for one or many soloists simultaneously

- consolidate two or more soloists
- beginner vs. 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 on the fly. This would allow students to see how successfully they are playing inside the chord changes of a tune, and would provide excellent feedback regarding their progress.

It would be interesting to explore other forms of jazz using ImproViz. What patterns could be seen in fast songs with a lot of complicated chord changes, like Charlie Parker playing *Donna Lee* or John Coltrane playing *Giant Steps*? Are there hidden melodic and harmonic patterns in the avant-garde solos of Ornette Coleman or Anthony Braxton?

SOURCES (all URLs accessed April 2004)

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