Beyond MIDI: Theoretical foundations for the Voice-Instrument Digital Interface for Byzantine Music

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Background in Music History: Byzantine Music.
The transplantation of Byzantine Music (BM) legacy within the information society has started some 30 years ago. Gradually, many aspects of this music idiom get computerized, like its score writing capabilities, its OCR reading, and finally, its computerized sound reproduction (Politis, 1997, and many others since then).

Background in Music Perception and Computer Music semantics.
The quantitative differences lie in the intervals used in Western and Byzantine music. Byzantine chants contain certain intervals, accidentals, and tonal attractions which result in pitches that do not exist on the equally tempered keyboard, the standard for pitch relationships in contemporary Western compositions. These subtle differences add a unique beauty to BM melodies. Although there was a tendency to consider these differences of minor significance for transcription to the CMN corpus (Wellesz, 1958) recent advances in computer music reproduction schemes pose the need for a detailed and documented incorporation of these attributes to the digital interfaces of contemporary instrumentation.

Aims. Our research aims to create a standardized computer music handbook of musical codes (in binary and XML format) that accurately describe the principal quantitative and qualitative attributes of BM hymnography.

Introduction
When we use the term Byzantine Music, we mean the music that was used by the people of the Byzantine empire (4th to 15th century), composed to Greek texts as ceremonial festival or church music. Elements were derived from Syrian, Hebrew, and Greek sources (Columbia Encyclopedia, 2000). This musical system was not confined only to ecclesiastical music; it was a generalized musical system originating directly from ancient Greek Music and was used as the usual music surface by all the people living in the vast areas of the empire, from Southern Italy and the Balkans up to Russia and Armenia and down to Middle East and Egypt. The nations of Middle East were accustomed to the Greek language and (musical) civilization throughout the conquests of Alexander the Great and its successors.

Whereas secular Byzantine Music used instruments, ecclesiastical music was vocal. It is reported however that the organ was used for tuning or ear training, but not for the formal vocal performance (Psachos, 1980).

Two major characteristics of Byzantine music are its modal character and its homophonic performance (Jacobs 1980). By the term mode we do not merely imply the ways of ordering the notes of a scale, but a tropos, a way, a guideline of performance including various side effects like pitch bendings and accompanying prosodic transient phenomena (Spyridis and Politis, 1990).

After the Arab/Muslim conquest of Egypt and Syria, the nature of the state and culture was transformed. Byzantium became much more a Greek state. This is the divergent point for Western and Eastern Music: while in the West the heritage of antiquity was transformed gradually to the Ambrosian chant (Santus Ambrosianus), later to the Gregorian chant (Cantus Romanus, firmus Choralis) and finally to the polyphonic Western Music orchestration, in the East prevailed the Byzantine Music scheme. Although it resembles the plainsong character of the
Gregorian chant, it is rather homophonic than monophonic.

Byzantine Music is basically modal. Eight modes are used currently: four authentic (Modes A, B, C and D) and their plagal ones (Modes Plagal A, Plagal B, "Varys"-Grave and Plagal D). These came from a pool of about 15 modes used in Byzantine era. The ones that were not suitable for the solemnity of ecclesiastical music were diminished and have survived sporadically in Eastern musical traditions. Since Byzantine Music is a direct descendant of Ancient Greek Music, Ancient Greek modes like Dorian, Lydian, Mixolydian etc are rehashed. However, although the names of modes are taken from ancient Greek names, there is an ambiguity on the exact correspondence of Ancient Greek modes, Byzantine modes and the re-use of the Ancient Greek mode names in contemporary music forms like Jazz (Spyridis, 1987; Moysiadis and Spyridis, 1994). The last decade, as it can be seen from the relative URL references, a remarkable dissemination of Byzantine Music literature has been recorded worldwide, and chants in the English language have appeared.

**Computer Music Semantics**

The Byzantine Music system is a Delta musical system. Having an uninterrupted evolutionary course of about 15 centuries, it was reformed to an analytical system by Patriarchic Music Committees in 1814 and in 1881-85. These committees did not create a new musical system; they gave a more systematic approach to the underlying surface of the Byzantine Musical tradition and founded the theoretical values of contemporary Byzantine Music. Although their approach was focused on vocal ecclesiastical music, it engulfed the whole structure of Byzantine Music. As a result, the Greek musical heritage, whether ecclesiastical or secular has been transcribed to Byzantine Music notation, its inherent notation (Pantelopoulos, 1996).

The symbols of this notation came out of the numerous symbols of the earlier shorthand-like notations, like those exhibited in Figure 1.
These symbols comprise the musical alphabet of Byzantine Music, and as a whole they are described by the term *parasimantiki* (meaning parasemantics). It should be noted at this point that references to Byzantine Music are directed to the theoretical musical system of 1881 and its parasimantiki and not to the previous forms, which in their overall majority have been compiled to parasimantiki.

So, parasimantiki is a set of symbols that transcribe analytically the correct way for the interpretation and articulation of musical phrases. However, parasimantiki does not describe notes explicitly, but as an increment or decrement from the previous level, *as a phonetic transition from the current state to the next one*. Consequently, the symbols of parasimantiki in Figure 1 do not correspond to notes within a given scale, but describe the delta intervals of the notes and their durations within a predefined scale.

**Crispness and fuzziness of scale transcriptions**

The music samples explored in this paper are mainly in mode plagal D, the closest to Western music's diatonicism of the Major C scale.

While most notes of the diatonic scale are in the same position with the notes of the well tempered scale, in Byzantine Music there are alterations that can split whole note intervals to intervals considerably smaller than a semitone introducing a microtonal distribution of 72 moria. According to Byzantine Music theory, the least audible interval is that of 2 moria, so virtually the scales of Byzantine Music are split to 36 distinguished semitones. (If the reader may wonder why then 36 moria are not used instead of 72, he will get the answer that in rare occasions there are used intervals consisting of an odd number of moria).

Also, since Byzantine Music involves vocal performance, quality symbols exist denoting prosodic quantity. For instance, the prosodic quantity of an accent is denoted by quality symbol *psiphiston* , operating on the note implied by the quantity symbol on which it is ascribed.

Quantity symbols virtually imply prosodic pitch bendings of various kinds. Some of them have detected already by signal analysis techniques in instrumental and vocal performances. The quantity symbols, from a prosodic point of view, can be seen as tilt intonation patterns (Black 1995), that is like Bezier curves of the fundamental frequency F0.

Therefore, for some notes there is an ambiguity, especially when alterations occur. These ambiguities increase in number and difficulty of classification as one shifts to more chromatic scales. If a transposition takes place and the bases of the octaves are in the
same pitch level, then the comparison between Western and Byzantine music can be seen pictorially in Figure 2. Apart from the disparities due to scale mismatching, a more significant factor is that of intonation. Because in Western music the musical background of so many people is based upon or influenced by the piano, the piano scale is accepted as “natural” and is widely used as the interface for composition either pictorially or conceived as the equally tempered scale (Figure 3). However, a good violin player plays and a vocalist sings in an intonation different from equal temperament. Brass players tend to “lip up” or “lip down” certain notes and in so doing depart from equal temperament. If, for example, B₄ is being played as ti in the C-major scale, performers will tend to play it sharp in anticipation of do (B₅). If the same B₄ is played as mi in the G-major scale it will be played flat relative to the demand of equal temperament (Rigden, 1985).

Apart from the scale alterations, vocal performance involves transitory phenomena that cannot be described merely with pitch bendings, while voice quality issues arise out of fixed idiomatic pattern performance.

Consequently there is also fuzziness within the set of notes used. In modal plainchant systems fuzziness lies in transitory phenomena and implied pitch bendings; these phenomena are more tense in mode plagal A than in mode plagal D. For this reason the sample pool focuses on mode plagal D: it is the closest to Western Music scales and orchestration.

In the Computer Music sphere

The analysis performed in this paper is confined to the dimension or surface of melody. For this surface, the three categories of signs were adequate enough. However, in parasimantiki there is a great variety of signs, the roles of which are various, aiming at the description of the precise development of melody. For example, there are many signs of alteration (sharps and flats) which increase or decrease subtly the pitch of notes in an even number of Byzantine commas. One Byzantine comma = \(2^{1/72}\) (Spyridis, 1987). Moreover, for the other dimensions or surfaces of Byzantine Music, i.e. rhythm and harmony, there are specific signs which were not encountered at all since morphogenetic analysis was confined to the surface of melody (Lerdahl and Jackendoff, 1983).

Problem Formulation

In the approach described in the previous section, the statistical and melodic nature of Byzantine Music literature was demonstrated. However, the symbols of parasimantiki were perceived as statistical symbols and not as symbols that can produce music. This analysis scheme resembles the linguistic analysis performed on a certain language alphabet: grammar and syntax rules can be deduced but no accent or intonation information is encountered. Consequently, there is need for a new frame for the interpretation and interfacing of the musical notation that will
The issue of voice quality in Byzantine Music chants has lead to a generic description of prosodic patterns. Taking into account that the mathematical perception of quality is equivalent to a Bezier curve of the fundamental frequency, a voice scripting language has been proposed by Politis et al. (1998) that can describe such phenomena. This language has been named N-Delta. N is the arity of the representation, that is the complexity of the musical surfaces involved. In the compositions (II) & (III) of Figure 5 the arity is 3. The following example shows how N-Delta describes melodic and prosodic events and how their arity is determined.

Suppose we have a synthetic singer that has to reproduce the next melody or, its equivalent in terms of parasimantikiki.

Things seem to be pretty straightforward, apart from the inherent fuzziness of scales earlier described.

After having performed phoneme /e/ at the pitch level of note C₄, the singer will perform /e/ at the pitch level of D₄ with the duration of a two fourth-note. Consequently the fundamental frequency will have the time frequency representation of Figure 5 (I). Thus far the arity of frequency-time representation is 2. This means that the representation of time-frequency musical events can be described with a 2-dimensional vector.

However, to have quality prosodic phenomena, the fundamental frequency curve of the synthesized voice has to be reshaped. Adding one more dimension, we include quality operators that alter the pitch curve. In Figure 5 (II) and (III) two quality operators are shown: that of petasti and that of an accent (psifiston). If we want the phoneme /e/ in D₄ to be performed with the quality of petasti, then it is clear that we have to reproduce the curve of Figure 5 (II) which is beyond MIDI transcriptions.

There are ways to instruct a voice synthesizer to reproduce the pitch bendings mentioned previously, but we need to augment or enhance the MIDI descriptions at a meta-level.

The sound files that accompany this paper depict in an auditory manner these enhancements.

**Results and conclusion**

Although there is an inherent fuzziness when Byzantine Music melodies are transformed to CMN, in recent years there is the possibility to alter parametrically the MIDI characteristics...
of CMN melodies representing BM chants and to produce acceptable auditory results without using esoteric or niche products.

Lines like the one seen in Figure 6 can be reproduced using synthetic sound fonts with an acceptable performance, when compared to the actual hymn.

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**References**


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**Figure 6.** Kyrie Ekekraxa transcribed and performed by a MIDI keyboard.