

Learning Jazz Grammars

Jonathan Gillick (Wesleyan University, Connecticut, USA)

Kevin Tang (Cornell University, New York, USA)

Robert Keller (Harvey Mudd College, California, USA)

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Jazz Learning Approaches

□ Traditional:

Transcribe, and learn to imitate, solos of great masters.

□ Impro-Visor:

Write your **own** solos, understanding the chord changes in the process.

Use part or none of what you wrote, as you please, in actual improvisation.

Background: Impro-Visor

- **Improvisation + Advisor**

- Educational software to help musicians:

 - teach themselves to improvise jazz over chord changes

- “Advice” includes suggestions for jazz licks:

 - From a user-modifiable database, **or**

 - From a “lick generator”.

Impro-Visor v.4 Lead-sheet Screen Shot

The screenshot displays the Impro-Visor v.4 software interface. The title bar reads "Impro-Visor: 12-Bar Blues". The menu bar includes "File", "Edit", "View", "Play", "Utilities", "Window", "Grammar: My", "Preferences", and "Help". The toolbar contains various icons for file operations and playback controls. The "Program Status" section includes a "Click in notes, or type in textual entry field" button. The playback controls show a "Playback Location" from 0:00 to 0:16, a "Looping" section with a "Loop" button and a value of 2, a "Mute" button, a "Volume" slider, a "Tempo (Beats per Minute)" of 180.0, "Transpos" set to 0, "Bars per Chorus" set to 12, "Tracker Delay" set to 0, and "Parallax" set to 0. A "Textual Entry" field is present with a "Clear" button. The main area shows a "Chorus 1" section titled "12-Bar Blues" with a "Style: swing" setting. The lead sheet is written in 4/4 time and consists of three staves. The first staff contains measures 1-4 with chords F13, Bb13, Bo7, F13, Cm9, and F13b9. The second staff contains measures 5-8 with chords Bb13, Bo7, F13, and D7#5#9. The third staff contains measures 9-12 with chords Gm9, C13b9, F13, D7#5#9, Gm9, and C13b9. A blue progress bar is visible at the bottom of the sheet.

Constructing a Lick Database

- ❑ Educational in its own right
- ❑ Laborious and time-consuming
- ❑ Difficult to achieve coverage of every situation (e.g. every possible pair of consecutive chords)
- ❑ That motivated the Lick Generator.

Lick Generator

Chord Sequence In

Gm9 | C13b9

Generate

Lick Out

Gm9 C13b9

The diagram shows a flow from the input chord sequence 'Gm9 | C13b9' through a 'Generate' box to a 'Lick Out' musical notation. The notation is on a single staff with a treble clef. The first measure is for Gm9 and the second for C13b9. The notes are: G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes); G4, A4, B4, C5 (quarter notes). The notes G4, A4, B4, C5 in the first measure are highlighted in green. The notes G4, A4, B4, C5 in the second measure are also highlighted in green. The notes G4, A4, B4, C5 in the second measure are marked with a flat symbol (b) in green. The notes G4, A4, B4, C5 in the second measure are marked with a flat symbol (b) in green. The notes G4, A4, B4, C5 in the second measure are marked with a flat symbol (b) in green.

Lick Generator (SMC 2007, Lefkada)

- Built on a **probabilistic context-free grammar**.

$V2 \rightarrow X2$ (prob 0.2)
 $V2 \rightarrow X8 X4 X8$ (prob 0.8)
 $V4 \rightarrow X4$ (prob 1)

- Some rules add arguments to control **filling beats**

$P(Y) \rightarrow V2 P(Y-2)$ (prob 0.5)
 $P(Y) \rightarrow V4 V4 P(Y-2)$ (prob 0.5)
 $P(0) \rightarrow ()$ (prob 1)

$P(N)$ is the **start symbol** if there are N beats to fill

- **User-modifiable**
(by a sophisticated user)

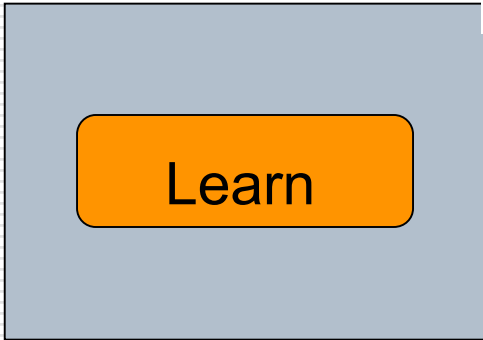
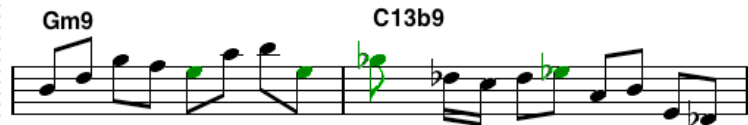
Constructing a Grammar

Difficulties Analogous to Constructing a Database

- Also educational in its own right
- Trial-and-error to get exactly the right style
- Motivates Grammar Learning

Grammar Generator

Performances
Transcriptions In



Grammar Out

- ...
- (rule (V2) (S8 S8 S8 S8) 0.3)
- (rule (V4) (H8/3 H8/3 A8/3) 0.01)
- (rule (V4) (H8/3 H8/3 H8/3) 0.05)
- (rule (V4) (H8/3 S8/3 H8/3) 0.02)
- (rule (V4) (N4) 0.22)
- (rule (V4) (V8 V8) 0.72)
- (rule (V8) (H16 A16) 0.01)

Vision

- Grammar generator would help construct a **repertoire** of selectable grammars
 - Different performance styles
 - Varying difficulties
 - Lick-trading patterns

Grammar Learning Problem

- Create, from a corpus of transcribed performances, a grammar that captures the stylistic elements represented in the corpus.

- How do we capture the style?
 - Note categories form abstract melodies
 - Contours, slopes give more micro-structure
 - Clustering reduces complexity
 - Markov chains give macro-structure

Note Categories

Over a given chord, each note in the chromatic scale has a pre-specified category, one of:

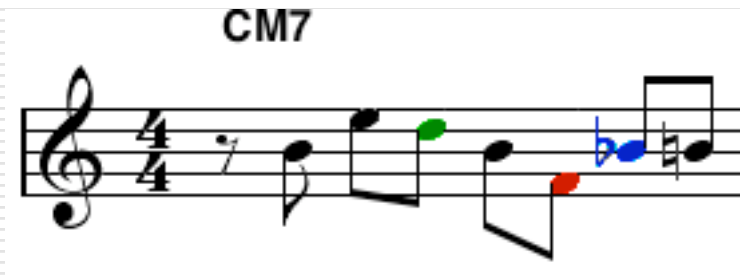
- Chord tone
- Color tone (not in chord, but sonorous with it)
- Approach tone (frequently used in jazz)
- Other (“outside”, in jazz parlance)

Color-Coding Note Categories

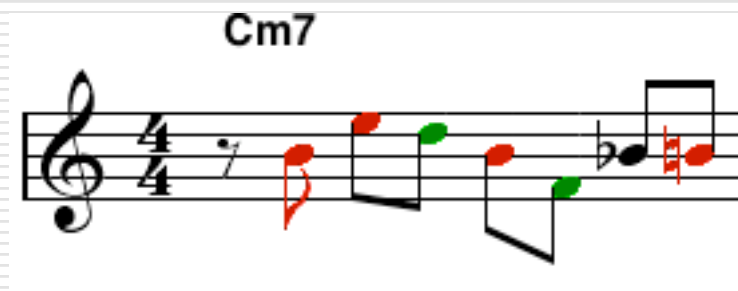
- Chord tone: Black
- Color tone: Green
- Approach tone: Blue
- Other: Red

Coloration Examples

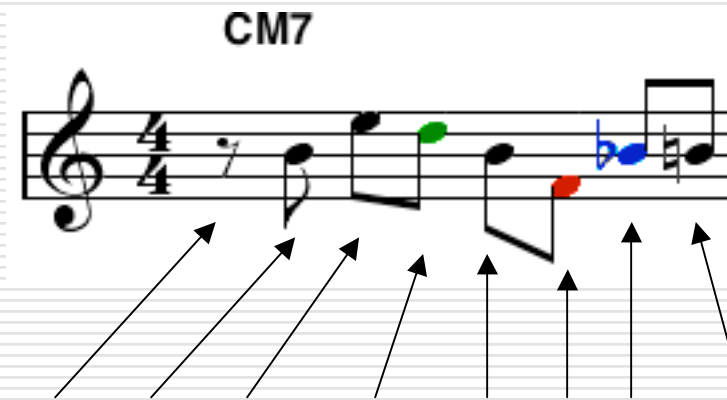
C Major 7th chord



C minor 7th chord



Textual Representation of Melody

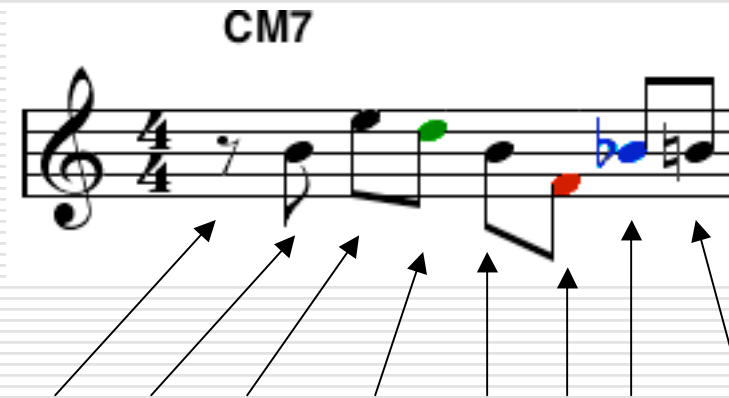


Concrete melody: r8 b8 e+8 d+8 b8 f8 bb8 b8

Textual Representation of Note Categories

- Chord tone: Black C
- Color tone: Green L
- Approach tone: Blue A
- Other: Red
- Scale: S
- Arbitrary: X
- Abbreviation: H = C or L
- R = rest

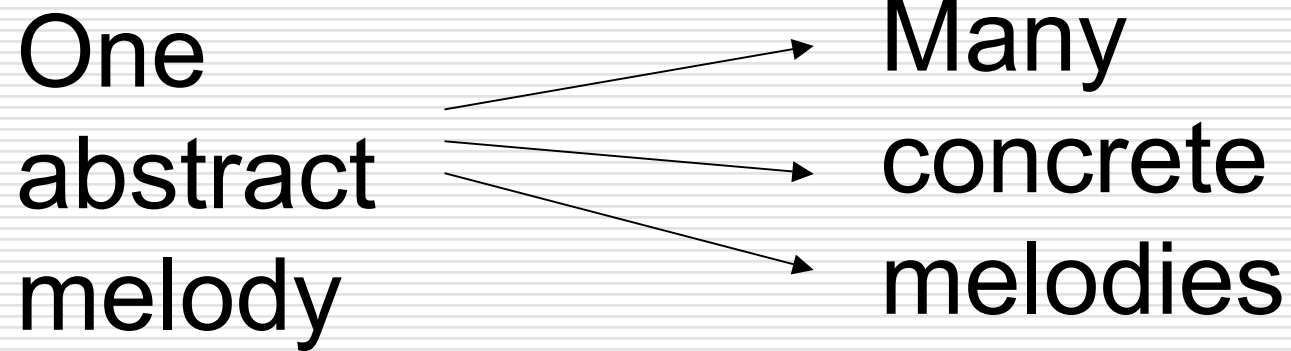
Textual Representation of Abstract Melody



Concrete melody: r8 b8 e+8 d+8 b8 f8 bb8 b8

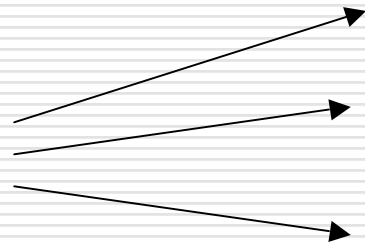
Abstract melody: R8 L8 C8 L8 C8 S8 A8 C8

Many-Many Relations



Many-Many Relations

One
concrete
melody

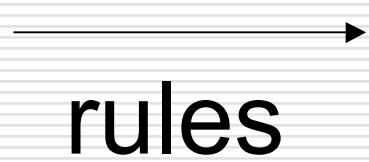


Many
abstract
melodies

But this direction can be
turned into a **function**
using a few procedural rules.

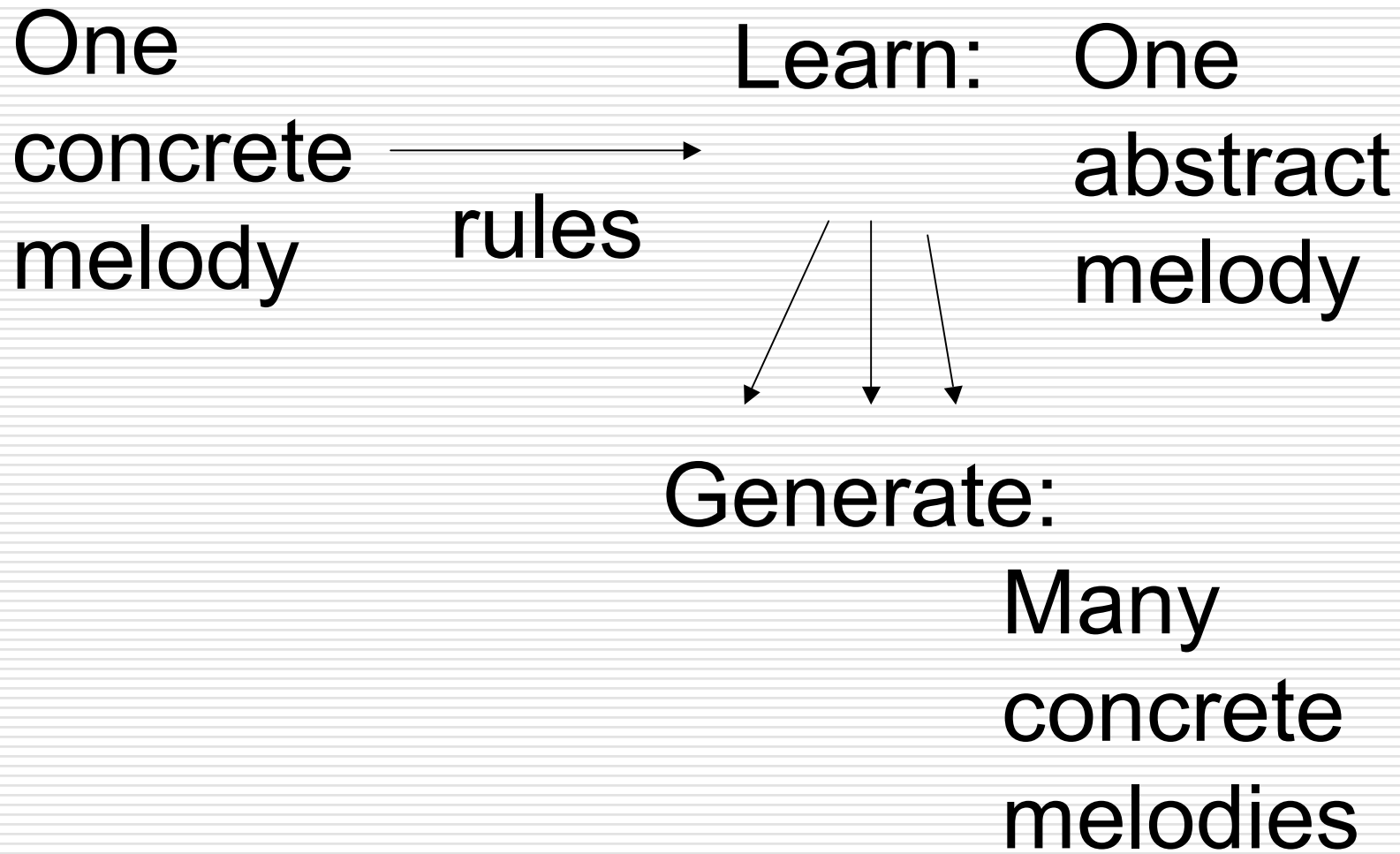
Many-Many Relations

One
concrete
melody



One
abstract
melody

Our Generation Principle



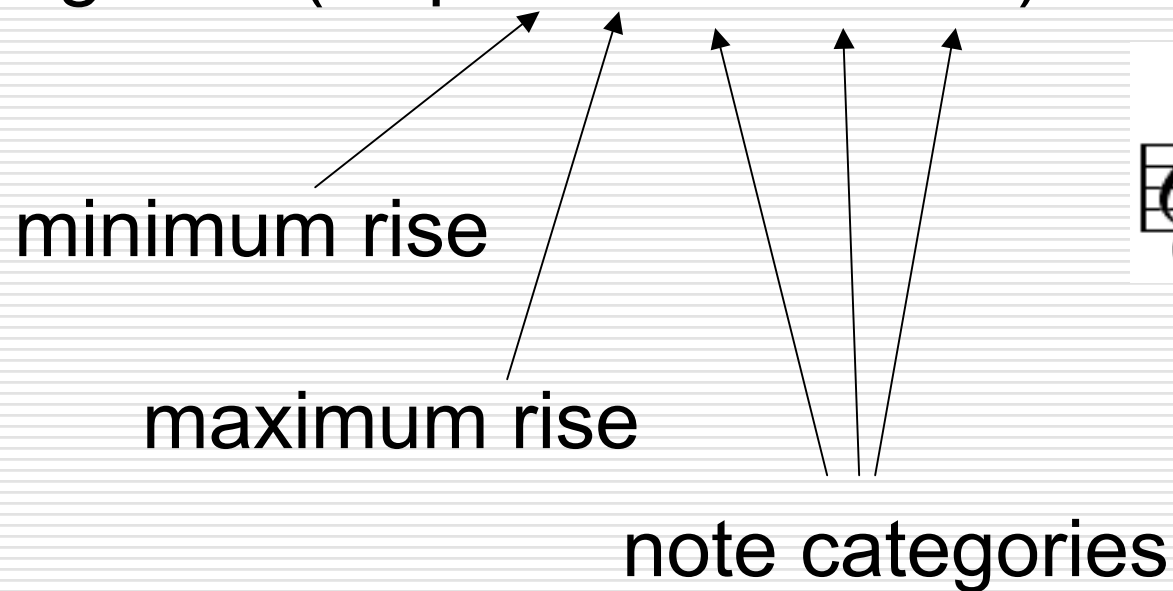
First Challenge

- Abstract melodies, as permitted so far, are too liberal in their generation.
- They cannot capture melodic **contour**.

Solution to First Challenge

□ Add new units to represent slope & contour

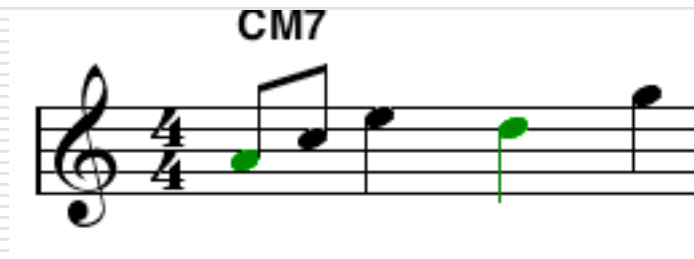
□ e.g. unit (slope 1 5 S8 S8 C4)



Solution to First Challenge, cont'd

□ Chained slopes = **Contours**

(slope 1 5 S8 S8 C4)(slope -2 -4 L4)(slope 5 5 C4)



[Some touching up may be done if the constraints of the contour can't be met exactly.]

Second Challenge

- ❑ Retaining too many abstract melodies in the grammar is apt to slow things down.

Solution to the Second Challenge

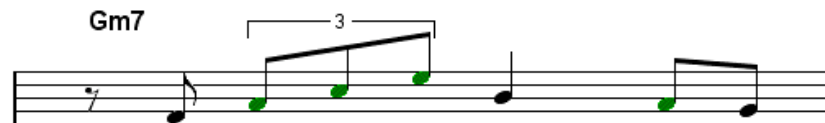
- **Cluster** the abstract melodies and select a few representatives of each cluster.
- This entails creating a distance metric between abstract melodies, which we have done.
- So far, only k-means clustering has been used.

Parameters Used in Metric

- number of notes
- total duration of rests
- average maximum slope
- phrase starts on or off the beat
- order of the contour (number of direction changes)

Cluster Examples

Three representatives from the same cluster:



Third Challenge

- ❑ Concatenating abstract melodies arbitrarily does not provide for a convincing style emulation.

Solution to the Third Challenge

- ❑ Infer transition probabilities for **Markov chains** between clusters.
- ❑ States of Markov Chain are non-terminals in the grammar.
- ❑ Incorporate the probabilities into the grammar rules, which are already probabilistic.

Markov Imitation Example

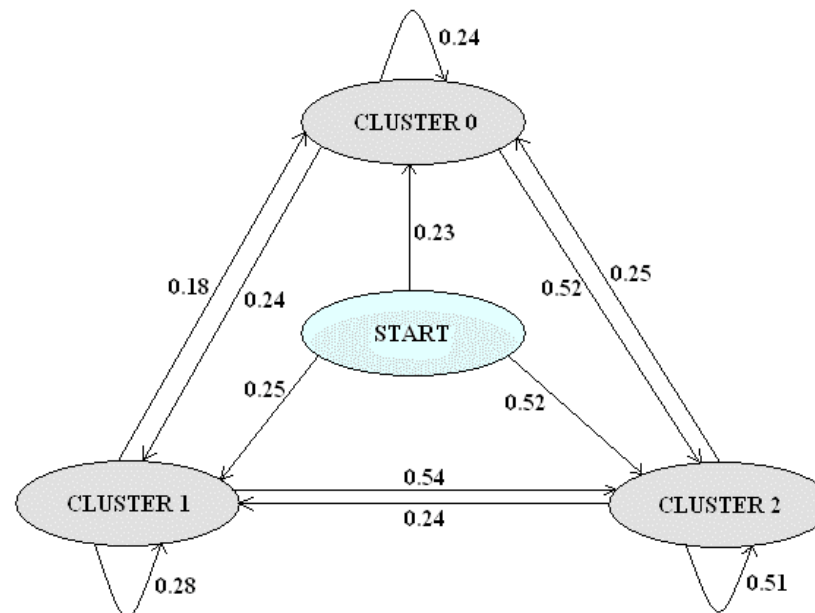
Original two-measure melody

and two measures of imitation with a Markov model:

The image displays two musical staves. The top staff, labeled 'F7', shows the original two-measure melody. The first measure contains a quarter note G4, a quarter note A4, and a quarter note B4. The second measure contains a quarter note C5, a quarter note B4, and a quarter note A4. A triplet bracket is placed over the first three notes of the second measure (C5, B4, A4). The bottom staff, also labeled 'F7', shows two measures of imitation. The first measure contains a quarter note G4, a quarter note A4, and a quarter note B4. The second measure contains a quarter note C5, a quarter note B4, and a quarter note A4. A triplet bracket is placed over the first three notes of the second measure (C5, B4, A4). The notes in the imitation are colored: green for the original notes (G4, A4, B4, C5, B4, A4) and blue for the imitated notes (G4, A4, B4, C5, B4, A4). A red note (C5) is also present in the imitation, indicating a deviation from the original melody.

Markov Models

Markov model diagram for grammar rules (next slide):



Example of Inferred Markov Grammar Rules

Inferred from a corpus of Charlie Parker solos:

- ❑ (rule (START Z) ((Cluster0 Z)) 0.23)
- ❑ (rule (START Z) ((Cluster1 Z)) 0.25)
- ❑ (rule (START Z) ((Cluster2 Z)) 0.52)
- ❑ (base (Cluster0 0) () 1)
- ❑ (base (Cluster1 0) () 1)
- ❑ (base (Cluster2 0) () 1)
- ❑ (rule (Cluster0 Z) (Q0 (Cluster2 (- Z 1))) 52.00)
- ❑ (rule (Cluster0 Z) (Q0 (Cluster1 (- Z 1))) 24.00)
- ❑ (rule (Cluster0 Z) (Q0 (Cluster0 (- Z 1))) 24.00)
- ❑ (rule (Cluster1 Z) (Q1 (Cluster2 (- Z 1))) 54.04)
- ❑ (rule (Cluster1 Z) (Q1 (Cluster1 (- Z 1))) 27.95)
- ❑ (rule (Cluster1 Z) (Q1 (Cluster0 (- Z 1))) 18.01)
- ❑ (rule (Cluster2 Z) (Q2 (Cluster2 (- Z 1))) 50.75)
- ❑ (rule (Cluster2 Z) (Q2 (Cluster0 (- Z 1))) 25.53)
- ❑ (rule (Cluster2 Z) (Q2 (Cluster1 (- Z 1))) 23.72)

Generated Solo Example

Chorus 1
Impro-Visor
Style: swing

Now's The Time
Charlie Parker

The musical score is written in 4/4 time and consists of 12 measures. The key signature has one flat (Bb). The chords and melodic lines are as follows:

- Measure 1: Chord F7. Melody: G4, A4, Bb4, A4, G4, F4, E4, D4.
- Measure 2: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 3: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 4: Chord F7. Melody: F4, G4, A4, Bb4, A4, G4, F4, E4.
- Measure 5: Chord Cm7. Melody: C4, D4, E4, F4, G4, A4, Bb4, A4.
- Measure 6: Chord F7. Melody: F4, G4, A4, Bb4, A4, G4, F4, E4.
- Measure 7: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 8: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 9: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 10: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 11: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.
- Measure 12: Chord Bb7. Melody: Bb4, A4, G4, F4, E4, D4, C4, Bb3.

Chords: F7, Bb7, Bb7, F7, Cm7, F7, Bb7, Bb7, Bb7, Bb7, Bb7, Bb7.

Assessment Experiment

Using our methodology, we inferred grammars from Clifford Brown, Freddie Hubbard, Miles Davis.

Generated solos from each grammar on a different song

Asked users to identify which solo belongs to which artist, how closely they resembled the style of the original

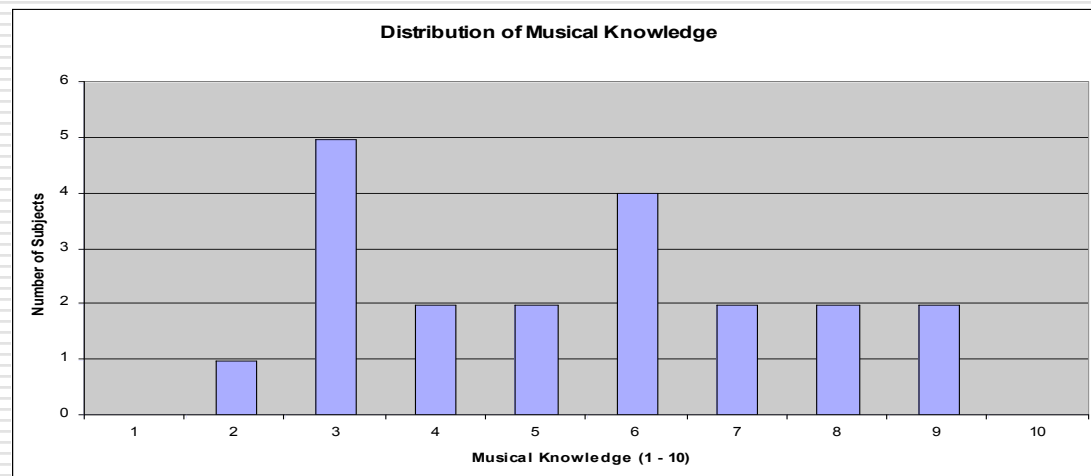
Used same midi instruments, same song that was generated on, and hidden artist names as control elements

Results

85% correct for matching all three generated solos to artists

Almost all subjects selected either “somewhat close” or “quite close” for resemblance between solo and original

Good diversity in musical knowledge of subject sample space



Impro-Visor v.4 Grammar Learning Tool

Grammar Learning

Please follow these steps to learn a new grammar from a corpus of solos as a folder of leadsheets. Click the rectangular buttons from top to bottom.

Step 1: Load the grammar on which you wish to build, such as Bare.grammar.
If you do nothing, it will build on whatever grammar is current.

Step 2: IMPORTANT: Use **Save as ...** in the Grammar menu to save your new grammar under a new name, in case you want to return to the old grammar.
Also save your leadsheet if you need it, as the leadsheet window will be used as a workspace.

Step 3: (Optional) Set the parameters below:

Window Size (beats)

Number of Representatives per Cluster

Window Slide (beats)

Use Markov (ordered connection of phrases) Chain length:

Step 4: Clear the accumulation, unless you want to accumulate from several corpuses into the same grammar.

Step 5: Select a corpus of solos from which to learn. Each solo is a leadsheet file.
Selecting any file any a folder is equivalent to selecting the entire folder.
The leadsheet you selected will be left in the window at the end. The process is over when the last chorus appears.

Step 6: Click the Add Accumulation button to create and save the grammar and Soloist file.

You can try your grammar at generation immediately without further loading, on the current or any other leadsheet, however it will not appear in the main window until you restart the program.

Step 7: Try Generating a Solo with Your Grammar

Conclusions

- Devised a method of grammatical inference for jazz solo generation

- Key Ideas
 - Abstract musical representation
 - Extraction windows
 - Clustering/Markov Models

- Successful implementation of grammatical inference and solo generation for a variety of artists

For Further Information

- ❑ www.impro-visor.com
(don't forget the hyphen)
- ❑ or Google impro-visor
- ❑ launch.groups.yahoo.com/group/impro-visor/
to download our software (free!)