

A SYSTEM FOR MATCHING THE TUNING IN A RECORDING

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Abstract

This paper presents a new tuner system implemented in Java. The main difference from existing tuners is the use of one or more recordings as reference instead of theoretical presets. The target here is to help the musician to tune her instrument as in one or more given recordings. For that purpose, first, the fundamental frequency analysis is performed for the given recordings. Then, pitch distributions are obtained and matched to get an overall distribution plot. Finally, on the main display panel of the tuner, the real-time frequency estimate from the input signal is plotted together with the pitch distribution. The musician adjusts her instrument to match the frequency estimate of the input signal with a peak of the histogram to perform the tuning operation.

1) Introduction

Musical instrument tuners are widely used devices or software that help the musicians adjust the tuning of musical instruments to match a given theoretical preset such as a 12-Tet (tone equal temperament), Pythagorean tuning, etc. For some instruments (for example the wind instrument family), tuning refers to adjustment of a single tone frequency since the hole positions are fixed on the instrument. In string instruments however, multiple strings need to be tuned. One extreme example is the Turkish instrument *kanun* which has 24 to 26 triplets of strings hence a large number of strings need to be tuned. In addition, in various folk music traditions, many string instruments use movable frets (the Turkish folk instrument, *baglama*, is one example). For this case, one may need or would like to tune all the possible tones with respect to a reference, to adjust fret locations.

Until recently, handheld tuning devices were among the popular electronic devices in the music technology market. The literature on musical tuners mainly contains patents on hand-held electronic devices. Today, consumers are more and more inclined towards preferring software tuners that run on smartphones or other multipurpose computing machines.

Conventional tuners designed for 12 TET (tone equal temperament) find limited use within the context of various folk music traditions due to use of non-standard tone-scale systems. In such context, there is also the danger that conventional tuners induce changes in the traditional tuning system (causing a shift towards the 12 TET system) since no other technology is available to help the musicians. We have to be aware that use of technology dedicated to a specific standardized music theory may be a threat to the local music cultures if culture specific technologies are not available.

In many folk music traditions, tuning choices vary with respect to the master musicians or the local culture and may not necessarily fit to a specific tuning theory. For tuning in such a setting, the main source of the tuning information, or the main reference, is the recording of a master musician. A system that uses recordings as reference for tuning operation is needed.

In this work, we propose a software tuner system that accepts one or more recordings provided by the user and perform an automatic analysis to create a reference for the tuning operation. The user then adjusts her instrument to match the tuning in the recording with the help of the tuner interface. The output of the analysis part is a text file containing the reference information and can be shared among users of the tuner. The work proposed here is an alternative implementation to (Bozkurt 1). In that work, automatic stable segment detection and loop creation were used to create the references from the audio signal and fundamental frequency estimation was avoided by using a frequency comparison algorithm (without actually measuring the frequency). The method described here does not include any of the mentioned steps and is based on a pitch histogram representation.

2) The system architecture

The tuner system proposed in this work contains two parts. The first part is for analysis of the given recordings to form the reference information. The second part is the user interface/ display (implemented in Java) which presents real-time visualization for the actual tuning operation. Once the first part performs an analysis of the recording(s), the results/references are saved and analysis does not need to be redone next time the tuner is operated. These references obtained from authentic recordings are considered as presets of the tuner system. After the analysis of a recording is performed, the data can be stored and shared as a preset so that it can be reloaded with ease. This feature presents the possibility of a large library of authentic tuning presets.

2.1 Recording analysis part

For a given recording, first, frequency analysis is performed for each 10 msec. window/frame using YIN (de Cheveigne and Kawahara 17), a popular fundamental frequency detection algorithm. In the second step, pitch histograms are obtained for each recording as explained in (Bozkurt 43) with a resolution of 159 bins per octave. Since the diapason may vary in a traditional music context, it is advantageous to represent the pitch information as interval information (with respect to tonic). The tonic detection can be performed automatically (Salamon, Gulati and Serra 499) or manually, depending on the specific music culture.

In Figure 1, we present an example pitch interval histogram computed from Tanburi Cemil Bey's *Çeçen Kızı* recording (in makam Hüseyni). The tonic (automatically found using the makam information) is indicated as 0 on the x-axis. As seen from Figure 1, all histogram peaks do not match the vertical lines (which correspond to the 12-Tet presets).

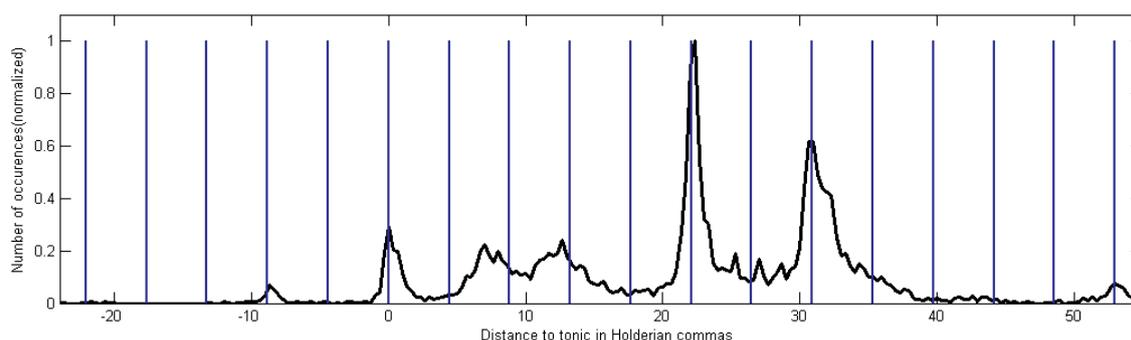


Figure 1 Pitch histogram of Tanburi Cemil Bey's Çeçen Kızı recording [1].
Vertical lines indicate 12-Tet tones

This histogram is saved in a text file as the reference. If desired, the peaks of the histogram could be detected to automatically estimate interval sizes. In our tuning system, this is not necessary since the histogram plot itself is sufficient for visual feedback as explained in the next section. If more than one recording is given, pitch histograms are matched using cross-correlation (Bozkurt 43) and an overall pitch histogram is obtained by averaging histograms.

2.2 User display for tuning

The user display part of the microtonal tuning software acquires musical data from the analysis part and displays the authentic intervals along with the live input from the user. The system has been implemented in Java. Once the software is run, a file browser dialog appears so that the user can select the analysis data obtained from the desired recording. The histogram is a text file containing the frequencies with corresponding frequency of occurrences as a data matrix.

Once the file is selected, the algorithm detects the file path in disk and assigns the data in the analysis file to two string arrays. The contents of the row and column arrays are stored in a two-dimensional float number matrix. In order to identify the peak values of the histogram, the second column values are sorted and assigned to another float array. On user request, the histogram can be smoothed to get rid of spurious peaks.

The histogram is displayed with the default 30 frame rate within the looping draw function. A two-dimensional iteration scans and matches each value of the matrix and these points are connected with lines to visualize the histogram. Another task that runs during the two-dimensional iteration is the detection of the corresponding frequency values of the sorted array's largest values. By this data, the algorithm suggests the peak values by highlighting them with circles. This provides visual feedback during the tuning operation.

The software uses the Minim Audio class (Di Fede, "Minim") to analyze real time audio input and synthesize pure tones for the peak frequencies. A forward fft (Fast Fourier Transform) operation is performed on the audio input buffer to detect the frequency partial with the highest amplitude. Autocorrelation and salience function methods are used in order to estimate the fundamental frequency. The input frequency estimate acquired is displayed as a vertical red line that moves horizontally on the histogram display. The location of the line is calibrated so that it matches the frequency axis of the

histogram, hence the tuning operation can be achieved by vertically aligning the input frequency with the peaks in the histogram. During the interaction, the user is provided with visual feedback as the vertical tuning cursor's color switches to green every time alignment with a histogram peak is achieved.

For the sake of better interaction as well as efficient input data analysis, the tuning cursor's movement is smoothed out with an easing factor. A gain meter is provided so that the user can adjust input microphone level if it is too weak or strong. It is possible to click on the peaks in the histogram and synthesize pure tones if the user prefers to tune by ear to the analyzed frequencies without the aid of the real-time frequency input display. Once a preset is loaded and the histogram is visualized, the tonic is displayed at its original frequency. If the user wants to transpose to a certain register in order to match her instrument, it is possible to transpose the display to the desired range via specified key input. Figure 2 displays the tuner interface during tuning operation. The analysis data of Tanburi Cemil Bey's *Çeçen Kızı* recording is loaded as a preset and the smoothed pitch histogram option is selected by the user.

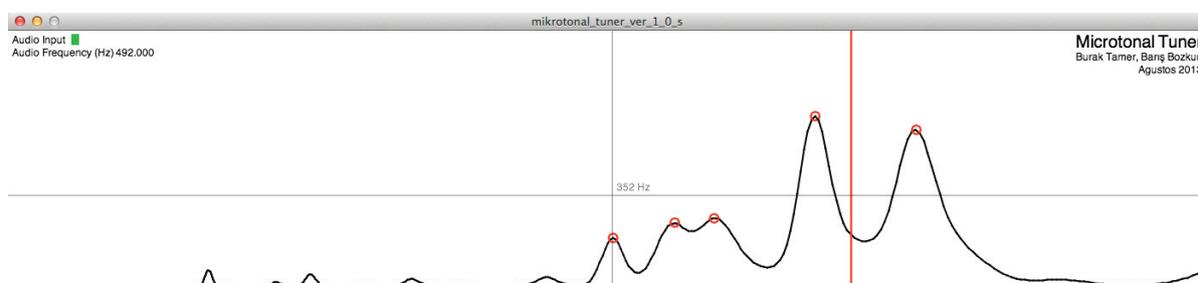


Figure 1 Tuner display

3) Conclusion

In this paper we have presented a novel musical instrument tuner that is specifically designed for folk music traditions. While the first tests with the authors' instruments are satisfactory, we should mention here that no testing has been yet performed and this is among our future goals.

Acknowledgments

This work was funded in part by the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013) / ERC grant agreement 267583 (CompMusic).

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