BIGRAM EDITOR: A SCORE EDITOR FOR THE BIGRAM NOTATION

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ABSTRACT

The Bigram Notation is an alternative approach to musical notation, based on the chromatic nature of Western music. As observed historically with alternative notation systems, their spread and consolidation is based on the existence of complementary and supportive tools, as ideosyncratic instruments and specific written material. Accordingly, we present the binary keyboards and the Bigram Editor, a graphical bigram score editor with automatic transcription and reproduction capabilities.

1. INTRODUCTION

It is commonly accepted that the conventional music notation system has its origin in the 11th century with the *tetragram* from Guido d'Arezzo. Since then, it has been evolving and adapting itself along with evolution of musical language [1], until conforming its modern version.

However, conventional music notation presents a number of systematic problems [1]; for instance:

- Pitch distances are not equally distributed along the vertical axis.
- Octave equivalence is not usually present in notation
- The use of accidentals might lead to a variety of signs for representing the same sound (enharmony)

In addition, conventional notation takes as a reference the C Major scale. Consequently, writing music *far* from the C Major diatonic scale might lead to understandability reduction. Figure 1 shows an excerpt from Franz Liszt's "Hungarian Rhapsody No.2", in F# Major (extracted from [2]). F# Major is the farthest diatonic scale from C Major (they only share two notes), and furthermore the passage has numerous accidentals.

In order to reduce the aforementioned problems, a large number of alternative notation systems has been proposed. Thomas Reed [3] gathers more than 500 different notations, being the earliest of them (by H. Richter) first documented in 1847. Reed also founded the *Music Notation Modernization Association* (MNMA) in 1985, which was the predecessor of the present *The Music Notation Project* (MNP), founded in 2008. The MNP's mission is "To raise awareness of the disadvantages of traditional music notation, to explore alternative music notation systems, and to provide resources for the wider consideration and use of these alternatives" [4].

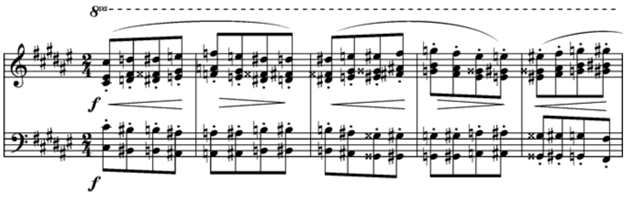

Figure 1. Score excerpt from Franz Liszt's "Hungarian Rhapsody 2"

The Music Notation Project has even presented a set of design criteria for new notation developments [5], based on the evaluation considerations of a notation comparison performed by the MNMA. The seventeen criteria emphasize the importance of concepts such as ease of writability and readability, flexibility, pitch-distance and time-distance proportionality, or octave periodicity.

However, none of those systems have been widely accepted. Parncutt proposes several explanations for that fact, highlighting the lack of a big score collection as one of the biggest potential handicaps [1, 6].

Therefore, we present a new music notation environment, called the *Bigram*, which is currently under active development. Despite its resemblance with other existing notation systems, as we will present in Section 2.2, the main strength of our proposal lies on the fact that it tries to avoid the aforementioned handicaps (lack of written material). Accordingly, the Bigram environment is divided into three main areas:

- *Bigram Notation*, a state-of-the-art notation system which meets the MNP criteria

- *Binary Keyboards*, layout-modified keyboards with high resemblance to the Bigram Notation
- *Bigram Editor*, a graphical software score editor with automatic transcription and reproduction capabilities.

Those three areas will be discussed in detail in the following Sections 2, 3 and 4, respectively.

2. BIGRAM NOTATION

2.1 Notation vs. Tablature

Traditional keyboard layout and conventional notation system share the inner structure of white keys - non-accidental notes (and, of course, *full considered* note names); therefore, conventional notation might be considered a special interpretation of keyboard tablature.

Parncutt [1] introduces the idea that, for beginners, tablature notation might be the most appropriate, due to its easiness. However, experimented interpreters might prefer conventional notation, for its resemblance with our bidimensional perception of pitch and time.

This fact gives us the opportunity to explore a new approach to musical notation. What if we could design a notation that could resemble clearly the pitch-time graph, but at the same time be an explicit representation of the finger positions in the keyboard? Such a system would be, according to Parncutt, convenient for both beginner and expert musicians, and would provide a faster learning process.

In order to reach that goal, a convenient keyboard layout should be designed. This keyboard will be discussed in Section 3.

2.2 Bigram

As a consequence of the previous idea, we developed the *Bigram Notation*. It takes its name from the fact that, in the staff, each octave presents only two equidistant lines, separated a tritone. Consequently, we preserve the octave periodicity, and minimize the cognitive overhead of counting lines to identify the note (both desired criteria from [5]).

Figures 2 and 3 show the A Major scale and the chromatic scale, respectively, written in bigram notation.

Figure 4 shows the same excerpt from Figure 1 in bigram notation.

2.2.1 Pitch representation

One of the most predominant characteristics of the bigram notation is the pitch representation by black and white noteheads. The A note was (arbitrarily) chosen to be represented over the first line, and to be black. When ascending in the chromatic scale, each new note presents a different color, alternating white and black noteheads (as in Figure

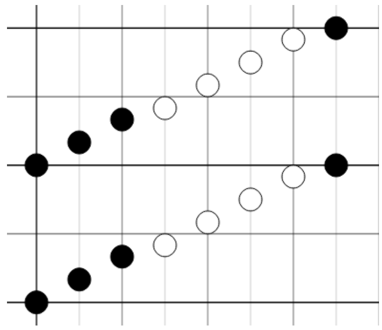

Figure 2. Bigram notation. The A Major scale

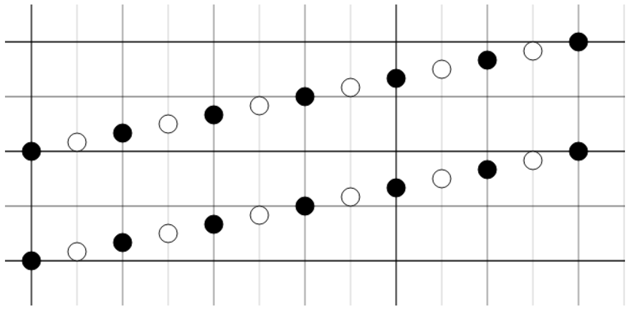

Figure 3. Bigram notation. The chromatic scale starting on A

3).
This approach causes the intervals to be color-consistent, making very explicit the inner structure of melodies and harmonies, and emphasizing intervalic reading [7]. In addition, it reduces the amount of required staff lines, facilitating note identification and minimizing cognitive overhead.

Notice that, in Figure 2, the semitone structure of the Major scale become self-evident. Furthermore, the Listz's excerpt (Figure 4) clearly reveals its structure: symmetric parallel chromatic movements, maintaining the voice's intervalic relationships.

The bigram pitch structure itself can be seen therefore as a combination of 6-6 black & white notehead systems (such as *Isomorph Notation* by Tadeusz Wójcik or *6-6 Klavar* by Cornelis Pot), with systems with staff lines separated a tritone (*MUTO Notation* by MUTO Foundation or *Express Stave* by John Keller, 2005) [3].

2.2.2 Rhythm representation

Regarding the rhythmic notation, we opted for a representation that preserves the time-distance proportionality, as suggested in the MNP criteria [5]. As in conventional notation, time is divided into bars. Each bar has a number of pulses, which have a number of divisions. Bars, pulses and divisions are represented by vertical lines, whose width is proportional to their position in the time hierarchy.

As an example, the scale in Figure 2 occupies one whole bar, with four pulses and two pulse divisions. The notes are placed in each one of the 8 bar divisions.

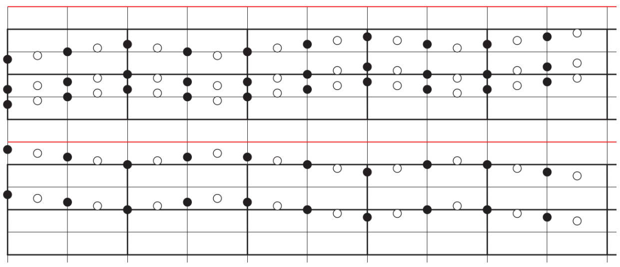

Figure 4. Bigram notation example from Franz Liszt's "Hungarian Rhapsody 2"

The notes are placed in the space that proportionally corresponds to a given pulse or division. When a irregular subdivision of pulse or division occurs, a number within a bracket or slur is used to indicate the transient subdivision.

Although notes are expected by default to last until next note, silence signs are also available. For other articulations, conventional signs are used.

2.2.3 Other Considerations

The bigram system fulfills each one of the seventeen design criteria for notation design established by the MNP. We must highlight that, although its development is subject to continuous evaluation, the potential changes that might occur will not change radically the basic ideas exposed here.

Regarding further extensions of the concept, the authors are investigating a compact and adequate way of representing harmony within the bigram context. Due to the interest of the authors on jazz, the research is focused on the most common 4-note chords and its variations.

3. MODIFIED INSTRUMENTS

3.1 Binary Keyboards

As already mentioned in Section 2.1, one of the strengths of the bigram notation is that it relies on the existence of keyboards with high resemblance to the written notation. With such instruments, it would be even possible to play a bigram notation score without knowing which notes are being represented (even though this practice is not recommended).

The authors are investigating on the prototype and fabrication of such keyboards, which are referred as *binary keyboards*. Figures 5 and 6 show two current working prototypes: a MIDI controller and a melodica, respectively. We believe that, even if the binary keyboard layout differs completely from standard layout, conventional piano playing techniques might be applied to binary keyboards, since both layouts share the two-rows key disposition.

The A notes are presented in the keyboards with a different color. This fact mimics the bigram notation, in which

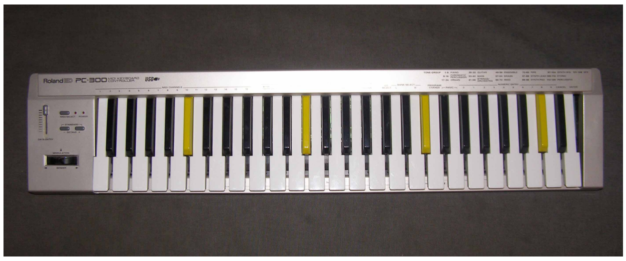

Figure 5. Binary MIDI keyboard prototype

Figure 6. Binary melodica prototype

the A notes are situated over the main staff line, and therefore used as a reference.

The authors are currently investigating the appropriateness of introducing tactile feedback cues, such as using different material or introducing marks. The tritone note (D#), which occupies the central line in the staff, might also present a distinction.

Those tactile feedback cues might be helpful both for visually impaired people, and for experienced players, which might need to know their hands position without looking to the keyboard (as experienced conventional piano players usually do using the cues of black keys' absence).

From the first insight into the binary keyboard layout, it is possible to become aware of one of its main benefits. Since it is *isomorphic*, there only exists two different positions for playing any passage - starting on a white key, or starting on a black key. This fact highly contrasts with the 12 potentially different positions in conventional layouts.

3.2 Similar approaches

The presented binary keyboard layout is not a new concept; first references to the idea appeared in 1859. In his book [8], K. B. Schumann presented his binary keyboard proposal, in a chapter called *"Das natürliche Sytem"* ("The natural system"). He also described there an alternative notation system based on a chromatic approach. In the same year, A. Gould and C. Marsh patented the binary keyboard in the USA [9], with the name "Keyboard for Pianos".

Bart Willemse gathers in his website [10] some other historic binary keyboard proposals, which he calls ”Balanced Keyboards”.

Another relevant approach can be found in 1882 in the *Janko keyboard* [11], which featured several rows of isomorphic keys. Among others, it did not succeeded commercially because of the lack of written material, due to the reticence of publishers (motivated in turn by the musicians' reticence) [11, 12].

The *Chromatone* [13] is a modern, digital revision of the Janko keyboard.

The *Tri-Chromatic Keyboard Layout* [14] is a layout designed by R. Pertchik, and implemented in his vibraphone. The layout is identical to the binary keyboard, excepting for the colors. Three different alternate colors are present, highlighting the minor third intervals (and, consequently, the three diminished chords).

We must also mention the Dodeka approach [15]. As in our research, Dodeka presents a notation system together with a modified keyboard. The notation system follows a regular pitch-space configuration, with 3 lines per octave. The keyboard is a representation of the notation system, with colour references each major third. However, all keys are placed in a single row, which might complicate playability and standard keyboard techniques adoption.

3.3 Conventional instruments

Despite the close resemblance of bigram notation with binary keyboard, the notation is potentially suitable to all kind of conventional instruments. Isomorphic instruments, such as orchestral strings, might appear beforehand as the most accessible instruments for bigram notation, due to their intrinsic representation of pitch and intervals. However, any other instrument might be potentially capable of performing bigram scores, if the relationship between notation and instrument notes is known.

4. THE BIGRAM EDITOR

As already commented, one of the major problems that alternative notation systems and keyboard layouts faced historically for their widespread adoption was the lack of a convenient score collection. For that reason, we decided to implement a bigram notation sofware, which could both serve as a score editor, and as a automatic transcriptor. We named that tool the *Bigram Editor*.

4.1 Implementation

4.1.1 Existing software for alternative notation

The MNP provides references of music edition software which supports alternate notations [16]. Two applications are shown as potentially compatible with alternative notations: *Finale* and *LilyPond*.

Finale [17] is a well known score editor. The MNP explains the method created by John Keller to convert between notation systems [16], by using *staff templates*. Therefore, it would be possible to create a bigram template, which might have a very low developing cost, and use it for our purpose.

However, in our opinion, Finale has some drawbacks. The most important of them is that it is proprietary software. We believe that a project such as the Bigram Editor, constantly evolving and with a high educational value, should be freely available and customizable - in other words, free software. Finale's platform dependency is also a disadvantage. Furthermore, its price ($600, $350 for students) makes it potentially prohibitive.

The other proposed alternative is LilyPond [18]. It is an original, WYSIWYM approach to score edition. Lilypond is highly flexible, and thus it is possible to define the score's appearance, allowing the usage of alternative notations. In addition, it is a muliplatform, free software editor.

Nevertheless, the text-based approach to score edition of Lilypond might represent a big usability problem for those not used to code or WYSIWYM interfaces. The Bigram Editor should encourage users to create music as soon as possible, minimizing the time spent on learning how to use the software.

4.1.2 Design considerations

Therefore, we opted for implementing our own custom Bigram Editor. Despite the increase in work load, the decision gave us the opportunity to fully adapt the software to our needs. The established design criteria were the following:

- WYSIWYG paradigm metaphor for creation and edition of scores, in order to facilitate its usage
- MIDI *import* functionality for automatic transcription of existing music
- Accordingly, MIDI *export* functionality for facilitating score exchange between different notations and applications
- Score reproduction
- Multiplatform and open source

We decided to implement our system with *SuperCollider* [19]. SuperCollider is an environment and programming language for real time audio synthesis and algorithmic composition [20]. Among others, it provides inbuilt GUI management functionalities, and MIDI in/out and parsing features. Furthermore, it is free software and platform-independent.

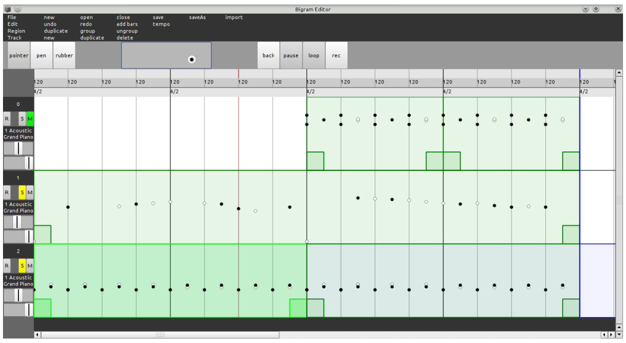

Figure 7. Bigram Editor : arrangement view

Although still in beta version, the Bigram Editor is already available at its code repository [21].

4.2 Features

The main interaction window is called the *Arrangement View* (see Figure 7) . It provides a general overview of the score in a multi-track sequencer style. Users can access from here to all available functionalities.

4.2.1 Tracks and regions

The musical material is organized into tracks or voices. Through the menus, the user can create, duplicate or delete tracks. For each track, following controls are provided:

- Track ID number
- Record/solo/mute controls
- MIDI instrument selector
- Panning and volume controls

Inside each track, users might place *regions*. A region is the structural element containing the notes. Three different tools are available for region managing:

Pointer Select a region and open the *Edit View*.

Pen Create a new region

Rubber Delete a region

Furthermore, it is possible to move, duplicate, merge and ungroup regions, through the mouse actions and/or the menus.

The *Edit View* (Figure 8) provides access to edit the music material. Users can insert, delete, duplicate or move notes using the *Input (I)* and *Edit (E)* controls. A binary keyboard reference is shown at the left margin of the score, along with the octave number.

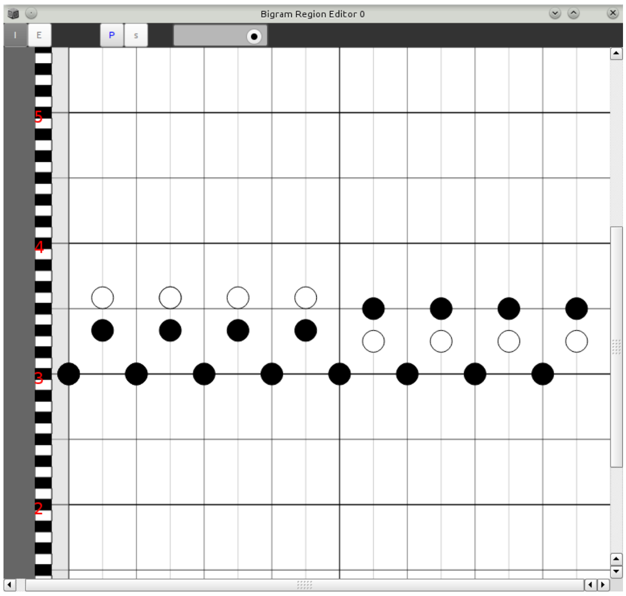

Figure 8. Bigram Editor : edit view

4.2.2 Reproduction

The *Arrangement Window* provides play/stop and loop reproduction controls; these are managed by the *reproduction bar* and the *loop bar* (vertical red and blue lines in Figure 7, respectively).

Sound is not synthesized by SuperCollider. Instead of that, the score is translated to MIDI and streamed in real-time to a MIDI synthesizer, which is platform-dependent. Currently, the system is using FluidSynth [22] for Linux, and default internal synthesizers for Windows and OSX.

4.2.3 File managing

The Bigram Editor provides file save and load functions. The score state is translated into a simple and custom description file based in XML. These files are generated automatically in the temporary folder every time a change in the score occurs; the undo/redo functions are built upon this functionality.

Furthermore, it is possible to import multi-track MIDI files from the menu in the *Arrangement Window*.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we presented the basis of the Bigram Notation, and the holistic approach to our alternative notation considering the notation theory itself, the modified keyboards, and the score editor.

Several experiments might be run in order to assess the usability of the Bigram Editor, in terms of Human-Computer Interaction. However, its usefulness is provided by the fact that it is currently the only available score editor for the bigram notation.

The authors have received good preliminary qualitative impressions from individual users that already started studying with the bigram system, using the software and the binary keyboards. Those impressions were specially remarkable in the case of people with few or very limited previous musical background or keyboard skills. We must remark that due to the current limited availability of binary keyboards, these test experiences cannot still be carried in a regular basis.

In the near future, an experimental case-study is planned, in order to evaluate the learning curve and the acquisition of musical skills in beginners, using the the bigram notation. That experiment would be a variant of the Parncutt's proposal [1], which has never been carried out. Such experiment would consist of two control groups of musical untrained subjects learning piano, one using conventional keyboard and notation, and the other using bigram notation and binary keyboards. The subjects' acquired musical knowledge (in terms still to be defined) would be evaluated over a broad enough period.

Regarding the Bigram Editor, a number of improvements might be implemented. One of the most relevant features would be the possibility of editing and exporting the score in a graphical format. That feature might allow to obtain high-quality scores in a printable version, for its usage without the computer.

Another potential improvement might be the adoption of the MusicXML markup language [23] for the description files. MusicXML is used by most of the score editors and Digital Audio Workstations; therefore, its adoption might widen considerably the range of available compositions for the bigram notation, and the score exchange possibilities.

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