

# **Automatic Harmonic Analysis of Melodies**

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## **Abstract**



# Chapter 1

## Introduction

The BLAH aim of this project is to learn a model that can map a musical melodic sequence to to harmonic sequence. More specifically this model takes a temporal, monophonic sequence of notes and predicts the corresponding sequence of chords. These chords correspond to the harmonic accompaniment intended by the composer to be played along with the piece.

The primary assumption of this project is that it is useful to treat the melody as an observed sequence generated by the underlying chord sequence. In this sense we have a noisy channel model, similar to a natural language processing problem, where the note sequence can be likened to a sequence of words in a sentence and the chord sequence corresponds to the underlying meaning represented in these notes.

To this we can add the Markov Assumption. Specifically that the notes generated by a chord at time  $t_i$  are conditionally independent of the notes generated by chords at all other times  $t_j, i \neq j$ , given the chord at  $t_i$ .

$$P(c_t | n_t) \tag{1.1}$$

This divides the problem into two distinct parts.

The first is modelling the generative process from chord to sequence of notes, here called the Emission Model. This model is very dependent on the frame of notes considered to be generated by a chord. This project works with two possible variants, either the Emission Model generates all the notes observed in the time frame associated with a certain chord, or we consider each note on it's own as independently being generated by a single chord instance and ignore the concept of frames. In the second case there will be a one-to-one correspondence between the chord sequence and the note sequence, and hence the former will consist of many repeated sections of chords.

### DIAGRAM

The second model we must consider is the transitions between the chords, here on the Transition Model. Each chord can be thought of as a state, and hence every transition a movement between two states. Under a first order Markov Assumption, where we

assume that the current state is only dependant on the previous one, then the transition model becomes a bigram model between chords, and the combined system becomes a Hidden Markov Model. Other possible transition models will be the focus of the remainder of this project.

The data required for this project is symbolic melodic sequences annotated the accompanying chord. Hence this is not a system that is built to model raw sound data, neither is it an unsupervised model that can develop a notion of chords from unlabelled data. In the first year of this project data was used from the Weimar Jazz Database. This data consists of transcribed solos from jazz musicians over jazz standards. The data is heavily annotated and comes with chord labels drawn from the standards. However solos are a special subset of melodies with huge room for seemingly random improvisation and other forms of noise. This makes the problem significantly harder and hence one of the aims of this year was to make a

# **Chapter 2**

## **Year 1**

The focus in the first year of this project was on finding the best Emission Model to use. Three methods were developed, a 'Bag of Notes' model, a 'Chord Tone' model and a 'Concatenative HMM'. They were all combined with a simple bigram transition model and trained using the Viterbi algorithm.

The results of the first year of this project did not show a substantial improvement over