# Analysis of Jazz Chord Sequences with Combinatory Categorial Grammar

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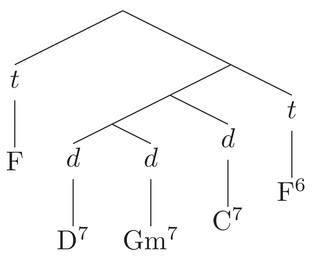
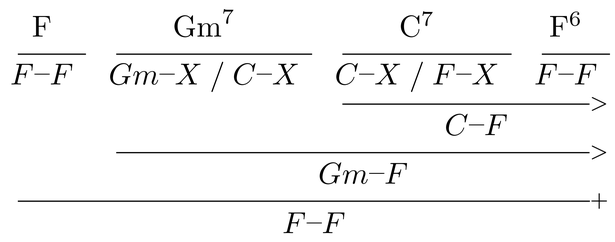



## Overview

Music is structured in various ways. Hierarchical structure can be found in meter and in harmony. This is similar to the hierarchical structure of syntax in language.

As with language, it is necessary to be able to process the syntactic structure of music in order to understand it. Recognising the structure is important for many music processing tasks.

We apply techniques from natural language processing to the problem of processing musical harmony. We use a combinatory categorial grammar (CCG) of jazz chord sequences to analyse harmonic structure. We are currently investigating statistical parsing techniques adapted from language processing to perform automatic musical analysis of jazz standards.




## Music's relationship to language

Music is often described by informal analogy to language. It exhibits structure in various aspects. The hierarchical structure found in harmony is similar to syntactic structure in language.

Harmony is analysed in terms of chords underlying the notes of a piece of music. The structural interpretation of the chords determines their relationship to each other and explains a listener's expectations.

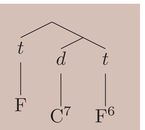
Recent evidence (e.g. Fedorenko et al. (2009), Patel (2003)) suggests the use of shared cognitive resources for the structural processing of language and music. We attempt to use techniques adapted from natural language processing to perform structural interpretation of music.

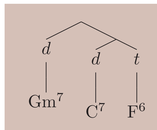
## Harmonic analysis

**Harmonic analysis** involves inferring the **structure underlying the harmony** given the notes of a piece of music. It is analogous to parsing the **syntax** of a sentence. Given a surface form of musical notes, the harmonic structure is highly ambiguous.

Analysing **chord sequences** is easier: the music has been divided into chunks and the important notes have been selected. However, much ambiguity remains and analysis is still difficult. For now we stick to handling chord sequences.

Chords are classified as having a **function**, which may be **dominant**, **tonic** or **subdominant**. A dominant chord creates a tension, leaving the listener expecting its **resolution** – a tonic chord rooted 7 semitones below. This dominant-tonic tension-resolution pattern is the basic building block of harmonic structure.



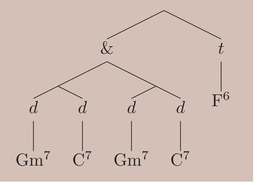




The dominant chord can be **recursive**: the resolution itself can function as a dominant and itself resolve again.

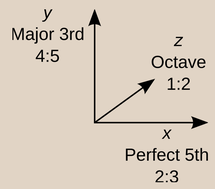
It can be **coordinated**: two consecutive dominant chords (or sequences of dominants) can share the same resolution, which follows the second one.

It can be **substituted**: one dominant can be replaced by a chord on a different root, which plays the same role, in certain contexts.

A **subdominant** chord behaves in a similar way, but with a different resolution.




## Musical semantics




The Western tonal system of pitches we use in our music is based on relations between the low components of the **harmonic series**. All intervals between notes are defined by ratios of small primes. Theoreticians such as Rameau (1722) and Helmholtz (1885) described relations between the notes of the tonal system in terms of the first three distinct intervals in the harmonic series. Longuet-Higgins (1979) formalised this in a **three-dimensional infinite discrete space** of pitches.

Since it is common to ignore octaves in harmony theory, we project this onto a **two-dimensional space**. A portion is shown here, using conventional note names and, for remote intervals, the note to which the pitch is closest, distinguished by $^+$ and $^-$.

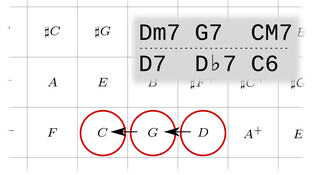



Today music is typically played in **equal temperament**, a tuning system which distorts the intervals to produce 12 semitones spaced equally over an octave. The basic intervals of the tonal space still underlie our perception of music.

We treat the true relations between notes and chords as seen in the tonal space as the **'semantics' of the music**.

- *Syntax → harmonic structure*
- *Semantics → tonal space interpretation*

**Two chord sequences that share the same semantics.**
The semantics is represented as the path through the tonal space followed by the chords' true roots.




## Musical grammar

We use **combinatory categorial grammar (CCG)** to model the syntactic structure of harmony. We use a modification of the standard CCG notation for language to express the harmonic syntax.

D7 Gm7 C7 F
D–F

**Atomic categories** reflect the tonality of the span of music. They consist of the (equal temperament) keys in which it starts and ends (*see left*). **Complex categories** are built with slashes, as usual with CCG. For example: *Dm–F* / *Am–F*.

The simplest category: the **tonic chord** (*right*).
It starts and ends in the same key – the key of the chord root.

F
F–F

A **dominant chord** (*right*)
receives a forward-facing slash category, representing the **expectation of its resolution** to the following chord.

C7
C–X / F–X

Note that only the starting key of the argument is specified, since the following span could resolve as expected and continue to any other key.

By adding a **semantics** to the lexical items representing **points and movements** in the tonal space, we can build a full interpretation of the chords as a path through the space.

## Current work: modelling

As with natural language grammars, **lexical ambiguity** makes full parsing infeasible. We are currently applying **supervised statistical parsing** techniques adapted from NLP.

We have constructed a small annotated corpus of jazz standards chord sequences on which we can train models. Two approaches we are currently investigating are the **PCFG-like generative models** of Hockenmaier (2001) and the **suppertagging model** of Clark (2002).

## References

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