

## Digital Koto Music Scores

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## 1 Introduction

Koto music originated in the seventeenth century and was traditionally taught orally, although modern koto students usually use written scores. Over the past century, several notation systems have been developed for preserving music in the Ikuta and Yamada schools of koto playing.

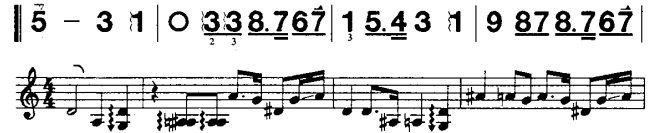
This paper describes a digital representation for koto music and a printing system for typesetting scores for koto performance. The printing system was designed in particular for non-Japanese koto students, since string numbers can be displayed in Arabic numerals rather than with kanji numbers. The format of the musical data closely resembles modern koto scores[1] and can be converted into other types of data such as MIDI or standard Western musical notation.

## 2 Koto-Humdrum Representation

The newly designed koto data representation is based on the Humdrum Toolkit for music research[2]. The format is text-based, so the data is easy to read and edit with any text editor. The Humdrum data format is useful for representing non-standard music repertoires and has been used to encode early Western music[3]. Figure 1 shows the first four measures of the traditional koto composition *Rokudan no shirabe* in the Koto-Humdrum format. The first column contains the koto score data, and the second column contains Kern-Humdrum data which is the standard format for representing Western music notation in the Humdrum Toolkit.

The koto representation consists of several types of symbols. The primary data components are the string numbers 1–9 plus the letters A–D used for strings 10–13. Rhythm is indicated by the symbols ‘|’, and ‘.’ which closely map to the beams and augmentation dots of Western music notation. With no rhythm qualifier, the duration of a string note is a quarter note. Beam symbols (‘|’) are added to indicate shorter durations, such as eighth-notes with one beam (e.g. ‘5|’) and sixteenth-notes with two beams (e.g. ‘5||’). Augmentation dots are added to lengthen string-notes, for example ‘5|.’ is a dotted eighth-note duration. The rest is represented by the number 0.

Strings are usually plucked with the right hand, while the left hand changes the pitch of the string. Left-hand techniques are indicated as modifiers of the string numbers in koto scores. In the example music given in figure 1, the symbol ‘o’ represents *oshi tome* (“push”) which is a glissando from the natural position of the string to a whole tone above the string’s natural pitch. The symbol ‘s’ represents the right-hand technique *sha* which is similar to an arpeggio in Western music. A full specification of the Koto-Humdrum format and all ornament encoding symbols are available on the internet[4].



**koto	**kern	**kuchi			
*tune[d:G:A:A#:d:d#:g:a:a#:dd:dd#:gg:aa]	*				
*M4/4	*M4/4	*			
5+H	2d	te	1c	4d	ton
-	.	n	5 .	8.d	koo
3	4A	ton	4	16A#	ro
1s	4d: 4G:	shan	3	4A	rin
=2	=2	=2	1s	4d: 4G:	shan
0	4r	.	=4	=4	=4
3 sb	8A: 8A#:	sha	9	4a#	chin
3 sc	8A: 8A#:	sha	8	8a	te
8 .	8.a	koo	7	8g	tsu
7	16g	ro	8 .	8.a	koo
6	8d#	rin	7	16g	ro
7 o	16g	chin	6	8d#	rin
.	16a	.	7 o	16g	chin
=3	=3	=3	.	16a	.
•	•	•	=5	=5	=5
			*-	*-	*

Figure 1: Sample music in Koto and Western notations.

Since koto strings can be tuned in any arbitrary manner, a description of the tuning is necessary at the start of the data for conversion to MIDI or Western notation. The second text line in figure 1 indicates what pitch to tune each string, in this case using the Hira tuning, the primary tuning of koto music. Other symbols in the koto representation are borrowed from the Kern-Humdrum data format. For example, ‘=’ is a barline, and \*M4/4 is the 4/4 time signature.

The third column in the text of figure 1 represents the original orally transmitted score. Mnemonic words called *kuchi-jamisen* (“spoken-instrument”) were originally used to help remember the music, but today most students of the koto instead use written scores. Pitch information is not exactly specified by *kuchi-jamisen*, which cannot be used by itself to reproduce a complete composition.

## 3 Koto printing system

PostScript has been chosen to print scores from Koto-Humdrum data since graphic objects can be flexibly scaled and placed anywhere on the page with this printing language. The layout of musical elements on the page goes through three main stages as illustrated in figure 2. First, the music is spaced in an ideal manner (line A), and a break in the music is determined. The music is then justified to fit within the margins (line B), and finally objects which do not affect width are added to the music (line C).

Musical elements which influence the width of the music include string numbers, barlines, the *sha* ornament and rhythm augmentation dots. Musical elements which do not determine the width of the music include most ornaments

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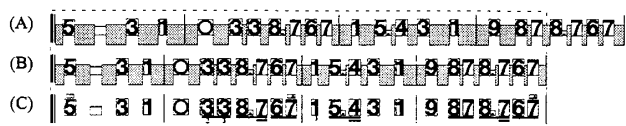


Figure 2: Line justification process.

(which are placed above the string numbers), fingerings, and rhythmic beams. The width-controlling musical elements are placed measure by measure from the left margin until a measure crosses over the right margin. Line (A) in figure 2 demonstrates this stage. Notice on line (A) that the last measure crosses over the right margin. If more than 50% of the measure falls inside the right margin, then the measure is kept on the current line; otherwise, the measure will be moved to the next line.

The spacing between musical objects on line (A) are determined by adding space before and/or after each musical object. The primary spacing is given by adding space after each note according to what the duration of the note is. A typical ratio between duration levels in Western music notation is about 1:1.6 when the duration ratio is 1:2. In addition to this duration spacing, extra space is placed according to the metrical position of notes to make the meter easier to read. Some items, such as augmentation dots or the *sha* ornament are attached to the primary duration objects before space is given to the primary duration objects.

Once the number of measures has been determined in stage one, the music must be justified to the right margin, either by expanding the line of music if the last measure was removed, or by shrinking the line of music if the last measure was kept. In figure 2, the last measure of music was kept, so the music must be shrunk to fit inside the margins. The width of musical objects on the line cannot change, only the spaces between objects can shrink. Each space will be reduced by the same fraction.

After music elements have been spaced and justified, vertical elements such as ornaments can be placed on the page in the third stage of music layout. Line (C) shows the addition of musical elements to the line of music which do not influence the spacing of the music. Once these secondary elements have been placed, the layout is complete, and the music can be displayed as shown at the top of figure 1.

## 4 Applications

### 4.1 Koto-Humdrum to Kern-Humdrum

The koto musical data shown at the bottom of figure 1 was entered manually in a text editor. The second column in figure 1 demonstrates automatically generated kern data. To convert from Koto to Kern-Humdrum format, the tuning of each string is provided with the `*tune []` interpretation so that an exact mapping of string number to pitch is easy to generate.

Most koto string ornamentations are realized in the Kern-Humdrum data translation. For example, the symbol `1s` is converted to two kern notes with an arpeggio marking: `"4d: 4G:"`. The symbol `7 | o` is translated to the two notes `16g` and `16a`.

Converting koto data into the kern format enables the use of many programs written for processing kern data in the

Humdrum Toolkit. For example, there are programs which convert kern data into MusicXML[5] for printing or into MIDI files for listening, as well as program tools to analyze structure and content of kern musical data.

### 4.2 Kern-Humdrum to Koto-Humdrum

Converting from Western-style notation into koto notation does not have a unique solution. Koto strings can be tuned in several ways by moving the bridges, however it is not acceptable for players to change the string tunings often. Therefore, we have defined the following two tunings for converting Western music in major keys into koto notation:

C major: C4 D4 E4 F4 G4 A4 B4 C5 D5 E5 F5 G5 A5

G major: C4 D4 E4 F#4 G4 A4 B4 C5 D5 E5 F#5 G5 A5

To convert music, the original key of the music must be transposed into either C or G major depending on the range of the pitches. The Krumhansl-Schmuckler pitch-profile algorithm is used to determine the original key[6]. The range of notes above and below the tonic pitch are then compared, and either C or G major is chosen as the transposed key. The Essen Folksong Collection[7] notated in the Kern-Humdrum format has been converted to the Koto-Humdrum format for performance with kotos.

## 5 Conclusions

Further issues are as follows: work is underway to develop a program which converts koto scores into a simulated performance in the MIDI format where the string sounding durations closely match a real koto performance. Also, we plan to convert Western classical music scores notated in Humdrum, MuseData[8], and MusicXML formats into koto performance scores. The koto pitch range is too small for Western instrumental music, therefore it will be necessary to arrange the original pieces for a more limited range.

The advantages of our system are as follows: (1) koto scores can be notated in an electronic format and can be used as a database. (2) koto scores can be easily edited and printed. (3) koto scores can be converted to the Western style and can be analyzed by using general analysis tools as well as played using MIDI. (4) Western music scores can be converted to koto scores. Many scores notated in Kern-Humdrum are available for printing as koto scores. Also, new pieces can be written in the Western style and can easily be converted into the koto score style. Some pieces converted by this system will be used in a class for introducing koto music at Stanford University.

## References

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