Musical Information Retrieval for Delta and Neumatic Systems

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ABSTRACT
In this paper an alternate to Western Music musical system is presented. This system has flourished for more than 15 centuries in the areas of Byzantine Empire and it implements Neumatic and Delta Interfaces in order to represent musical structures. Recently, a remarkable revival and propagation of this system has been recorded worldwide. The motivation for this paper has been given from a joint effort of the Department of Informatics at the Aristotle University and the Department of Music Science and Art at the University of Macedonia to register the musical content not only of contemporary manuscripts but also to record and correlate morphologically the evolutionary stages from the neumatic origin to the final Delta Analytical method.

KEYWORDS
Alternate Musical Interfaces, Neumatic and Delta Systems, Byzantine Music, Morphology, Information Retrieval.

1. INTRODUCTION: DELTA AND NEUMATIC MUSIC NOTATIONS
The world of music is not uniform nor unified; it consists of various segmented systems diversified on matters of scales, rhythms and transitional phenomena [1]. The Common Music Notation (CMN) scheme along with the MIDI specification are Western Music oriented. As a result, they are not able to clearly depict alternate musical forms and traditions. The methodology described in this paper implements an indexing scheme based on signatures characterizing the content they point to. Also, emphasis is given on content extraction mechanisms concerning the morphology of the melodies. The musical database selected for the application of this method is a Delta musical notation system known as Byzantine Music (Figure 1).

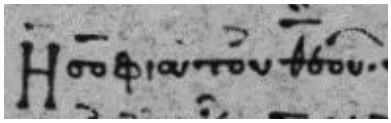

Figure 1. Byzantine Music Manuscipts. Detail of the so-called 'Chartres fragment' with musical notation, beginning of a sticheron in Mode 8, Monumenta Musicae Byzantinae, University of Copenhagen, Denmark.

The problem with Delta symbols is that the same sequence of symbols may yield a different melodic content, depending on the scales of the Mode in which a melody is deployed [2] (Figure 2).

2. PROBLEM FORMULATION
The major issues in MIR for Byzantine music melodies are: (a) how to locate specific sequences of symbols (b) how to associate morphological metadata with the content.

Although the answer to this question may sound obvious, that by forming any melodically meaningful text databases [3] we can use IR systems available for Free Text Retrieval, things are not that simple. IR systems appropriate for this purpose are the *Inverted File* and the *Signature File* indexing schemes, both used extensively for indexing Free Text Databases.

The Signature File indexing schemes have a simple structure and require significantly less storage overhead. In Figure 3 is presented the structure of a signature indexing scheme, as

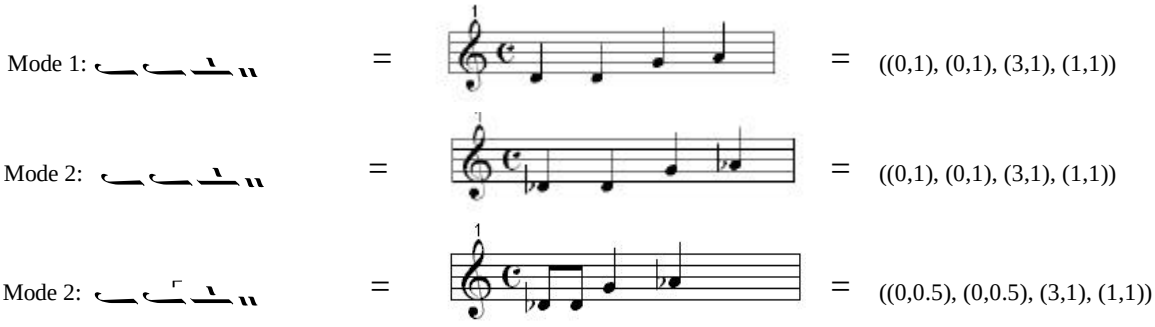

Figure 2. Variations of a motive in Modes 1 and 2 with D^4 serving as a melodic basis.

modified here to handle a Musical Database. The Audio Data File is a collection of original melodic data blocks. These blocks may contain both semantic data and comments appended in the form of text [4].

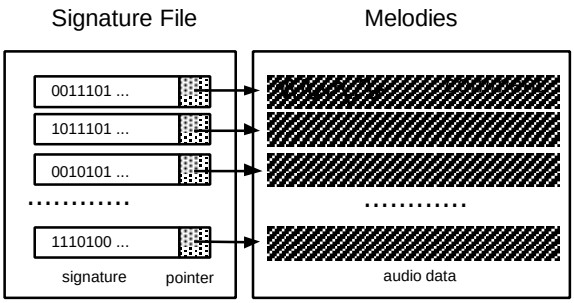

Figure 3. A Signature File scheme for digitally transcribed manuscripts.

In the Signature File are stored the signature records of the audio blocks and to each record is attached a pointer to the corresponding audio block. The Signature File and the Audio Data File may be kept and processed separately. The Signature File, which is of much smaller size, may be copied and distributed to many processors so that either many workers can take advantage of it or a form of parallel processing may be applied. In our case the signatures of a Delta musical file are attached to it as an appendix.

For a given query the Signature File is searched for **signature** records conforming to this query, then the pointers attached to these records are used to locate in the Audio Data File the corresponding audio block. It should be pointed out that queries scan for *motives* rather then isolated Delta notes which are meaningless by themselves (see again Figure 2).

In order to build a Database, an extension of the signature file method described in Figure 3 has been adopted which was originally presented for free text bases, the so-called *S-Index* scheme [5].

S-Index is a hybrid indexing scheme that combines many of the merits of Inverted File and Signature File schemes. Its performance is tunable between two extreme ends. At one end S-Index turns into a Signature File and at the other end it becomes an Inverted File. One advantage of the adopted indexing method is that frequently queried terms or certain user selected terms may be indexed via an Inverted File method, for speed, whereas the bulk of the terms may be indexed in the form of a tree of signature segments, which requires a lower storage overhead and also is more suitable for multiple term queries.

Since most RDBMS do not support direct use of binary variables or Boolean operators on binary variables, a table was created simulating the behavior of the proposed index. This architecture yields a binary tree of signature segments. Each node of this tree has the following structure:

```
SINDEXnn    (block_no    INTEGER,
             aa           INTEGER,
             node_no      INTEGER,
             sig          CHAR(k))
```

The value of parameter *k* depends on layers of the S-Index structure. For instance, for SINDEX4 it is $k=2^4=16$. Every table SINDEXnn (0 <= nn <= 14) records: (a) pointers to the audio file packages (b) pointers to the nodes of the internal tree structure and (c) the binary signature itself.

Apart from this RDBMS-centric methodology, the authors of this paper are seeking a method to encode digitally Byzantine melodies in a MIDI-like specification and to add to these files as accompanying metadata the *signatures* of each melody.

3. RESULTS

Following the analysis methodology described in the previous section, we have used Full Text Retrieval systems (BRS SIRSI and SQL Server 2000) along with custom made programs that calculate the probability of appearance for sequence 7 - 10 of symbols.

Some results are presented in Table 1. For the sake of simplicity, conditional probabilities for 3 symbol sequences are presented.

For these sequences digital signatures are built which accompany the digitally encoded manuscript.

Table 1. 3rd order stochastic sequences for the 3 more frequently appearing Delta symbols. P(So) is the probability for S_i as an initial symbol.

Symbol S	P(S)	P(So)	P(S1*S2*S3)
S1:	0,354	0	P(S1*S1*S3) 0,019
S2:	0,149	0.05	P(S2*S1*S1) 0,0154
S3:	0,146	0.55	P(S3*S1*S1) 0,018

Some results excluded from the statistical analysis tables:

(a) motives are on average 9 Delta symbols long.
(b) Non-terminating motive endings are declared by increased durations by one time unit for 95% of examined cases.
(c) If intermediate (i.e. non terminating) segmentation takes place, motive length drops to 8 Delta symbols.
(d) The terminating endings of a thesis are less than ten.

4. REFERENCES

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