Dataset Creation and Automatic Harmonic Analysis of Joseph Haydn's Op.20

Néstor Nápoles López

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McGill University

Introduction

- Work in the context of the CompMusic Project, at Universitat Pompeu Fabra
    - http://compmusic.upf.edu/
- Coordinated by Dr. Xavier Serra
- Supervision of harmonic analysis by Rafael Caro Repetto

Harmonic Analysis

Harmony

The simultaneous sounding of notes

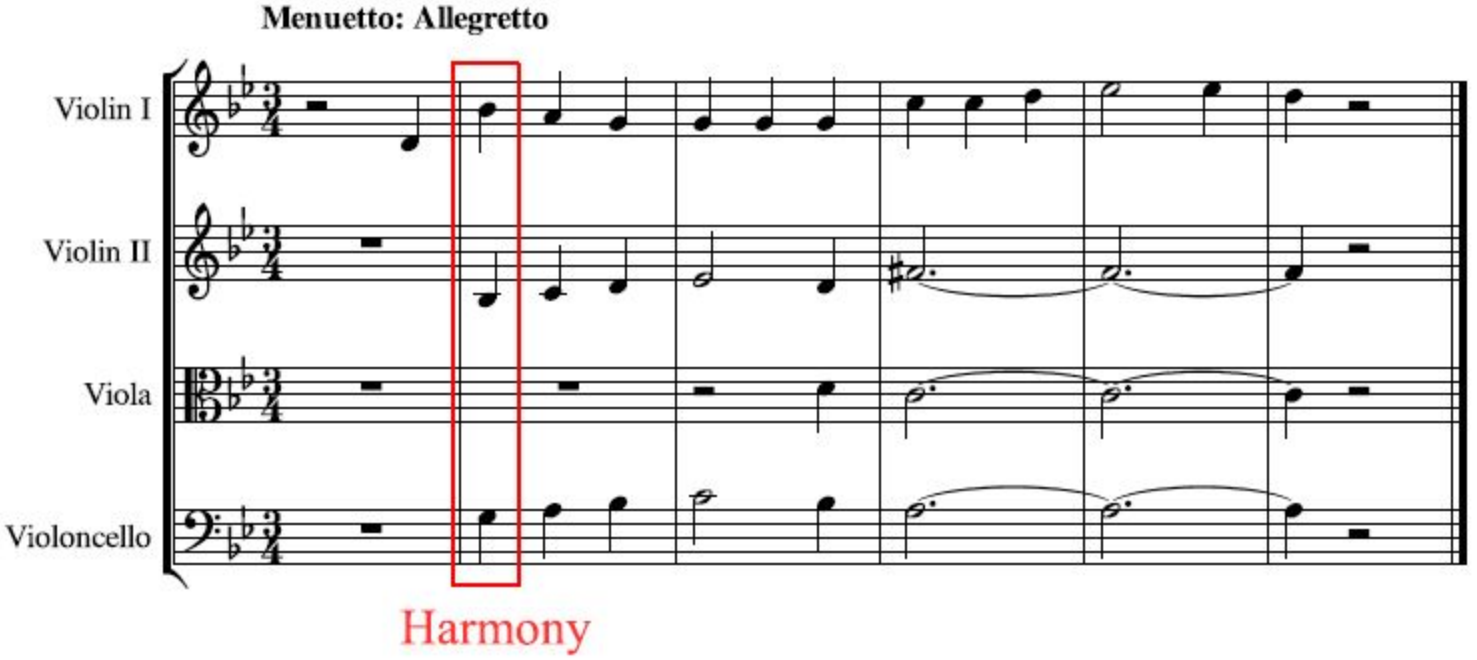


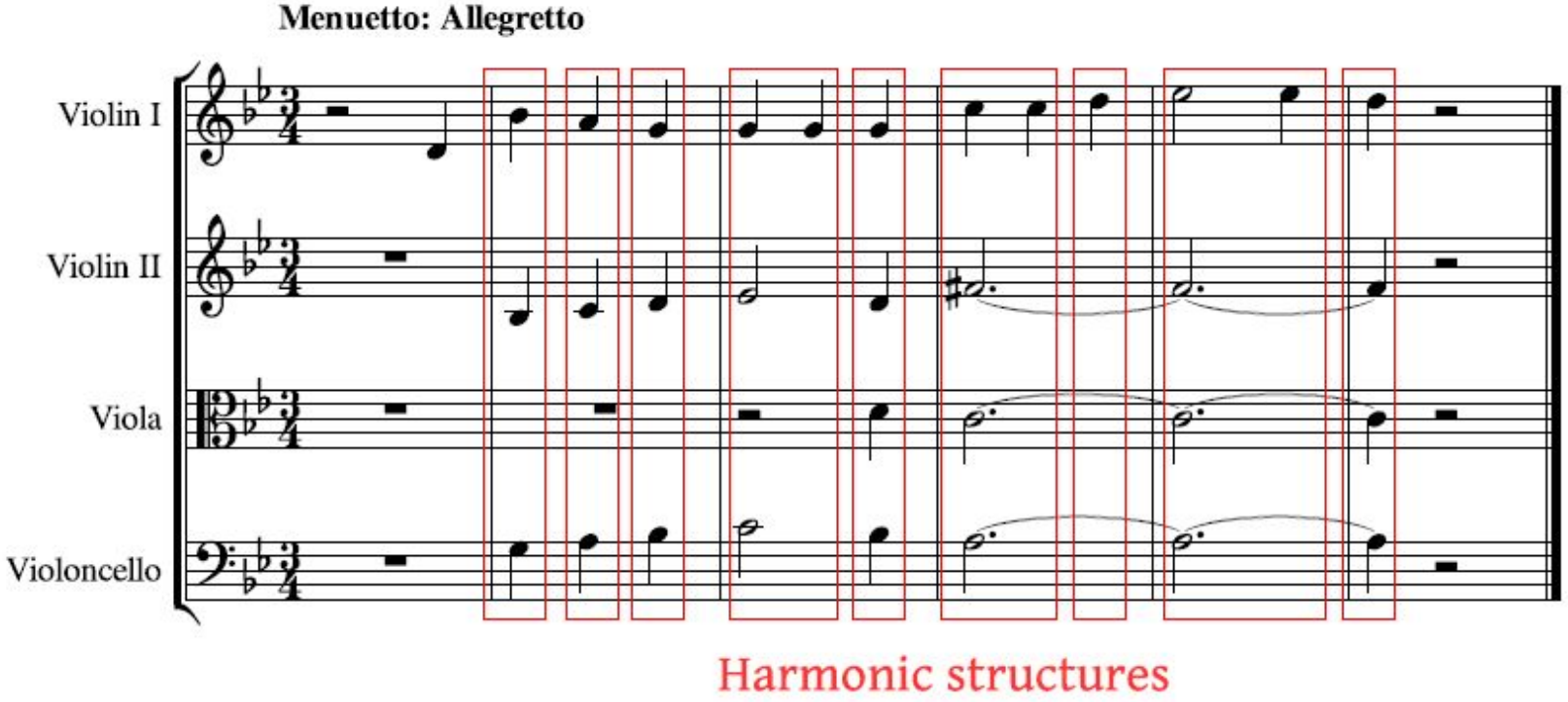
Figure 1: Excerpt from Joseph Haydn's Op.20 No.3 - II. Menuetto: Allegretto, mm. 1-6

Source: Nápoles (2017)

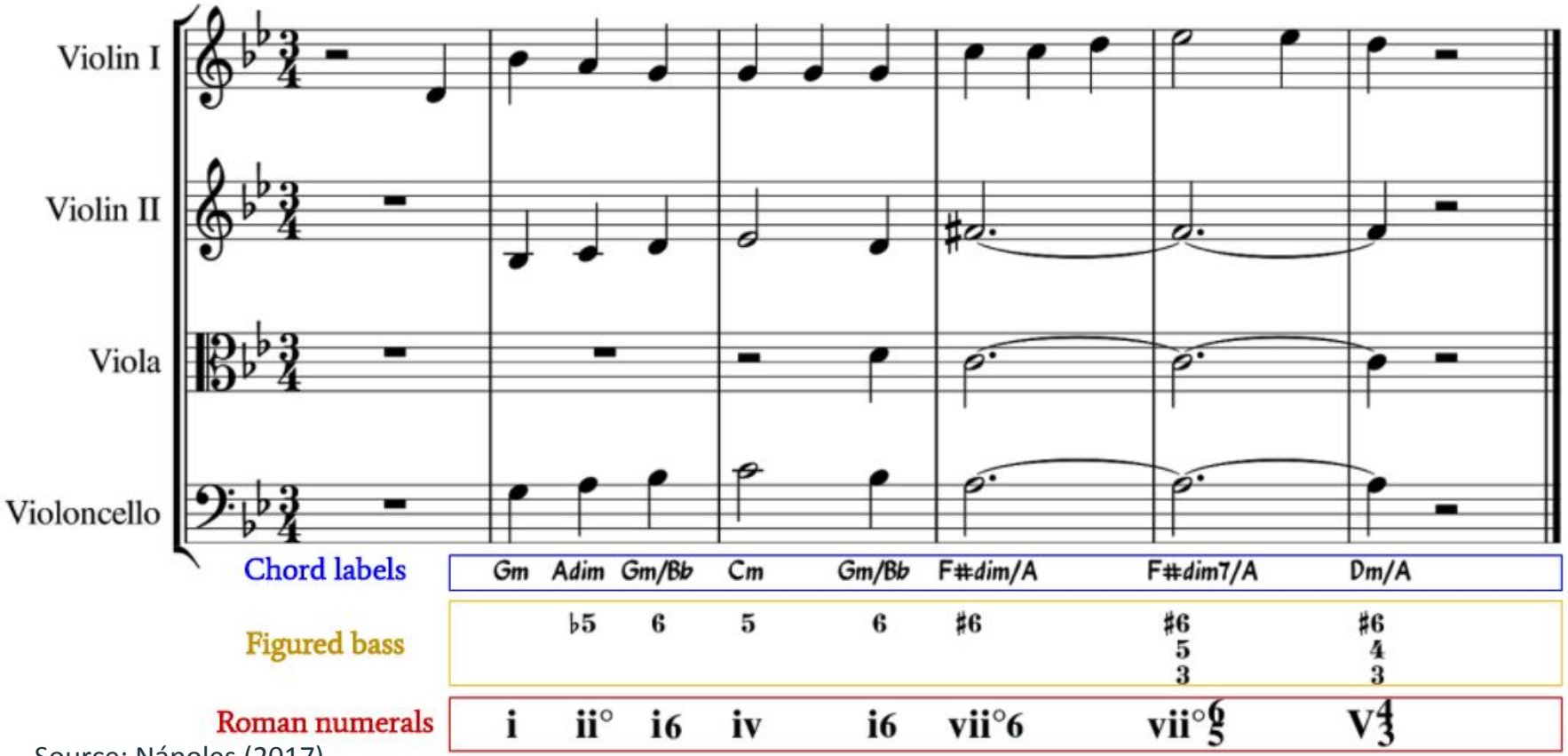
Harmonic Analysis

Harmonic Analysis

The interpretation of harmonic structures in music, their resolution into relatively simpler constituent elements (e.g., chord labels), and the investigation of the relevant functions between those elements



Source: Nápoles (2017)



Source: Nápoles (2017)

Harmonic Analysis

Which simpler elements?

- Chord labels
- Figured bass
- Roman numerals (functional harmonic analysis)

Harmonic Analysis

Which simpler elements?

- Chord labels
- Figured bass
- Roman numerals (functional harmonic analysis)

Creating the Dataset

Creating the Dataset

About the six string quartets, Op.20

Joseph Haydn wrote 68 string quartets in total

Chronologically, Op.20 corresponds to numbers 23-28

They were composed when Haydn was 40 years old

As a reference, Beethoven and Mozart composed 16 and 23 string quartets, respectively

Number	Movement	Tempo
Op.20 No.1		
1	I	Allegro Moderato
2	II	Minuetto. Allegretto
3	III	Affettuoso e sostenuto
4	IV	Finale. Presto
Op.20 No.2		
5	I	Moderato
6	II	Adagio
7	III	Minuetto. Allegretto
8	IV	Fuga a 4 Soggetti
Op.20 No.3		
9	I	Allegro con Spirito
10	II	Minuetto. Allegretto
11	III	Poco Adagio
12	IV	Finale. Allegro Molto
Op.20 No.4		
13	I	Allegro di Molto
14	II	Un poco Adagio Affettuoso
15	III	Allegretto alla zingarese
16	IV	Presto scherzando
Op.20 No.5		
17	I	Allegro moderato
18	II	Minuetto
19	III	Adagio
20	IV	Finale: Fuga a due Soggetti
Op.20 No.6		
21	I	Allegro di Molto e Scherzando
22	II	Adagio, Cantabile
23	III	Minuetto. Allegretto
24	IV	Fuga a 3 Soggetti. Allegro

Number	Movement	Tempo
Op.20 No.1		
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3	III	Affettuoso e sostenuto
4	IV	Finale. Presto
Op.20 No.2		
5	I	Moderato
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Op.20 No.3		
9	I	Allegro con Spirito
10	II	Minuetto. Allegretto
11	III	Poco Adagio
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24	IV	Fuga a 3 Soggetti. Allegro

Creating the Dataset

- Find/Encode the 24 scores into a symbolic music representation
- Annotate the harmonic analysis of all of them using a consistent and “parsable” nomenclature
- Present the output of a known automatic harmonic analysis algorithm using the same nomenclature as the manual annotations
- Compare the automatic annotations to our dataset of manual annotations

Creating the Dataset

- Find/Encode the 24 scores into a symbolic music representation

Creating the Dataset

KernScores

http://kern.ccarh.org/

A library of virtual musical scores in the Humdrum **kern data format

Already contains **19 out of 24** scores from Op.20 in Humdrum (**kern) format

Missing movement
Op.20 No.1 - III. Affettuoso e sostenuto
Op.20 No.2 - II. Adagio
Op.20 No.3 - I. Allegro con Spirito
Op.20 No.4 - I. Allegro di Molto
Op.20 No.4 - II. Un poco Adagio Affettuoso

**kern	**kern	**kern	**kern
*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]
*g:	*g:	*g:	*g:
*clefF4	*clefC3	*clefG2	*clefG2
*M3/4	*M3/4	*M3/4	*M3/4
2r	2r	2r	2r
4r	4r	4r	4d
=1	=1	=1	=1
4G	2.r	4B-	4b-
4A	.	4c	4a
4B-	.	4d	4g
=2	=2	=2	=2
2c	2r	2e-	4g
.	.	.	4g
4B-	4d	4d	4g
=3	=3	=3	=3
[2.A	[2.c	[2.f#	4cc
.	.	.	4cc
.	.	.	4dd
=4	=4	=4	=4
2.A_	2.c_	2.f#_	2ee-
.	.	.	4ee-
=5	=5	=5	=5
4A]	4c]	4f#]	4dd
2r	2r	2r	4r
.	.	.	4d

Creating the Dataset

Humdrum

A syntax that is not necessarily related to music

One popular representation that complies with the Humdrum syntax is the ****kern** syntax, and it is used to store relevant information of a **musical score**

Creating the Dataset

- Find/Encode the 24 scores into a symbolic music representation
    - **Encode the 5 remaining scores in Humdrum (**kern) format**

Creating the Dataset

Manual encoding in Humdrum for the following movements:

Op.20 No.1 - III. Affettuoso e sostenuto
Op.20 No.2 - II. Adagio
Op.20 No.3 - I. Allegro con Spirito
Op.20 No.4 - I. Allegro di Molto
Op.20 No.4 - II. Un poco Adagio Affettuoso

The 5 movements encoded total an amount of **868 measures** of music

Using as a reference the version edited by Wilhelm Altmann, which can be found in the Petrucci Music Library (http://imslp.org)

Joseph Haydn, *Quartets for Strings, Haydn, Ed. W. Altmann: Op. 20/33 (m.sc)* (Place of Publication Not Identified: Dover Publications, 1985).

Creating the Dataset

- Find/Encode the 24 scores into a symbolic music representation
- Annotate the harmonic analysis of all of them using a consistent and “parsable” nomenclature

Creating the Dataset

****harm**

Another representation that complies with the Humdrum syntax, and allows to encode relevant information about **functional harmony**

**harm	**kern	**kern	**kern	**kern
*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]
*g:	*g:	*g:	*g:	*g:
*	*clefF4	*clefC3	*clefG2	*clefG2
*M3/4	*M3/4	*M3/4	*M3/4	*M3/4
.	2r	2r	2r	2r
.	4r	4r	4r	4d
=1	=1	=1	=1	=1
i	4G	2.r	4B-	4b-
iio	4A	.	4c	4a
ib	4B-	.	4d	4g
=2	=2	=2	=2	=2
iv	2c	2r	2e-	4g
.	.	.	.	4g
ib	4B-	4d	4d	4g
=3	=3	=3	=3	=3
viiob	[2.A	[2.c	[2.f#	4cc
.	.	.	.	4cc
V7c	.	.	.	4dd
=4	=4	=4	=4	=4
viioD7b	2.A_	2.c_	2.f#_	2ee-
.	.	.	.	4ee-
=5	=5	=5	=5	=5
V7c	4A]	4c]	4f#]	4dd
.	2r	2r	2r	4r
.	.	.	.	4d

**harm	**kern	**kern	**kern	**kern
*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]
*g:	*g:	*g:	*g:	*g:
*	*clefF4	*clefC3	*clefG2	*clefG2
*M3/4	*M3/4	*M3/4	*M3/4	*M3/4
.	2r	2r	2r	2r
.	4r	4r	4r	4d
=1	=1	=1	=1	=1
i	4G	2.r	4B-	4b-
iio	4A	.	4c	4a
ib	4B-	.	4d	4g
=2	=2	=2	=2	=2
iv	2c	2r	2e-	4g
.	.	.	.	4g
ib	4B-	4d	4d	4g
=3	=3	=3	=3	=3
viiob	[2.A	[2.c	[2.f#	4cc
.	.	.	.	4cc
V7c	.	.	.	4dd
=4	=4	=4	=4	=4
viioD7b	2.A_	2.c_	2.f#_	2ee-
.	.	.	.	4ee-
=5	=5	=5	=5	=5
V7c	4A]	4c]	4f#]	4dd
.	2r	2r	2r	4r
.	.	.	.	4d

Creating the Dataset

Annotating the harmony of Op.20

- Analyzing on paper
  - Néstor Nápoles López, Master student
  - Rafael Caro Repetto, PhD student
- Encoding using **harm syntax
- **4961** roman numeral labels

Creating the Dataset

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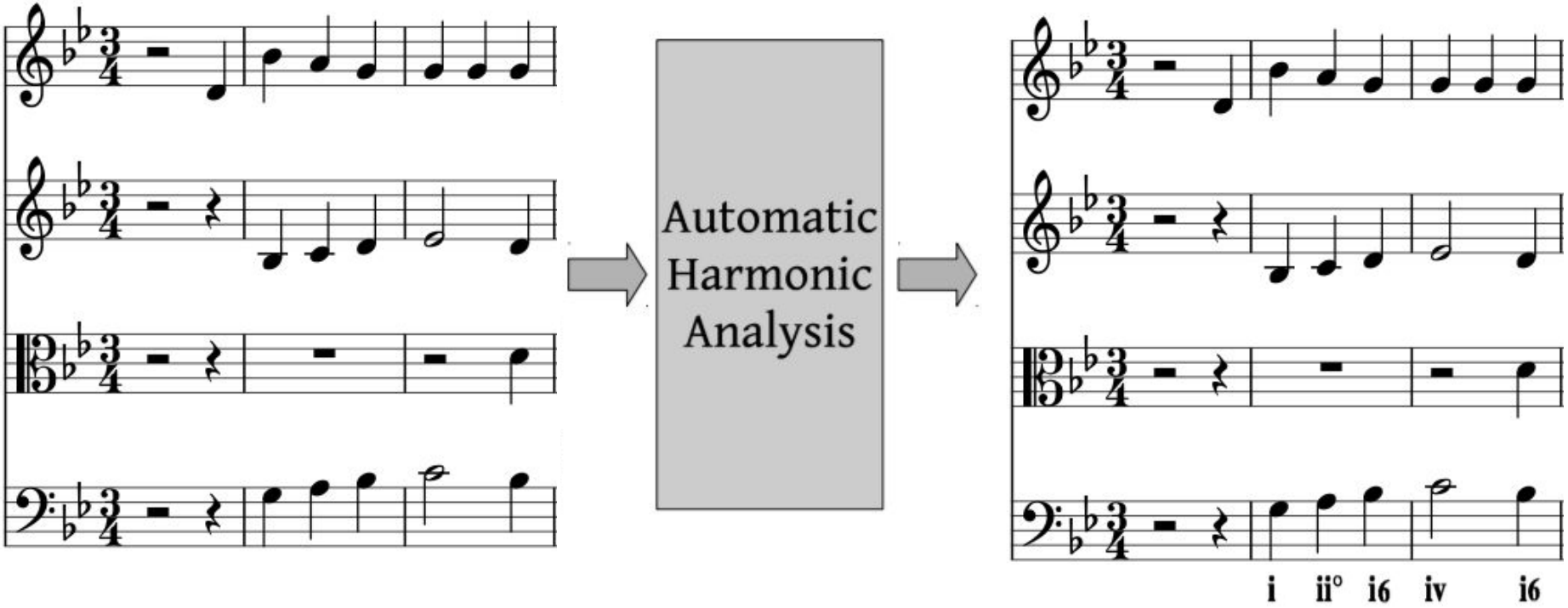
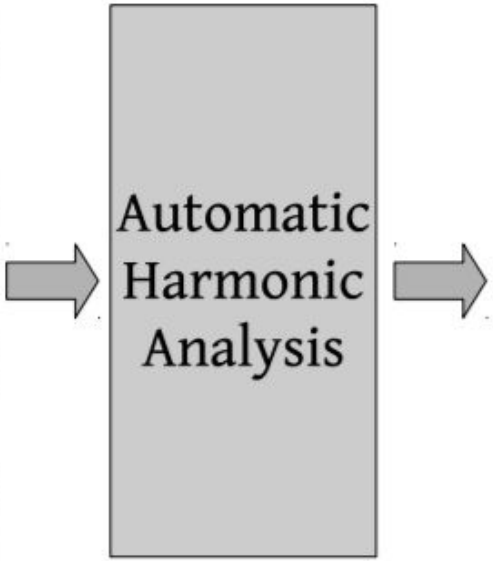


Source: Nápoles (2017)

**kern	**kern	**kern	**kern
*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]
*g:	*g:	*g:	*g:
*clefF4	*clefC3	*clefG2	*clefG2
*M3/4	*M3/4	*M3/4	*M3/4
2r	2r	2r	2r
4r	4r	4r	4d
=1	=1	=1	=1
4G	2.r	4B-	4b-
4A	.	4c	4a
4B-	.	4d	4g
=2	=2	=2	=2
2c	2r	2e-	4g
.	.	.	4g
4B-	4d	4d	4g
=3	=3	=3	=3
[2.A	[2.c	[2.f#	4cc
.	.	.	4cc
.	.	.	4dd
=4	=4	=4	=4
2.A_	2.c_	2.f#_	2ee-
.	.	.	4ee-
=5	=5	=5	=5
4A]	4c]	4f#]	4dd
2r	2r	2r	4r
.	.	.	4d



**harm	**kern	**kern	**kern	**kern
*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]	*k[b-e-]
*g:	*g:	*g:	*g:	*g:
*	*clefF4	*clefC3	*clefG2	*clefG2
*M3/4	*M3/4	*M3/4	*M3/4	*M3/4
.	2r	2r	2r	2r
.	4r	4r	4r	4d
=1	=1	=1	=1	=1
i	4G	2.r	4B-	4b-
iio	4A	.	4c	4a
ib	4B-	.	4d	4g
=2	=2	=2	=2	=2
iv	2c	2r	2e-	4g
.	.	.	.	4g
ib	4B-	4d	4d	4g
=3	=3	=3	=3	=3
viiob	[2.A	[2.c	[2.f#	4cc
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V7c	.	.	.	4dd
=4	=4	=4	=4	=4
viioD7b	2.A_	2.c_	2.f#_	2ee-
.	.	.	.	4ee-
=5	=5	=5	=5	=5
V7c	4A]	4c]	4f#]	4dd
.	2r	2r	2r	4r
.	.	.	.	4d

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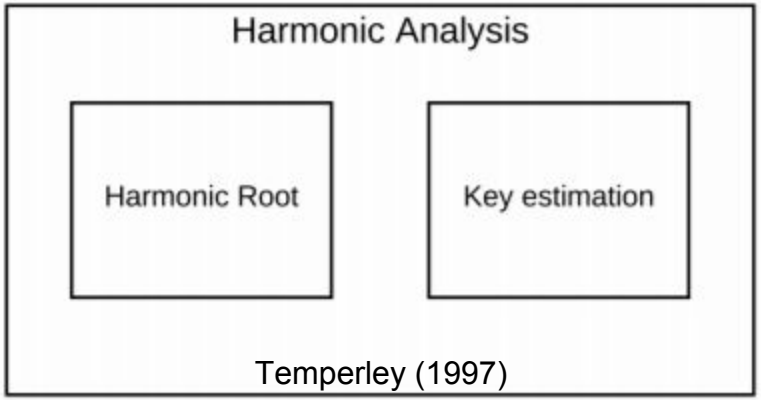
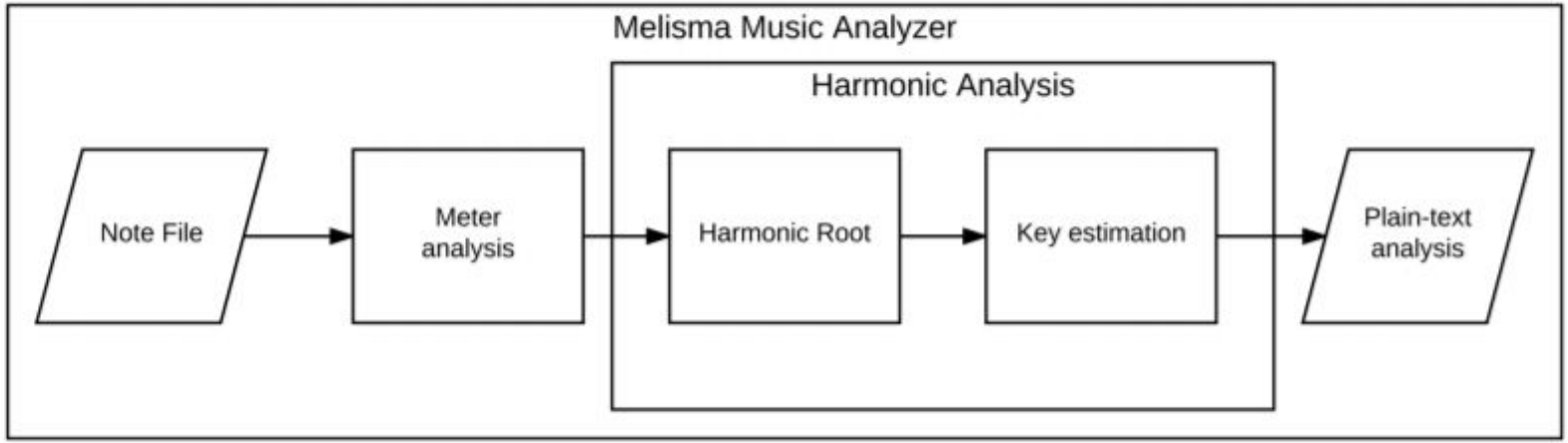


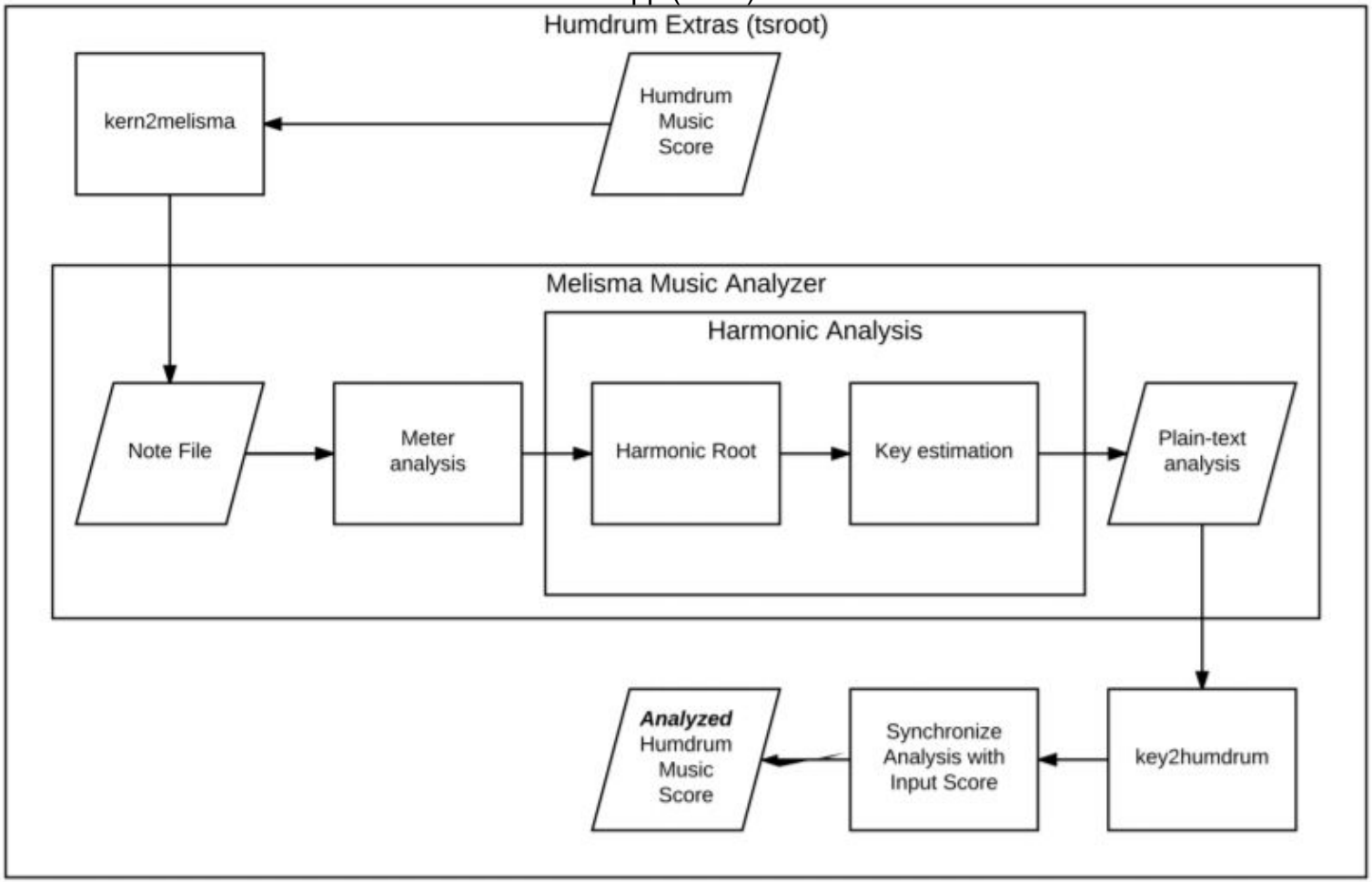
Image taken from: Nápoles (2017)



Temperley and Sleator (2001)

Image taken from: Nápoles (2017)

Sapp (2013)



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Problems of Comparing Harmonic Analyses

1. Functional harmonic analysis involves not only the roman numeral labels, but the key changes and their exact location

Problems of Comparing Harmonic Analyses

Example:

Development section of the sonata form with trivial chords but ambiguous key

Problems of Comparing Harmonic Analyses

1. Functional harmonic analysis involves not only the roman numeral labels, but the key changes and their exact location
2. **harm syntax provides an infinite possibility of roman numeral labels, and comparing them is not trivial

Problems of Comparing Harmonic Analyses

Example:

III+c/i[V+b]

Re-spelling an augmented dominant as an augmented third degree in the minor mode

Problems of Comparing Harmonic Analyses

1. Functional harmonic analysis involves not only the roman numeral labels, but the key changes and their exact location
2. **harm syntax provides an infinite amount of labels, and comparing them is not trivial
3. No baseline evaluation of functional harmonic analysis

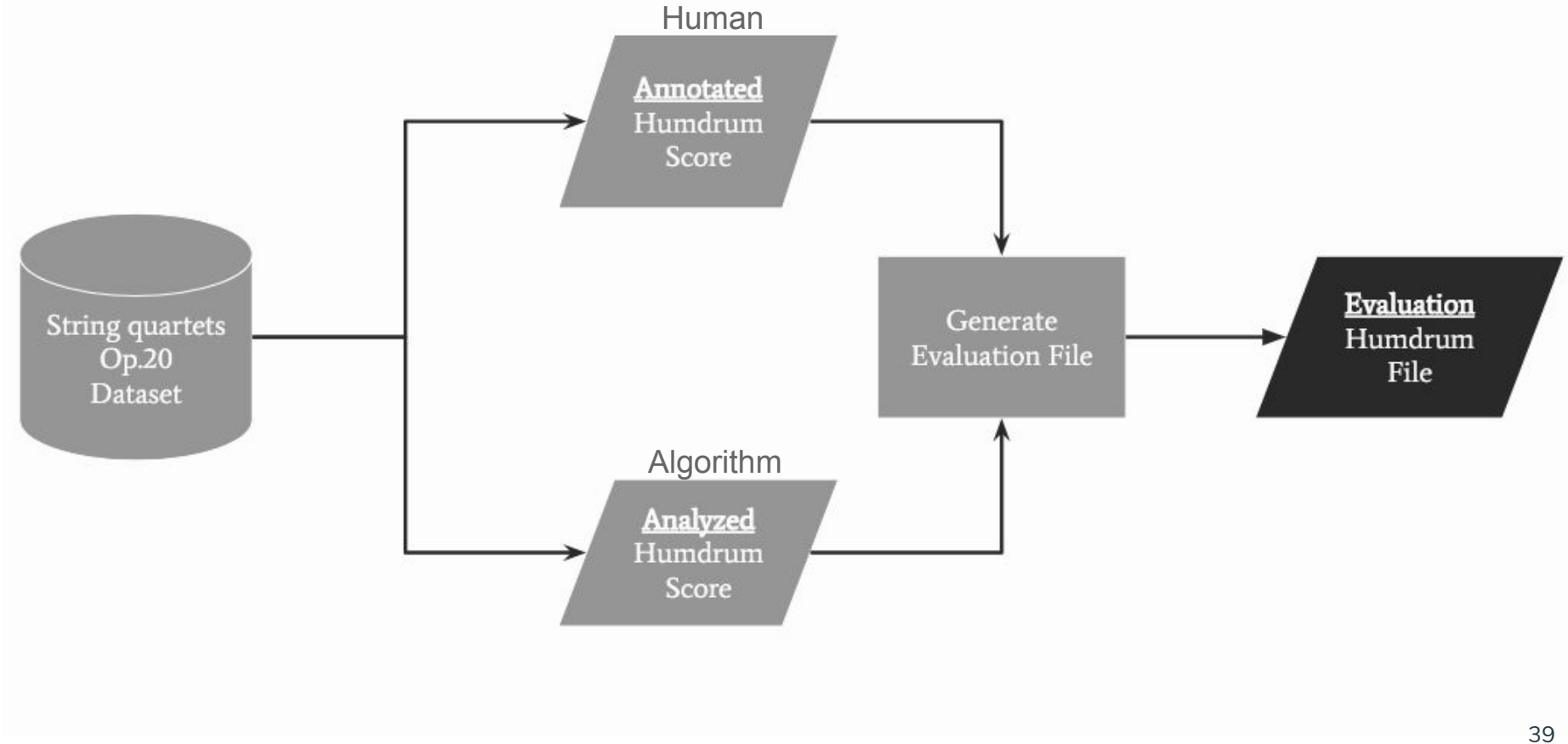
Comparison (plan B)

Resolution of harmonic roots

C major: I == G major: IV

C major: V/V == G major: V

C major: V7/vi == D minor: V7/v



Source: Nápoles (2017)

Manual analysis		Automatic analysis	
**harm	**root	**harm	**root
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
=1	=1	=1	=1
i	g	.	.
.	.	.	.
iio	a	iv	f
.	.	.	.
ib	g	.	.
.	.	.	.
=2	=2	=2	=2
iv	c	ib	c
.	.	.	.
.	.	V7c	g
.	.	.	.
ib	g	.	.
.	.	.	.

Table 5: Sample evaluation file.

Source: Nápoles (2017)

Time unit	Root 1	Root 2	Match
1	.	.	Yes
2	.	.	Yes
3	.	.	Yes
4	.	.	Yes
5	.	.	Yes
6	.	.	Yes
7	g	.	No
8	g	.	No
9	a	f	No
10	a	f	No
11	g	f	No
12	g	f	No
13	c	c	Yes
14	c	c	Yes
15	c	g	No
16	c	g	No
17	g	g	No
18	g	g	No

Table 10: Matching the root spines from an evaluation file

Movement	Matching time units	Total time units	Score
Op.20 No.1			
I	2261	3489	64,80%
II	221	805	27,45%
III	1319	1730	76,24%
IV	332	1289	25,76%
Op.20 No.2			
I	1254	5137	24,41%
II	1119	2017	55,48%
III	713	1033	69,02%
IV	309	1945	15,89%
Op.20 No.3			
I	2426	4322	56,13%
II	121	535	22,62%
III	3386	4069	83,21%
IV	535	1681	31,83%
Op.20 No.4			
I	2464	3663	67,27%
II	1992	3922	50,79%
III	65	223	29,15%
IV	1651	6289	26,25%
Op.20 No.5			
I	4950	7729	64,04%
II	793	1201	66,03%
III	2617	3061	85,49%
IV	798	1473	54,18%
Op.20 No.6			
I	1808	3985	45,37%
II	6217	7585	81,96%
III	405	505	80,20%
IV	1361	3041	44,76%

Source: Nápoles (2017)

Towards a Better Comparison

- Having an easier way to work with **harm syntax labels
  - https://github.com/napulen/harmparser

    Unfortunately, it was developed during the end of this research project and it was not used for the evaluation presented here

References

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Thank you