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ON COMPUTATIONAL MODELING IN ETHNOMUSICOLOGICAL RESEARCH: BEYOND THE TOOL

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1. INTRODUCTION

During the last decade, a rapidly increasing amount of work has been done in the area of *Digital Humanities*. Conferences were established. Research programs were launched. Departments and institutes were founded. Although there is still much confusion and debate about the essence of the field, some recurring themes can be observed. It seems that much of the current effort goes into creating research environments and infrastructures combining large interoperable, harmonized data sets and user friendly search and visualization tools that enable humanities researchers to search and explore the data and make new, previously unimaginable, discoveries.

Among these humanities data sets, there are musical data as well. Ethnomusicological archives have been digitized. Many scores of important composers are currently available in various digital formats. Massive amounts of user tags from services such as Last.fm are available. This enables data-rich research on music on a large scale.

The question is how to extract new knowledge from this data. One approach is to use generic search and visualization *tools*. Such tools enable discoveries in the data that also could have been done 'by hand', but would take a lot of time. For example, finding all occurrences of the name 'Joachim' in Brahms' letters, or finding all occurrences of the Landini cadence in the compositions of Gilles Binchois. This kind of automatic retrieval is of course very important, since it can save a tremendous amount of time. However, the resulting knowledge is typically not of computational nature. After being used, the computational tool is put away. One could call this computer-aided, or computer-assisted research.

Notwithstanding the importance of such tools, there is a next level of integration of computational methods and musicological research. It is on this level that the current contribution focuses. The core of this approach is to construct computational *models*, or rather to perform *computational modeling*. In contrary to the tool-scenario, the resulting knowledge is expressed in computational terms.

On a theoretical level, methodology for this approach has been proposed by Willard McCarty in his 2005 book *Humanities Computing*. There are, however, not much practitioners already following these research methods. In this contribution, I will take McCarty's rather abstract approach as point of departure and present some concretizations for doing computational ethnomusicology.

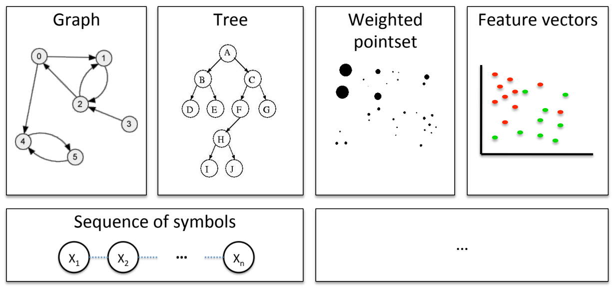

Figure 1: Examples of abstract data structures.

2. ABSTRACT DATA STRUCTURES AND ALGORITHMS

Computer Science provides numerous abstract data structures and algorithms that operate on these data structures. Examples of data structures are sets, trees, graphs, weighted point sets, sequences of symbols, vectors of feature values, etc. Some are depicted in Figure 1. Examples of algorithms are classification algorithms, Bayesian inference algorithms, alignment algorithms, sorting algorithms, etc., etc. A very important property of many of these data structures and algorithms is that they are abstract. E.g., symbols in a sequence could represent anything: characters in words, words in sentences, notes in melodies, chords in hymns, etc. Exactly this property enables the inclusion of domain knowledge.

3. COMPUTATIONAL MODELING

Computational modeling of musical knowledge involves expressing a musical problem in terms of abstract data structures and algorithms. It is the creativity of the researcher to find or design appropriate data structures and algorithms for the musical problem at hand. The better the musicological problem can be expressed in terms of data structures and algorithms, the more relevant the results are from a musical point of view. As foreseen by Leonard Meyer (1996): "I have no doubt about the value of employing computers in such studies, not merely because they can save enormous amounts of time but, equally important, because their use will force us to define terms and traits, classes and relationships with precision – something most of us seldom do."

The general research cycle is as follows (Van Kranenburg et al., 2011):

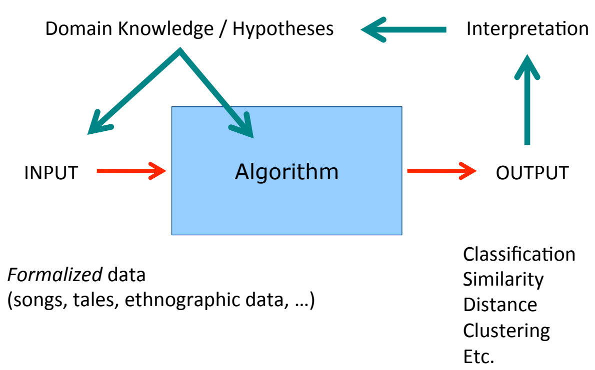

Figure 2: Research cycle for computational modeling.

1. Understanding the musical problem, which involves studying relevant musicological literature, especially the specific discourse concerning the research question at hand;
2. Designing musically meaningful data-structures and algorithms: the computational model as hypothesis;
3. Interpreting the algorithmic output;
4. Revising the model in case of failure;
5. Integrating the results in the musicological discourse.

Especially steps 1 and 5 are often absent in studies that can be found in the research area of Music Information Retrieval. Such studies are less relevant from the perspective of musicology.

The data structures and algorithms that are developed in the second step can be considered hypotheses. They reflect the current understanding of the musical phenomenon in a formalized way. The formalization of data is a research topic in itself. A computational data structure is a model of – in our case – musical data. In the third step, the hypotheses are 'tested' by interpreting the algorithmic output. The fourth step is a key idea of McCarty's approach: knowledge gain is possible in cases where the model fails. Therefore, these cases offer opportunities to improve the model in the next iteration of the modeling.

The third step poses us for serious problems. The question is: what to compare the output of an algorithm with? For relatively simple questions it might be possible to collect a set of examples that can be used as reference set or *ground-truth*. This is common practice in fields such as Music Information Retrieval, in which ground-truth data is collected by inquiring musicological experts or by crowd-sourcing. These data are considered the intended output of the computational model and the model is evaluated in terms of its ability to *reproduce* the ground-truth. From a musicological point of view, a pitfall of this research method is to mainly focus on accuracy rates, resulting in algorithms that might be able to reproduce ground-truth, but do not reveal any knowledge about the involved musical phenomena.

In most cases, however, mere collecting of proper ground-truth data is already problematic. Reasons for this include the multi-dimensional character of music and musical phenomena, lack of knowledge about the subject of study, or differences in opinion in musicological discourse.

One approach to avoid these problems is to involve the construction of ground-truth data in the research cycle, and by making the assumptions behind the ground-truth explicit and questionable. Then, not only the algorithm will be subject to revision in each iteration of the modeling, but also the reference or ground-truth data. One step further would be to employ the algorithmic output to explore and explain the properties of empirical data.

4. TOOLS AND MODELS

A tool is supposed to function properly. Therefore, tool-building complements modeling, in which, on the contrary, failure is the main focus of interest. In each iteration of the process of modeling, the model reflects the current understanding of a musical phenomenon in computational terms. Construction of a tool based on that model necessarily inherits the limitations of the model. In many cases, it is important to understand the underlying model to make proper use of the tool.

5. MUSIC

Some examples of ethnomusicological research that can be addressed by taking a computational approach are: studying the geographical differentiation of recitation on a large scale, classification of folk song melodies, modeling oral variation, finding common rhythmic or pitch patterns in large bodies of music, and ultimately, testing hypotheses on human musicality as such.

6. FUTURE WORK

The full potential of computational modeling has by far not yet been realized. On the longer term, computational modeling could build a body of explicitly defined (ethno)musicological knowledge, which would enrich and complement traditional approaches.

7. REFERENCES

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