A COLLECTION OF MUSIC SCORES FOR CORPUS BASED JINGJU SINGING RESEARCH

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ABSTRACT

The MIR research on jingju (also known as Beijing or Peking opera) music has taken audio as the main source of information. Music scores are an important resource for the musicological research of this tradition, but no machine readable ones have been available for computational analysis. In order to explore the potential of symbolic score data for jingju music research, we have expanded the Comp-Music Jingju Music Corpus, which contains mostly audio, with a collection of 92 machine readable scores, for a total of 897 melodic lines. Since our purpose is the study of jingju singing in terms of its musical system elements, we have selected the arias used as examples in reference jingju music textbooks. The collection is accompanied by scores metadata, curated annotations per score and melodic line, and a set of software tools for extracting statistical information from it. All the gathered data and developed software are available for research purposes. In this paper we first discuss the culture specific concepts that are needed for understanding the contents of the collection, followed by a detailed description of it. We then present a series of computational analyses performed on the scores and discuss some musicological findings.

1. INTRODUCTION

In recent years, jingju (also known as Beijing or Peking opera) music received an increasing attention from MIR researchers for tasks such as mood recognition [7], pitch contour analysis [8, 12, 13, 21–23], lyrics to audio alignment [10], timbre analysis [11, 17], percussion analysis [16, 19], and structural segmentation [18], all of them taking audio as the main source of information. In order to carry out these tasks, several corpora for jingju music research were gathered. The Jingju Music Corpus gathered in the Comp-Music project [14] contains a collection of commercial audio recordings and their metadata, as well as some datasets for specific tasks. [1] The corpus built in [18] also consists of

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[1] http://compmusic.upf.edu/corpora

commercial recordings, annotated for structural segmentation analysis. Only the corpus created in [7] [2] contains a cappella recordings made by its authors, as well as annotations for the task of mood recognition.

The core component of jingju music is singing. In order to study the musical system developed in this tradition (see Section 1.1) it is therefore essential to analyse the sung melodic line. However, extracting its pitch contour from commercial recordings did not produce fully satisfactory results [13]. On the other hand, the a cappella recordings contained in the corpus gathered in [7] do not cover the whole jingju musical system and are not annotated for this goal, since it was created for a different purpose. Music scores are a meaningful alternative to audio recordings. The lack of MIR research based on jingju scores could be possibly motivated for two reasons: the secondary role that music scores play in this tradition (see Sections 1.1 and 1.2), and the lack of music scores in machine readable format available for computational analysis.

The goal of the Jingju Music Scores Collection (JMSC) presented in this paper is to offer a comprehensive and complete resource for the study of jingju singing in terms of its musical system. That is to say, jingju singing, as opposed to instrumental accompaniment, is taken as our research object with the aim of understanding not its acoustic or intonation characteristics, but the elements that build the jingju musical system.

1.1 Jingju Musical System

When talking about music in jingju, there are two important general considerations to take into account. First, jingju is a theatrical genre, in which the main structural element is the dramatic plot. Music, as the rest of the disciplines that integrate this comprehensive art form, is at the service of this dramatic goal, which implies that lyrics determine the music structure. Secondly, jingju music originated as folk music, [3] a fact that carries two implications. This music was not traditionally created by a composer, but arranged by the actors and musicians from a repository of folk tunes to fit the lyrics of new plays. Secondly, it has been orally transmitted, and even nowadays written material takes a secondary role.

In order to convey the expressive needs of the dramatic plot, music in jingju has been deeply convention-

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[2] http://isophonics.net/SingingVoiceDataset
[3] During the 20th century it evolved into composed music.
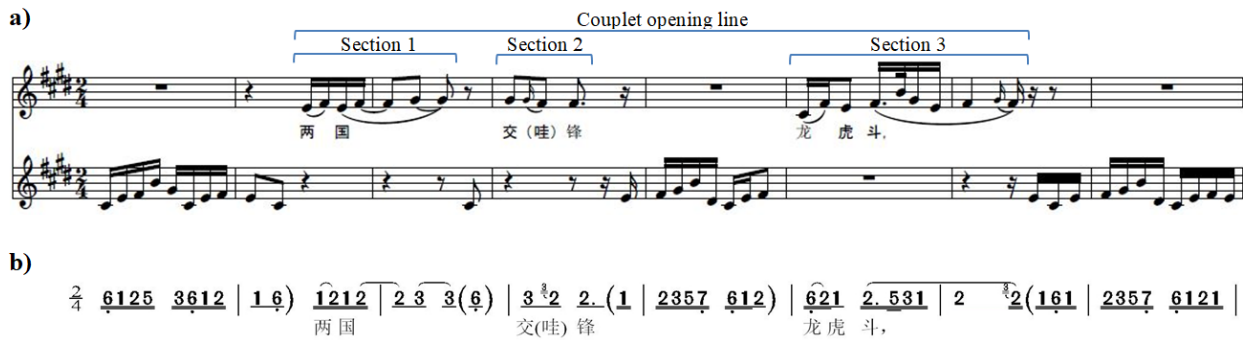
Figure 1. Example of a couplet opening line and its corresponding melodic line, both in its original *jianpu* notation (b) and the transnotated version (a) in JMSC. The three sections of the line are marked.

alised according to three elements that form its musical system, namely *shengqiang*, *banshi*, and role type. Each of the original folk tunes upon which jingju music was built evolved into a melodic framework called *shengqiang*, and it was associated to a specific emotional atmosphere. Although jingju uses many of them, *xipi* and *erhuang* are the ones that give this genre its musical identity.

More precise expressive functions are achieved by rhythmic transformations of the *shengqiang*'s melodic framework. Each of these transformations is codified in a pattern called *banshi*. There are about 12 commonly used ones, although no fixed number is agreed in the literature. The *banshi* in which the melody is conceived as the closest form to the *shengqiang*'s original tune, in medium tempo and 2/4 metre, is called *yuanban*. *Manban* is conceived as the transformation of *yuanban*'s melody to the slowest tempo range and 4/4 metre, *kuaiban* is conceived as its transformation to the fastest tempo range and 1/4 metre, and each intermediate tempo range forms a different *banshi*. Besides, there is a set of *banshi* in which the melody is rendered in different forms of free metre.

The third element is the role type (that can be understood as an acting profile), which the singing character belongs to. There are four broad categories of role types, with different degrees of subdivision. In terms of the musical system however, all of them can be classified in either the male or female styles of singing, represented respectively by the role types *laosheng* and *dan*.

A last important factor to consider is the lyrics structure, which determines the musical structure of the arias.[4] The lyrics of jingju arias are arranged in couplets, and each of the two lines of the couplet is usually subdivided in three sections. The melodic unit in jingju corresponds to the line of lyrics, so that each *shengqiang* defines a melodic line for the opening line of the couplet, and another one for the closing line, both of them subdivided into three melodic sections corresponding to the poetic ones (see Figure 1). One single aria is usually set to only one *shengqiang*, but according to its expressive content, it can contain different *banshi*. When dialogues are set to music, characters of the same or different role types can sing in the same aria.[5]

1.2 The Concepts of Work and Score in Jingju

Before describing the collection, two more considerations are needed to be taken in order to completely understand its usability and representativeness of the repertory. As stated in Section 1.1, jingju music was originally created and transmitted orally. Professional performers rarely rely on music scores, but try to convey what they learnt from their teachers, although inevitable changes occur in this transmission line. Therefore, music scores are notations of preexisting music, either for documentation purposes, or as learning material for amateurs. Most scores do not reference a source, what might indicate that the author is notating what he or she recalls as a standard version. Consequently, different score editions of the same work present noticeable discrepancies, and very rarely any of them perfectly matches a commercial audio recording of that work, although the melodic core generally is common to all.

The final remark has to do with the very concept of work.[6] The plots of jingju plays are rarely original, they are taken from well-known historical events, literary works or legends. Hence, a jingju play is just a passage from a greater encompassing story already known by the audience. Furthermore, since jingju plays did not have an author, but were adapted from these preexisting stories, performers have the possibility of adapting those passages to the needs of a specific performance. As a consequence, the title of a play always refers to the same plot, characters and usually the same set of arias, but specific performances can omit, extend or modify certain elements.

In a similar way, arias are sung passages of greater encompassing dramatic plots. Although most of them have musical signals indicating their start and end, they are usually intermingled with acting and reciting sections, what blurs their limits. When recorded or notated for commercial releases, the arias are named after its first line, but different performers or transcribers might have different criteria for deciding how to delimit the aria or how to deal

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[4] Although translating the original term *changduan* as aria might cause some misconceptions, for the sake of clarity we will use this term throughout the paper to refer to sung sections in a jingju play.

[5] For a more detailed description in English of the jingju musical system, please refer to [20].

[6] We take the term work from MusicBrainz's terminology as "a distinct intellectual or artistic creation" (https://musicbrainz.org/doc/Work).

with non musical interpolations. For example, an aria set to more than one *banshi* can be recorded or transcribed in one release as a unit, whilst in another release each *banshi* can be listed separately. All these considerations pose important challenges for organizing our collection and integrating it in our Jingju Music Corpus (see Section 2.3).

The remaining of the paper is structured as follows. In the next section the jingju music scores collection is described in detail. In Section 3 we present computational analyses performed on it, and some musicological findings are discussed in Section 4. In the last section we present some concluding remarks and point out future work.

2. DESCRIPTION OF THE COLLECTION

2.1 Sources and Generation Process

In order to ensure the representativity of the selected scores, we have taken as sources three jingju music textbooks [3–5]. These textbooks have been suggested as reference works for the study of the jingju musical system by professors from the National Academy of Chinese Theatre Arts (NACTA), where the first author did field work. In these textbooks, the explanations of the music elements presented in Section 1.1 are illustrated with specific arias. In [5] and [3], the scores were given directly in the textbook. In the case of [4], some scores were given, while others were referenced by title.

	laosheng	dan	laosheng+dan	total
erhuang	20	17	1	38
xipi	24	27	3	54
total	44	44	4	**92**

Table 1. Content of JMSC, according to role type and *shengqiang*

To build JMSC, we have taken the arias used to illustrate the main metred *banshi*, namely *yuanban*, *manban*, and *kuaiban* (see Section 1.1), as they are used in the two main *shengqiang*, that is, *xipi* and *erhuang*, for the two main role types, *laosheng* and *dan*. When other related *banshi* are explained together with these, their sample arias have been also included in our collection. Those only referenced by title in [4] have been looked for in two printed scores collections that accompany our Jingju Music Corpus [1, 2]. Only eight have not been found. If different scores for the same aria occur, all versions have been included. As a result, JMSC contains 92 scores covering 80 arias. Table 1 shows the distribution of scores per role type and *shengqiang*. *Banshi* is not included here because some arias contain more than one. However, since the main melodic unit is the line, the information in Table 2 is a better representation of JMSC's potential for the study of the jingju musical system elements. All the arias have been included in its full original form, resulting in some samples of other instances of the musical system elements also being present in the collection, as shown in Table 2.

The original sources use a style of cypher notation called *jianpu* (see Figure 1.b). We transnotated them man-

	daeh	daxp	lseh	lsxp	total	ldeh
manban	72	50	66	17	205	
sanyan			12	17	29	2
zhongsanyan	6				6	
kuaisanyan	14		26	6	46	
yuanban	54	55	112*	47	268	
erliu		12			12	
liushui		121		78	199	
kuaiban		47		85	132	
total	146	285	216	250	**897**	
daoban		1				
sanban		2	2	3		
yaoban		1	1	8		
*kutou			4			

Table 2. Content of JMSC per melodic line, according to role type, *shengqiang* (columns), and *banshi* (rows). On the upper heading, *da* stands for *dan*, *ls* for *laosheng*, *ld* for *laodan*, *eh* for *erhuang* and *xp* for *xipi*. Gray background indicates samples of instances not considered as focus of our research.

ually using MuseScore 2.1 [7] to staff notation, and exported them to MusicXML format. Since both notation systems are based in the same principles, the transnotation was straightforward. The main decision taken was the key, not given in the sources. [8] We unified all the scores in E major, a common key for the two role types considered, as stated in the reference textbooks.

Jingju singing is accompanied by an instrumental ensemble in heterophony. Therefore, in order to represent the instrumental accompaniment it is customary to only notate the lead instrument in the ensemble, namely the jinghu, in an independent staff. In these cases, both the voice and the instrumental lines are notated in different staves in our transnotation. In other cases, since the voice and the instrumental ensemble conceptually play the same melody, the original *jianpu* notation represent both in one single staff with the instrumental sections in brackets, as shown in Figure 1.b. In those cases, our transnotation divides the original single staff into two, one for the voice and one for the accompaniment, as shown in Figure 1.a. Of the 92 scores, 53 (57.61 %) of them contain full accompaniment.

2.2 Coverage, Completeness and Reusability

Serra proposes in [15] five criteria for building research corpora which we followed for creating JMSC. Among them, *purpose* has been described in detail in Section 1, and we argue that the *quality* of the scores is assured insofar as our transnotation, as described in Section 2.1, maintains all the information contained in the original sources. Therefore, we discuss here the remaining criteria.

In terms of *coverage*, the collection includes the two main *shengqiang*, *xipi* and *erhuang*, and the two main role types, *laosheng* and *dan*. In order to evaluate their relevance for jingju music research, we have measured their occurrence in the recordings collection of the CompMusic Jingju Music Corpus, as published in [14]. *Xipi* and

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[7] https://musescore.org/
[8] The specific tuning is chosen, within a certain range, according to the performer's needs.

erhuang stand for 80.25 % of the *shengqiang* present in the recordings collection, and *laosheng* and *dan* stand for 73.66 % of the role types. The whole range of metred *banshi* is represented in the collection, with special focus on *yuanban, manban, liushui* and *kuaiban* (see Table 2), as the most relevant ones (see Section 1.1). There are two main reasons for excluding the non-metred ones: metred *banshi* present more direct relations between them, what facilitates the study of the transformation processes. On the other hand, we are still looking for a satisfactory method to process non metred melodies. There also exist a few auxiliary *banshi*, whose occurrence is very occasional, and therefore no representative of the norm.

Considering *completeness*, the collection contains the metadata of the scores and annotations both at the score and the line level, organised in separate spreadsheets. For the scores, the metadata contain the title of the work in Chinese, role type, *shengqiang*, *banshi*, whether it contains full accompaniment (see Section 2.1), the reference of the original score, and if existing, the list of the MusicBrainz IDs of the recordings in our Jingju Music Corpus corresponding to the same work as the score. As for the lines, each of them is annotated with the role type, *shengqiang*, *banshi*, line type, that is, opening—which in the case of *erhuang* is divided in two types—or closing, the lyrics for the whole line and for each of its sections, the linguistic tones of the lyrics, and the starting and ending offsets of the line and each of its sections. Annotations have been done by the first author, linguistic tones have been extracted automatically [9] and corrected manually by the first author and by a Chinese native speaker knowledgeable about jingju, and specific doubts about line segmentation have solved by two professors in NACTA.

Regarding *reusability*, all the scores, including metadata and annotations, are available for research purposes. Due to copyright issues, they are only available on demand, by contacting the authors.

2.3 Integration in the Jingju Music Corpus

JMSC was gathered as part of the Jingju Music Corpus from the CompMusic project, also created with the purpose of studying jingju singing in terms of its musical system elements. To exclude the influence of academic compositional techniques applied to jingju during the 20th century, only plays from the traditional repertoire were considered for the corpus, including JMSC. Consequently, two samples of revolutionary plays from [5] were discarded.

The scores are integrated in the corpus via the work they represent. If a particular recording in the corpus contains a performance of a work to which a particular score is related, due to the circumstances described in Section 1.2, it can not be assumed that the recording contains a performance of the score. Consequently, scores and recordings are indirectly related through works. Taking this into account, 63 of the 92 scores (68.48 %) are related to works associated to one or more audio recordings.

2.4 Potential of the Collection

JMSC has great potential for the computational research of jingju singing in terms of its musical system elements. In the following section we present statistical analyses with that aim. However, it is also suitable for other research tasks. Since the variety of melodic material is conceived as transformations of original tunes, these scores offer an excellent opportunity for pattern discovery and similarity analysis. These tasks can benefit from the accompanying annotations to develop culture specific heuristics. The annotated linguistic tones for the lyrics allow the research of their relationship with melody using symbolic data, whilst such studies have been carried out so far using only audio [22, 23]. Since the scores contain full or partial notation of the accompaniment, they are a good resource for the analysis of the relationship between the singing and instrumental lines. Finally, although scores and recordings are not directly related, the similarity between those which share a common work still allows combined analyses.

3. ANALYSES PERFORMED ON THE JINGJU MUSIC SCORES COLLECTION

In order to take advantage of JMSC, we have extracted statistical information with the aim of testing musicological claims made in the reviewed literature [3–6, 20]. To process the scores we have used the `music21` toolkit [9], and the developed code is openly available. [10] We introduce now the four types of features considered for analysis, together with their musicological motivations:

Pitch histograms. Jingju music is based on an anhemitonic pentatonic scale, each of whose degrees can be the finalis of a mode (*diao*), a defining characteristic of each *shengqiang*. Hence, *xipi* is associated to the *gong* mode, which has the first degree as finalis, and *erhuang* to the *shang* mode, whose finalis is the second degree. The 4th and 7th degrees, usually omitted, can be used as expressive notes. Male and female styles of singing, represented by the *laosheng* and *dan* role types are defined by different pitch registers. Pitch histograms can help to gain a deeper understanding of pitch distributions for each *shengqiang* and pitch register for each role type, as well as to evaluate the role of the expressive notes.

Interval histograms. One of the melodic features given in the literature for distinguishing *xipi* from *erhuang* is that it uses larger intervals. Analysing intervals through histograms will shed light upon this claim.

Cadential notes. One of the more common characteristics given in the literature when comparing *xipi* and *erhuang*, and closely related to their modal associations, is a schema of cadential notes (*laoyin*) for each line of the couplet and each of their three sections.

Melodic density. Understood as the proportion of notes per syllable, this feature is used for characterizing *banshi*, arguing that the slower the *banshi* is, the more notes are used for singing each syllable.

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[9] The software used for extracting the linguistic tones can be obtained here: https://github.com/zangsir/Native-to-Pinyin

[10] https://github.com/MTG/Jingju-Scores-Analysis/releases/tag/v1.0

Our code computes the aforementioned features for any combination of role type, *shengqiang*, *banshi* and line type. Histograms show blue bars for *laosheng* and orange ones for *dan*, whilst *shengqiang* is indicated by the hatch, \ for *xipi* and / for *erhuang* (see Tables 3, 4, and 5). A solid red line marks the first degree (E4) in pitch histograms, and a dashed one its higher octave (see Tables 3, and 4). Interval analysis can consider interval direction or not. Cadential notes are computed for each section of the line, distinguishing opening and closing lines (see Table 6). Melodic density box plots show results for individual scores and for the average of all of them (see Table 7).

For this paper we computed the four aforementioned features for the whole collection considering all the combinations of role type, *shengqiang*, and *banshi*. For a first approach to the results, we grouped the *banshi* in three groups: *yuanban* and *erliu*, in 2/4 metre and medium tempo ranges; *manban*, *sanyan*, *zhongsanyan* and *kuaisanyan*, in 4/4 metre and slower tempo ranges than the previous group; and *kuaiban* and *liushui*, in 1/4 metre and faster tempo ranges than the first group. To ease readability, each group is referred to in the next section by the first *banshi* of the group. All the resulting plots are available. [10]

4. DISCUSSION OF THE RESULTS

From the results of the aforementioned analyses we have obtained the following musicological findings. Pitch histograms in Table 3 show that the role types *laosheng* and *dan* are well defined in terms of pitch range. The predominance of the 5th and 6th degrees for *dan* (B4 and C#4) is explained in the literature as a transposition of the modal center a fifth higher. In terms of pitch distribution, it can be observed that the finalis of each of the modes associated to each *shengqiang*, namely 1st (E4) for *xipi* and 2nd (F#4) for *erhuang*, or their transpositions a fifth higher for *dan*, are in fact the most predominant pitches, but not very far from other degrees. The exception is *laosheng erhuang*, whose most predominant pitch is the lower 6th degree (C#3), and that can be characterised by a relatively major importance
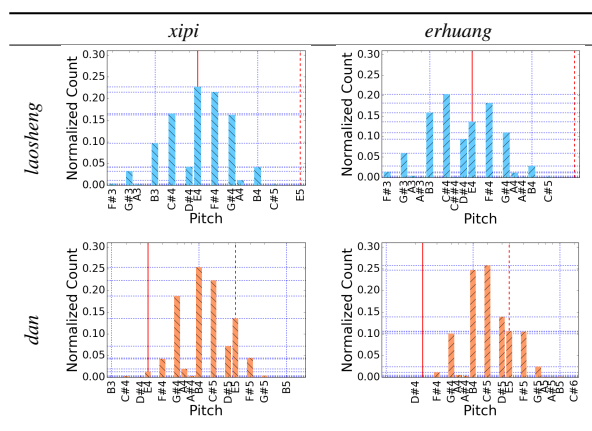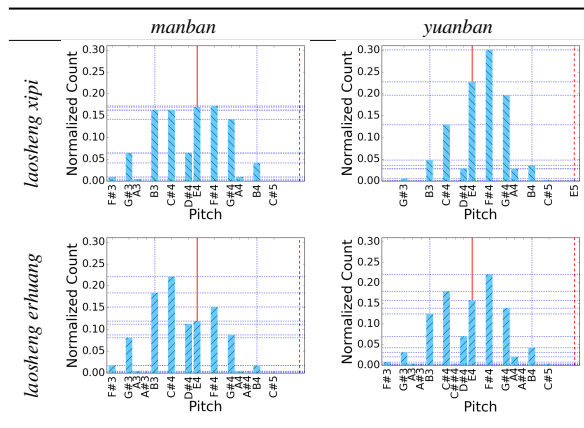

Table 4. Pitch histograms for the role type *laosheng*, comparing the *banshi* groups *manban* and *yuanban* for the *shengqiang xipi* and *erhuang*

of the lower region of its register. The use of the 7th degree (D#4) is also remarkable, specially prominent for *dan*, what can be explained by the transportation of the modal center, resulting in that this pitch acts as a 3rd degree. The 4th degree (A4) appears, but very rarely, and also its sharpened version (A#4). The appearance of these two versions could be due to the fact that its absolute tuning differs from the equal temperament [8], and transcribers use different approaches to notate this pitch.

We have also found that pitch histograms are useful for characterizing different *banshi*. In Table 4 it can be observed how slow *banshi* (*manban* group) explore lower pitch regions than the ones closer to the original tune (*yuanban* group). That is especially relevant in *xipi*. It can also be observed how the former make a more frequent use of the expressive tone D#4, the 7th degree.
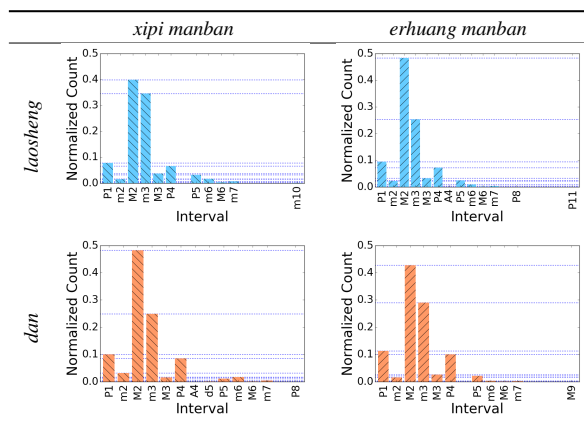

Table 3. Pitch histograms for the role types *laosheng* and *dan*, and the *shengqiang xipi* and *erhuang*. All *banshi* included

Table 5. Interval histogram for the role types *laosheng* and *dan* and the *shengqiang xipi* and *erhuang*, considering only the *banshi* group *manban*

Our findings on interval distributions support the musicological claims stated previously, but also help to observe some nuances. Table 5 shows that, in the case of *laosheng*, diatonic steps are more frequent than minor third
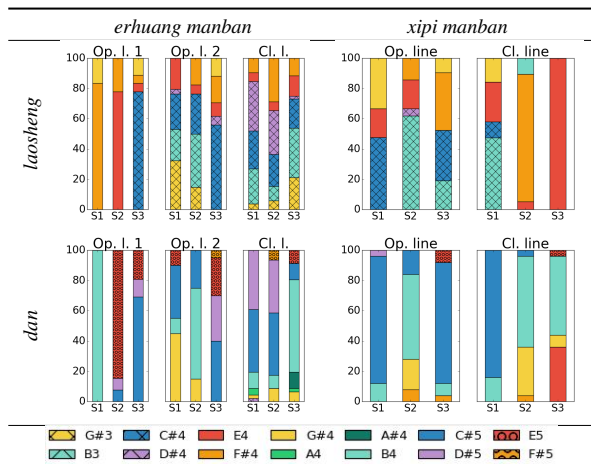
Table 6. Cadential notes in the *banshi* group *manban* for the role types *laosheng* and *dan* and the *shengqiang erhuang* and *xipi*, for opening (Op.) and closing (Cl.) lines in each of their three sections (S1, S2, and S3)

steps in *erhuang* than in *xipi*. However, in the case of *dan*, the results do not support the claim. In all cases, it can be observed that intervals larger than the minor 3rd are rare in both *shengqiang*, with the exception of the perfect 4th, whose distribution is similar in the four cases. Consequently, the major use of large intervals in *xipi* as compared with *erhuang* can be nuanced in light of these plots.

It is an agreement in jingju music literature to define *laosheng xipi* as cadencing in the 2nd degree for the opening line of the couplet, and in the 1st degree for the closing line, and *erhuang* as the opposite, 1st degree for the opening line and 2nd degree for the closing line. In the case of *dan*, cadences will be 6th and 5th degrees for opening and closing lines in *xipi*, and higher octave 1st and 5th degrees for *erhuang*. Different sources refer with different degrees of precision to cadential notes for each section of the line and to exceptions to these general rules. Focusing now only in line cadential notes, that is, those for section 3 (S3), Table 6 shows that only closing lines in *laosheng xipi manban* completely match the rules given previously, presenting the 1st degree (E4) as cadential note in all cases. As for *laosheng erhuang manban*, the cadential notes established in theory occupy a very small percentage, especially noticeable in opening line 1. That is also the case for *dan erhuang*, which presents a more varied range of possibilities for cadential notes than *dan xipi*, and where those established in the literature stand only for a minimum percentage in opening lines.

Finally, Table 7 shows how different *banshi* groups can be characterized in terms of melodic density. The duration unit for measuring a syllable length is the crotchet. Two aspects are interesting in these plots. The median for each group shows, as expected, that sung syllables are longer as the tempo decreases, and compared with *laosheng*, the *dan* role type shows slightly higher median values in *yuanban*. But the outliers also provide meaningful information. These correspond to a singing feature known as *tuoqiang*,
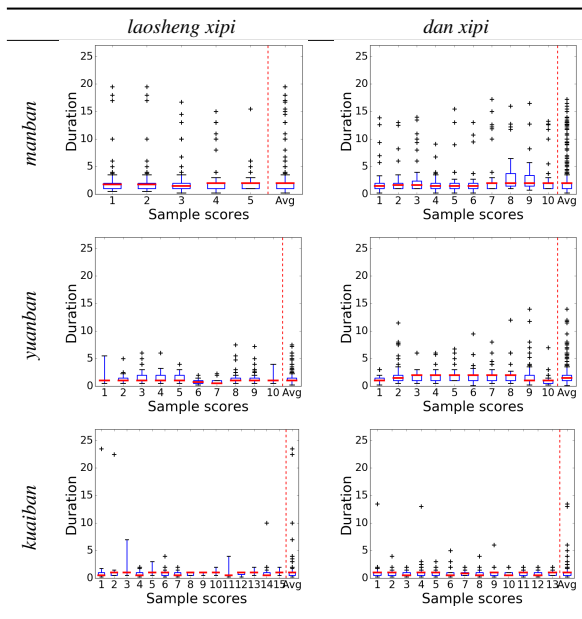
Table 7. Melodic density for the *banshi* groups *manban*, *yuanban*, and *kuaiban* and the role types *laosheng* and *dan* in the *shengqiang xipi*

literally "dragged tune", by which the melody of a syllable, usually at the end of a line or a line section, is extended by a long melisma. Table 7 shows how much more frequently this phenomenon occurs in *manban* than in *yuanban*, and how it is almost non-existing in *kuaiban*. However, when it appears in this *banshi*, it can be longer than in *yuanban*.

5. CONCLUSIONS AND FUTURE WORK

In this paper we presented the first collection of machine readable scores for the study of jingju singing in terms of its musical system elements. It includes 92 scores covering 897 melodic lines, and is accompanied by their metadata and curated annotations per score and melodic line. The collection is part of the corpus gathered in the CompMusic project for jingju music research. Its potential for jingju singing analysis has been tested by a series of statistical analyses, and some musicological findings have been discussed. The whole collection, together with the metadata, the annotations, and the developed code are available for research purposes.

In future work, it is expected to expand the collection by including other instances of the musical system elements that are not currently present, especially non metred *banshi*. At the same time, the collection's potential, as pointed out in Section 2.4, will be exploited for different research tasks. Among them, pattern discovery is a promising topic, since the accompanying structural annotations can be used to design heuristics to incorporate to state of the art approaches, as well as the analysis of the relationship between linguistic tones and melody. Most importantly, we hope that JMSC contributes to open up a new range of possibilities for MIR research on jingju music.

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