Learning to analyse tonal music

Plácido R. Illescas PLACIDOROMAN@GMAIL.COM
David Rizo DRIZO@DLSI.UA.ES
José Manuel Iñesta INESTA@DLSI.UA.ES
Departamento de Lenguajes y Sistemas Informticos, Universidad de Alicante, Spain

Keywords: harmony, tonal analysis, genetic algorithms

Abstract

This work is an effort towards the development of a system for the automation of traditional tonal analysis of polyphonic scores in symbolic format. The system detects chords with their tonal functions, and key changes. All the possible tonal and key analyses are represented as a weighted directed acyclic graph. The best analysis is the path that maximizes, through a dynamic programming algorithm, the sum of weights in the graph. The selection of the weights according to the importance of each possible harmonic progression is a key issue. A genetic algorithm is proposed to learn them from a training corpus of a given music style. The proof of concept of this approach has been tested on Bach chorales.

1. Introduction

Musical analysis is a means to better understand the thought of the composer when creating a piece. A musician must perform a good musical analysis to execute a correct interpretation of a work. The melodic, harmonic, and tonal function analyses are the basic elements in order to achieve an optimal musical analysis. Besides, there are many applications of automatic analysis to diverse areas of music: education, score reduction, pitch spelling, harmonic comparison of works, etc.

The automatic tonal analysis has been tackled under different approaches and objectives. Some works use grammars to solve the problem (Winograd, 1992), or probabilistic models like that in (Raphael & Stoddard, 2004) and others based on preference rules or scoring techniques (Temperley & Sleator, 1999). The *music theory workbenck* (MTW) system (Taube, 1999) solves the problem by means of model matching. A more comprehensive review of these works can be found in (Barthelemy, 2001). To the best of our knowledge, there is no work nowadays that learns from a training corpus.

Our objective is not only to obtain a high percentage of correct analyses, but also to describe in a human-readable way the reasons why the system has chosen an analysis.

2. Methodology

In order to analyze a musical piece the system segments each bar into a number of time windows, all possible chords are obtained from the notes in each. After this, the valid keys for each window are selected, given the accidentals of the notes involved. From these data, a weighted acyclic directed graph (wDAG) organized by layers is built. Each layer represents a window. The nodes of the graph correspond to chords with tonal functions in a tonality. The edges of the graph represent the valid progressions between the nodes in successive layers, weighted according to the importance of those progressions in order to establish a tonality.

Once the graph is built, a dynamic-programming approach is utilized to compute the best path along the graph, discovering the best tonality and tonal function sequence. The output is the Roman numeral analysis with tonality segmentation.

The main problem here is how to establish the values for those weights, because the performance of the system is very sensitive to them. Moreover, these values may be conditioned by the music genre. For example, valid progressions for jazz music were prohibited

Preliminary work. Under review by the International Conference on Machine Learning (ICML). Do not distribute.

in Baroque. Therefore, a method able to adjust the weight values from a training set of a given target musical genre is desirable.

Our proposal is to use a genetic algorithm to do this task. The chromosome encodes the set of weights to be optimized. Each gene represents a weight. The range values valid for each weight are based on those used in (Illescas et al., 2007).

The fitness function evaluates their suitability for a correct analysis. A set of Bach chorales have been analyzed by an expert. The algorithm tries to minimize the number of errors made by the analysis system when compared with the expert's in a window frame basis. This fitness function has proven to render parameter values close to those that would be empirical set by an expert for analyzing Bach chorales.

The system has been implemented using the JGAP [1] package using the default configuration.

3. Experiments

To test the system, transcriptions in MusicXML format of the harmonized chorals from J.S.Bach (BWV-253, 26, 437, 29, 272, and 438) have been used. The manually tagged corpus can be downloaded from our website quoted below. (http://grfia.dlsi.ua.es/cm).

Table 1. Compared tonality (T.) and tonal function (T.F.) success rates for the system using fixed weights and the system with weights learnt by the genetic algorithm

	Without GA		With GA	
	T.F.	T.	T.F.	T.
BWV-26	80	64	86	55
BWV-272	61	21	65	43
BWV-29	79	50	64	50
BWV-253	79	15	73	31
BWV-437	71	56	72	74
BWV-438	72	71	55	43

A leave-one-out scheme has been used to learn the weights to be used for testing the system. The results in Table 1 show the genetic algorithm approach outperforms the system using weights established by a human expert. To understand the figures, whenever the system gives the tonal function correctly but not the tonality, it is failing in the tonality mode. The mode of the chord is not currently included in the weights that are learnt.

[1] http://jgap.sourceforge.net/

Since two different analyses sometimes can be both valid we cannot give success percentages in order to compare to those reported by MTW. For our point of view, the MTW fails in some tonal function progressions and seems to make mistakes when analyzing alternative tonalities by not solving the chord cadence (e.g. BWV 2-6 at bar 3, beats 2-4). Our system corrects those errors by means of the cadence scoring. However, we must correct some errors the MTW does not make.

4. Discussion and conclusions

This paper presents a system to analyze automatically a score from the melodic and harmonic points of view, providing the tonality changes and the Roman numeral analysis of each chord along with its tonal function.

The system performs comparably to MTW, but it has the advantage to be ready to work with monodic melodies only adding more possibilities of analysis at each layer of the graph.

The use of the learning system avoids the arbitrariness or subjectivity of a set of values given by a human expert and, in addition, it permits the system to fit its performance to different music genres.

Acknowedgements

This work is supported by the Spanish PROSEMUS project (TIN2006-14932-C02) an the research programme Consolider Ingenio 2010 (MIPRCV, CSD2007-00018).

References

Barthelemy, J. (2001). Figured bass and tonality recognition. *ISMIR*.

Illescas, P. R., Rizo, D., & Iñesta, J. M. (2007). Harmonic, melodic, and functional automatic analysis. *Proceedings of the 2007 International Computer Music Conference* (pp. 165–168).

Raphael, C., & Stoddard, J. (2004). Functional harmonic analysis using probabilistic models. *Comput. Music J.*, *28*, 45–52.

Taube, H. (1999). Automatic tonal analysis: Toward the implementation of a music theory workbench. *Comput. Music J.*, *23*, 18–32.

Temperley, D., & Sleator, D. (1999). Modeling meter and harmony: A preference-rule approach. *Comput. Music J.*, *23*, 10–27.

Winograd, T. (1992). *Linguistics and the computer analysis of tonal harmony.* Cambridge, MA, USA: MIT Press.