INFORMATIONAL DATABASE ON SELECTED MUSIC WORKS

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Abstract: Basing on the review of available literature devoted to applications of programming tools in research on mechanism of music perception, the first results of my own research devoted to mining of hidden regularities in pieces of various types of music is presented. General characteristics of the developed databases, methodology of executed research, and discussion of the discovered knowledge structures for selected types of music pieces are briefly dealt with.

Keywords: attributes of music, decision trees, inference rules

1. Introduction

Application of computers to explain mechanisms of perception of music and its influence on human beings has for a long time been an objective of broad and numerous research. Particular attention has been devoted to cognitive psychology of music [1–4], algorithmic representation of compositions [5, 6], or formalisms used for description of musical knowledge [7]. Recently, new research directions like simulation and computer improvisation in music [8], or the use of machine learning in understanding of personal style differences between individual artists [9], have been reported. But the available literature does not supply any information about machine learning methods applied (in broader sense) in advanced classification of music works (compositions); we are talking here about classification based on the inspection of standard music notations. Development of methodology for such classification could show how machine learning could profitably be applied to study various problems in the field of tonal music. Moreover, elaborated classifiers can be broadly applied in modern teaching of musicology. These reasons disposed me to undertake broader research, generally dealt with classification (identification) of chosen music works.

One of the most interesting problems in this research seemed to be a preliminary appraisal of the attempt to elaborate ways for mining hidden regularities present in selected compositions of Polish (and foreign) composers. It was expected that developed classification methodology could play a crux role, in:

a) discovering of characteristic features (even not known until now) of musical compositions,
b) equipping the process of searching for these features with rational foundations, based on clearly specified logical relations, omitting truth–less assumptions, conjectures, or intuitive judgments, and
c) identifying characteristic features of the production of a given composer.

Each of the enumerated fields of application of the developed classification methodology can be beneficial for the advanced education of musicology and pedagogical upbringing in music.

Realization of the planned research required access to specialized informational database on selected objects (music works).

2. Description of the developed database

Informational database allowing realization of the planned research has been completed in the form of a source file with open architecture. This file was then used to create — according to current needs — various sub–bases in a format matched to the requirements of programming tools used for development of decision trees and/or production rules. This approach was substantiated by a very low suitability, in our investigations, of typical database architecture and computer programs for searching data. Using a standard query tool, the user probably always assumes that the regarded feature is affected by a relation, known to him/her. For example, rising a question "*what is the fraction of music compositions with progression of melody for etudes, and what is it for ballades?*", the user certainly assumes that progression of melody is influenced by the type of music composition. On the other hand, machine learning methods (and directly connected with them data mining procedures) tackle the broader underlying goal, trying to determine the most significant factors that affect hidden features of music pieces. In this way machine learning (and data mining, too) methods try to discover the relationships and hidden patterns that may not always be obvious. Taking into account specificity of the research performed, some descriptive attributes (features) have been defined, which aimed at representing of musical knowledge on investigated objects (pieces of music) and their mutual interrelations. These attributes (beat_characteristic, structure, figuration, harmony, imitation, melody, motif, repeating_of_motif, succession_of_harmony, succession_of_melody, repeating_of_ succession, and rhythm_disorder) simultaneously stand for names of fields in records of the discussed database. In these fields values of subsequent attributes are stored, and assigned to the investigated cases (see Table 1).

Table 1. Descriptive attributes for music works and their values

<Beat_characteristic>	[mixed][bichronic][trichronic][tetrachronic] [pentachronic]
<Structure>	[homophonic][polyphonous]
<Figuration>	[absent][is_8][is_16][is_32][is_64]
<Harmony>	[absent][dur_moll][modal]
<Imitation>	[absent][present]
<Melody>	[wavy][figurative][cantillate][falling][raising] [ornamental]
<Motif>	[absent][wavy][arched][falling][raising]
<Repeating_of_motif>	[absent] [literal][spread out][abridged][variant]
<Succession_of_harmony>	[absent][mod_falling][mod_raising] [not_mod_falling][not_mod_raising]
<Succession_of_melody>	[absent][falling][raising]
<Repeating_of_succession>	[absent][twofold][threefold][fourfold][fivefold]
<Rhythm_disorder>	[absent][present]

The prototype database has been completed in the form of a few sub–bases, containing data about separated types of music works, e.g. polonaises, etudes, ballades, mazurkas, etc. It should be mentioned that during the creation of sub–bases, labels containing data about composer, name of composition, etc. were neglected. However, each case in the base got a binary decisive attribute according to the current goal of the research.

This article presents preliminary results, intentionally limited to searching of a sub–base of Chopin's polonaises [g–moll from 1817, B–dur from 1817, As–dur from 1821, A–dur op. 40 no. 1, es–moll op. 26 no. 2, d–moll op. 71 no.1), and polonaises of other Polish composers ('Polonez staropolski'[10], 'Polonez' by Chmielowski, from 1738, 'Pożegnanie Ojczyzny' (a–moll) by Ogiński, 'Polonez Miechodmucha' by Kurpiński, and polonaise 'Kto z mych dziewek serce której' by Moniuszko [11]). The results gained in the initial experiments supported the feasibility of the research conducted. To fulfill the main goal, all cases in the investigated sub–base were equipped with a binary decisive attribute ([Chopin], [Not_Chopin]). Simultaneously, other classification experiments were executed using other sub–bases with different types of musical works.

3. Research methodology. Programming tools used

The classification of compositions contained in the sub–base of polonaises was executed using computer program system 1st Class [12]. Analysis of the database performed by this tool supplied quasi–optimal decision tree(s) generated by searching for the largest decrease of the difference H(X) — H(X,A). Here, H(X) is entropy of information calculated for the entire set of cases (compositions) in database, whereas H(X,A) stands for entropy of information of the analyzed set, split according to values of the attribute A. It should be stressed that the programming tool used is extremely convenient; it allows to use a single (physically) database as a "mother" for family of apparently various sub–bases to test diversity of ideas and to retrieve different knowledge structures. Creation of various sub–bases from a single base can be done by controlled inactivation of selected attribute(s) (omitting of selected column(s)), and/or by intentional inactivation of chosen case(s) (omitting of chosen case(s)).

In the second step of our investigations, inference rules were generated using two specialized programs: LERS [13] (based on theory of rough sets [14]), and GTS [15] (implementation of a new recursive covering algorithm). Finally, in dubious cases, tentative attempts to optimize classification methodology were made using VVT–program [16] for virtual visualization of multidimensional objects (abstractions, ideas, concepts, notions, etc.) in 3D–space.

4. Development of decision trees and inference rules: optimization of results

Initial analysis of the investigated database has shown that from 12 attributes used to describe examined music compositions (polonaises) only four are necessary for the development of a decision tree. They are (in sequence of appear-

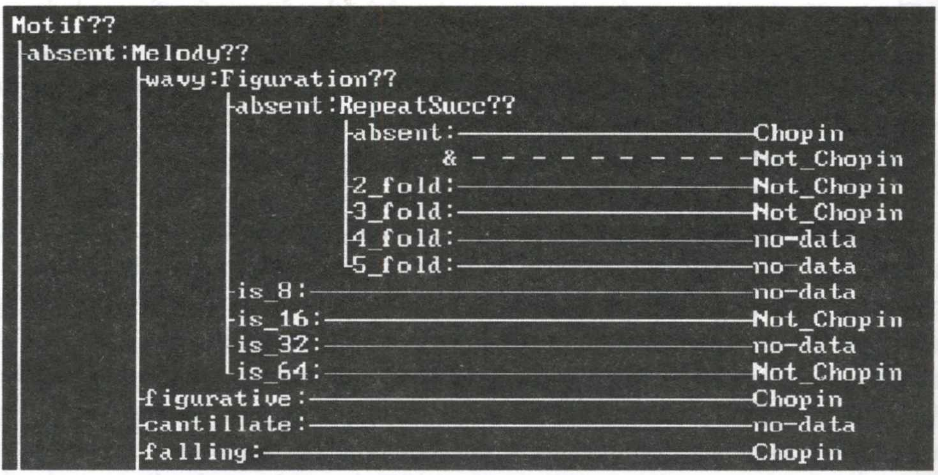

Figure 1. Fragment of the decision tree for classification of chosen polonaises

ance in the decision tree, Figure 1): <Motif>, <Melody>, <Figuration>, and <Repeating_of_succession>).

The tree shown in Figure 1, further called tentative tree, does not reveal that classification of music compositions (even of single type) is extremely difficult. Incidentally, it should be pointed out that classification along the path: [<Motif>: absent: <Melody>: wavy: <Figuration>: absent: <Repeating_of_succession>: absent:] led to ambiguous identification.

The next series of experiments was devoted to the estimation of discriminative power of attributes, used here for the description of music compositions. It was found, for example, that: <Beat_characteristic>, <Figuration>, <Harmony>, <Imitation>, and <Rhythm_disorder> cannot be placed in the root of a decision tree (in other words, no decision tree can be generated using any of these attributes alone). But one of these attributes (<Figuration>) was used in paths of some developed decision trees.

Analysis of the database content by means of the program LERS revealed the existence of inconsistent cases, however, their location and deeper causes were at that moment not clear. This finding was confirmed by means of the VVT program. It was found, that cases <5> and <10> (polonaise 'Polonez Miechodmucha' by Moniuszko,

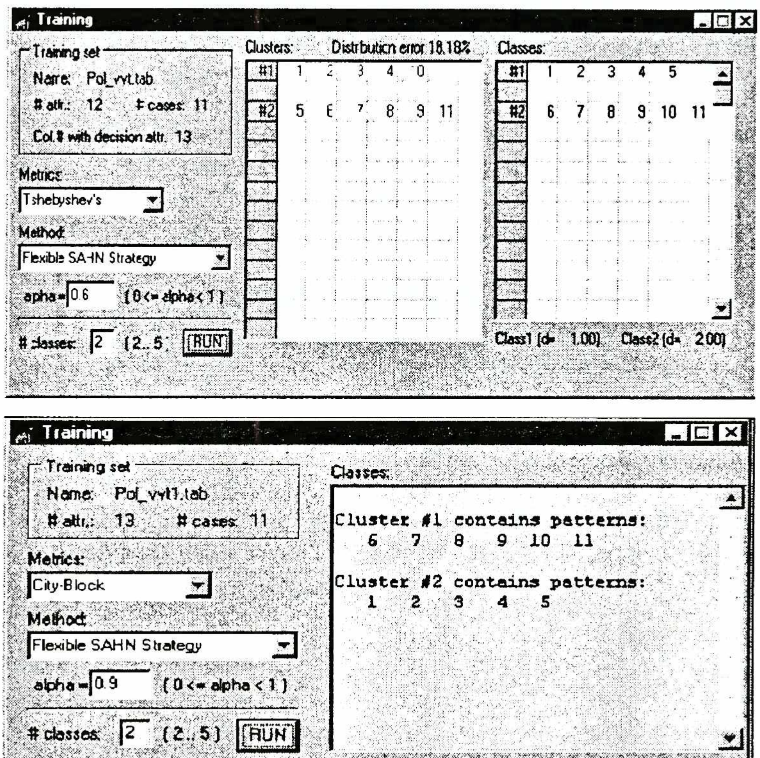

Figure 2. *Upper screen: (supervised learning) — correct classification of investigated works (cluster #1 — polonaises by Chopin, cluster #2 — polonaises by other composers). Bottom screen: (unsupervised learning) — cases <5> and <10> marked (in red) by the program as not suitable for correct classification*

and polonaise es–moll op. 26 no. 2 by Chopin, respectively) were incorrectly classified, using initially selected attributes (Figure 2). Removal of these cases (as a mater of fact, inactivation of the respective cases) led to very concise decision tree (Figure 3) based on three attributes only (<Succession_of_melody>, <Figuration>, and <Beat_characteristic>). The final decision tree classifies all the investigated cases and also unseen cases, i.e. compositions (polonaises not used in the learning process). Optimization of the decision tree was independently confirmed by the development of a set of inference rules modeling all the paths contained in the tree.

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SuccMelody??
├absent:Figuration??
│         ├absent:─────────────────────────────────Chopin
│         │
│         ├is_16:Beat_char??
│         │        │
│         │        │
│         │        ├3_chronic:──────────────────Not_Chopin
│         │        ├4_chronic:──────────────────Chopin
│         │        └5_chronic:
│         ├is_32:───────────────────────────────Chopin
│         └is_64:───────────────────────────────Not_Chopin
│
└raising:───────────────────────────────────────Not_Chopin
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Figure 3. Quasi–optimal decision tree for classification of investigated music compositions

Using the VVT visualization tool one interesting conclusion can be drawn: attributes used for the description of investigated music works were correctly fixed, as they allowed to nicely separate both clusters (polonaises by Chopin, and polonaises by other composers). This feature is shown in Figure 4.

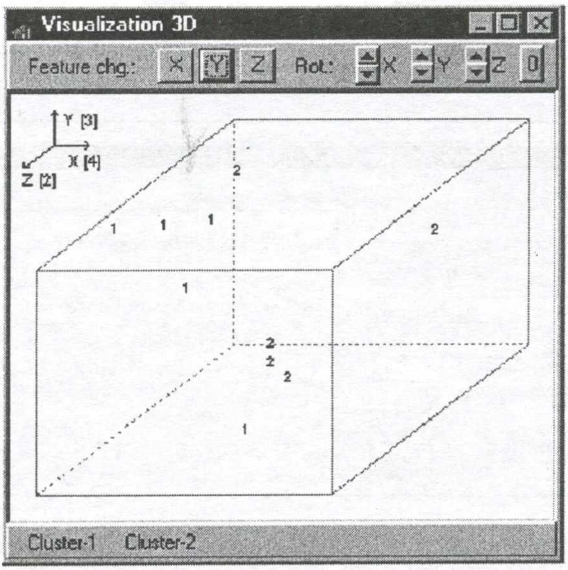

Figure 4. Very fine separation of investigated clusters: 1 — represents cases 'polonaises by Chopin', 2 — stands for 'polonaises by other composers'

5. Conclusion. Further directions of research

The first results presented here are connected with the introductory part of this long–range research. However, even now they seem to be very promising in accessing keys (descriptors) for classification of unknown musical works. Selection of descriptive attributes and estimation their hierarchy of importance — by means of algorithmic methods — can create foundations for critical evaluation of principles currently accepted as standard knowledge about musical forms. It may be believed that experiments with machine learning performed within this research, have yielded a number of interesting musical results. They certainly may be treated as a viable alternative or addition to more traditional methods in musicology.

Further research will focus attention on more extended databases and profound interpretation of resulting observations in musical terms.

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