VIBRATO CHARACTERISTICS AND FREQUENCY HISTOGRAM ENVELOPES IN BEIJING OPERA SINGING

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1. INTRODUCTION

Beijing opera, also known as Peking opera, is the predominant opera genre in China. The compound art form comprises of singing, instrumental playing, and acting. There is now growing interest in the study of Beijing opera from a computational perspective in recent years. Repetto & Serra (2014) created a dataset of sung Beijing opera melodies for computational analysis. Tian et al. (2014) investigated onset detection for Beijing opera percussion instruments using non-negative matrix factorization. Srinivasamurthy et al. (2014) utilized a Hidden Markov Model to transcribe and recognize percussion patterns. Sundberg et al. (2012) studied acoustically the singing for two Beijing opera roles, Laosheng and Dahualian, and found that the singing sound pressure level and pitch are higher than that of speech; furthermore, the vibrato rate was reported to be around 3.5Hz, which is lower than that generally found in Western classical singing. However, research into the expressivity of the featured singing and instrumentation in Beijing opera is still lacking in the literature.

Oriental opera singing possesses characteristics distinct from Western opera. This study aims to investigate the expressive characteristics of Beijing opera singing focusing on pitch and vibrato. Like the Sundberg et al. study, we will also focus on two major Beijing opera roles, those of Laosheng and Zhengdan. Our study involves a larger dataset, 16 performances instead of 7. While Sundberg et al.'s study focused on sound pressure level, pitch, and long-term average spectra, with vibrato being a side discussion, we will consider frequency distributions and details of vibrato parameters such as rate, extent, and sinusoid similarity.

We choose to focus on pitch because it is one of the most important features in computational music analysis; this is also true for analysis of world music. For example, Koduri et al. (2012) examined pitch histograms in Indian Carnatic music. Similar research is lacking for Beijing opera singing. Moreover, Chinese traditional music relies on a system with unique characteristics different from that of other music cultures (Tian et al., 2013).

Vibrato is one of the most important ornamental performing techniques in Beijing opera (Wichmann, 1989). Investigation into the nature of vibrato use in Beijing opera singing will thus assist in the understanding of the overall plots and the motifs of the story and the roles. We are also interested in investigating the relationship between vibrato use in singing vs. in the main instrument, i.e. jinghu, in Beijing opera. Jinghu is the predominant instrument and frequently doubles the singing voice in Beijing opera, but we lack vibrato statistics for the instrument. The jinghu and erhu belong to the same two-stringed instrument family, and possess similar form and, we anticipate, vibrato characteristics. In order to compare Beijing opera singing and jinghu vibrato characteristics, we use data previously established for the erhu (Yang et al., 2013).

2. DATASET

We used the singing voice dataset [1] described in (Black et al., 2014). This study is focused on two Beijing opera roles: Laosheng (老生) and Zhengdan (正旦) (also known as Qingyi (青衣)).

The dataset consisted of a total of 16 monophonic performances of well-known phrases in the opera sung by 6 different Chinese opera singers. All vibratos in each performance were labelled by the first two authors using Tony [2]. We found a total of 344 vibratos from the Laosheng role, and 273 vibratos from the Zhengdan role.

3. RESULTS

Figure 1 shows the smoothed frequency histogram envelopes for the Laosheng and Zhengdan data, respectively. The sung frequencies were extracted using the Tony software. The extracted frequencies were summed into one-cent bins, and the results were smoothed to obtain the histogram envelope.

Because Zhengdan is a female role, we expect the part's pitches to be higher than those of the Laosheng role. The results show that this is indeed the case; however, Laosheng's phrases utilize a wider pitch range than that of Zhengdan, and the highest pitches are in fact higher than most of Zhengdan's pitches. This maybe helpful in role type classification. It is interesting to note that the peaks in the frequency plot show that the Chinese opera melodies also use a semitone scale like that in Western music, although the most prevalent pitches use the traditional Chinese pentatonic scale.

Figure 2 compares the distributions of the vibrato rates, extents, and sinusoid similarity measures for the recorded

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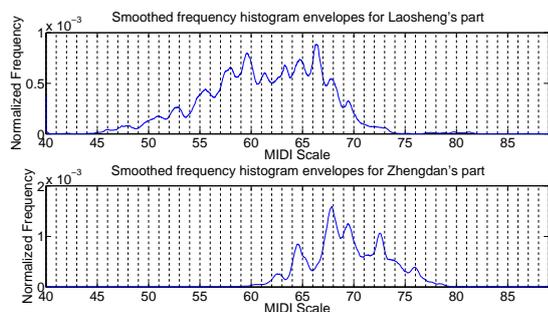
Figure 1: Smoothed frequency histogram envelopes for Laosheng's and Zhengdan's parts.
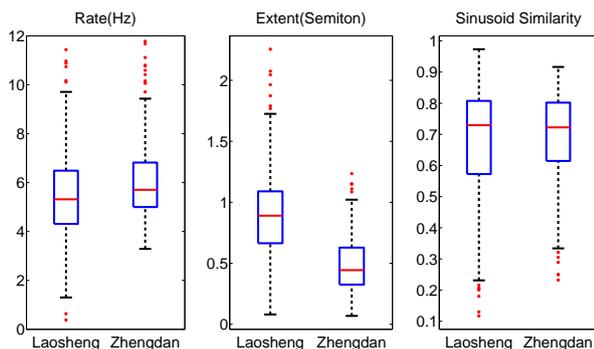

Figure 2: Box plots of vibrato statistics (rate, extent, sinusoid similarity) for Laosheng and Zhengdan.

singing for the Laosheng and Zhengdan roles. The vibrato parameters were obtained using methods described in (Yang et al., 2013). The plots show that the Laosheng and Zhengdan roles are sung with similar vibrato rates ranges, similar to vibrato employed in Western opera singing. This observation contradicts the findings of (Sundberg et al., 2012), in which the vibrato rate was shown to be about 3.5Hz. The singing vibrato rate range is also similar to that of erhu described in (Yang et al., 2013)

The Laosheng role was sung with vibrato having an average extent of almost one semitone, while Zhengdan's role is sung with mean vibrato extent approximately half a semitone wide. These extent values are consistent with those in Western opera singing, which ranges from 0.34 to 1.23 semitones (Prame, 1997). The vibrato extent range is similar to that found for the erhu in (Yang et al., 2013).

The vibrato sinusoid similarity for both roles have a median of 0.71, which is lower than the 0.85 found in erhu playing (Yang et al., 2013). This indicates that singers may have more expressive freedom than erhu players, leading to more non-sinusoid shaped vibratos. Also, it may be more difficult for a singer to control the voice in a perfectly periodic manner.

4. CONCLUSION

In this study, we examined the pitch histograms and vibrato statistics of singing of two Beijing opera roles, Laosheng and Zhengdan. Laosheng (a male role) employs lower

pitches, but a much larger pitch range, than Zhengdan (a female role). The singing employed all twelve pitches in the Western scale, and the vibrato rates and extents are similar to those in Western opera singing. Laosheng's role is sung with significantly larger vibrato extents than that of Zhengdan.

Some interesting phenomena have been noticed. Vibratos in Beijing opera singing have rates and extents similar to that of erhu performance, which we use as a proxy for characteristics of jinghu vibratos. This is a demonstration, to some degree, of the hypothesis that string instruments are designed to mimic the human voice. The similarity between jinghu and erhu vibratos should be confirmed in future work.

Finally, portamenti also form an important characteristic of Beijing opera singing. Future work will include statistical analysis of portamenti properties in Beijing opera performance.

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