

Chapter 17

Using Geometric Symbolic Fingerprinting to Discover Distinctive Patterns in Polyphonic Music Corpora

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Abstract Did Ludwig van Beethoven (1770–1827) re-use material when composing his piano sonatas? What repeated patterns are distinctive of Beethoven’s piano sonatas compared, say, to those of Frédéric Chopin (1810–1849)? Traditionally, in preparation for essays on topics such as these, music analysts have undertaken inter-opus pattern discovery—informally or systematically—which is the task of identifying two or more related note collections (or phenomena derived from those collections, such as chord sequences) that occur in at least two different movements or pieces of music. More recently, computational methods have emerged for tackling the inter-opus pattern discovery task, but often they make simplifying and problematic assumptions about the nature of music. Thus a gulf exists between the flexibility music analysts employ when considering two note collections to be related, and what algorithmic methods can achieve. By unifying contributions from the two main approaches to computational pattern discovery—viewpoints and the geometric method—via the technique of symbolic fingerprinting, the current chapter seeks to reduce this gulf. Results from six experiments are summarized that investigate questions related to borrowing, resemblance, and distinctiveness across 21 Beethoven piano sonata movements. Among these results, we found 2–3 bars of material that occurred across two sonatas, an andante theme that appears varied in an imitative minuet, patterns with leaps that are distinctive of Beethoven compared to Chopin, and two potentially new examples of what Meyer and Gjerdingen call *schemata*. The chapter does not *solve* the problem of inter-opus pattern discovery, but it can act as a platform for research that will further reduce the gap between what music informaticians do, and what musicologists find interesting.

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17.1 Introduction

The topic of borrowing, between composers or within a single composer's oeuvre, has long been a concern for musicologists studying various periods and genres (Burkholder, 2001). George Frideric Handel's (1685–1759) music has received much attention in this regard, so it seems appropriate to begin this chapter with an example of Handel's borrowing from Reinhard Keiser (1674–1739), given in Fig. 17.1 (Roberts, 1986; Winemiller, 1997). In Fig. 17.1(a), Keiser's seven-note pattern occurs first in the oboe and is then sung by Clotilde. Shown in Fig. 17.1(b), Handel uses this same sequence of pitches, again in the oboe, but with a different rhythmic profile. Whereas Handel is often mentioned in connection with borrowing between composers, a composer well known for reworking of his own compositions is Beethoven:

More than a third of Beethoven's compositions reworked his existing music in some way.

(Burkholder, 2001)

Lutes (1974) identifies a pattern from the first movement of Beethoven's Piano Sonata no. 5 in C minor, op. 10, no. 1 (Fig. 17.2(a)) that recurs in the first movement of the Piano Sonata no. 6 in F major, op. 10, no. 2 (Fig. 17.2(b)). Beethoven, however, was also apt to borrow from other composers and Lutes (1974) credits Radcliffe (1968) with identifying the pattern in Fig. 17.2(a) as an instance of borrowing from Joseph Haydn's (1732–1809) Symphony no. 88 in G major, Hob.I:88 (Fig. 17.2(c)).

What do the pattern occurrences in Fig. 17.2 have in common, and how do we define the term *pattern*? Commonalities first (and see Sect. 17.3 for a definition of

Figure 17.1 consists of two musical examples, (a) and (b). Example (a) shows three staves: Oboe, Clotilde (soprano), and Bassoon (Bc). The Oboe and Clotilde parts feature a seven-note melodic pattern highlighted in red. The Clotilde part includes the lyrics 'Mit ein-em Schön-en En-de'. Example (b) shows two staves: Oboe and Bassoon (Bc). The Oboe part features a seven-note melodic pattern highlighted in red. The tempo marking '[Pianissimo ed Adagio]' is present above the Oboe staff.

Fig. 17.1 (a) Bars 1–5.1 of ‘Mit einem schönen Ende’ from *La forza della virtù* by Keiser. Two occurrences of a seven-note pattern are highlighted. (b) Bars 1–4.1 of ‘Must I my Acis still bemoan’ from *Acis and Galatea* by Handel. An occurrence of a seven-note pattern is highlighted. Throughout this chapter, ‘bar $x.y$ ’ means ‘bar x beat y ’