Exploring Dízi Performance Parameters with Machine Learning

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1. Introduction

- The Chinese transverse flute, Dízi (笛子; pronounced [títsi]) has a long history (>2000 years), but there has been minimal innovation in its construction and design relating to its acoustics and playing response.
- In the last two decades, a Singaporean master Dízi-maker (Teck Seng Ng) has systematically 'modernized' the Dízi, informed by acoustic and performance considerations. These instruments are described by players as having improved 'control', 'uniformity', 'responsiveness' and 'playability', when compared to the standard (traditional) Dízi. However, many of these perceptual qualities are subjective, multi-parameter and their salience may vary from player to player.

Modern (top) and traditional (bottom) Dízi in the key of C, compared alongside the embouchure hole (first hole on the left). Note the superficial similarities of hole placements and external dimensions.

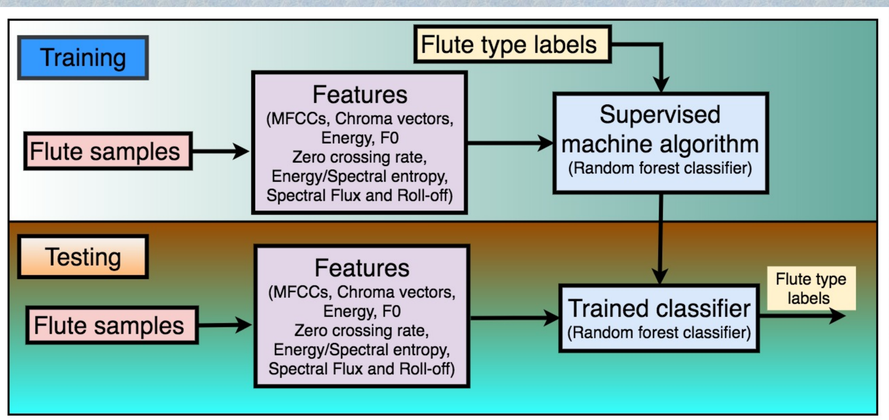
- In this exploratory study, we are interested in measuring the acoustic output and response of Dízi from two different manufacturing processes: standard (traditional) Dízi and Mr Ng's (modern) Dízi.
- To do so, we asked expert players to play on both sets of instruments, performed feature extraction on the audio samples and applied a machine learning classifier algorithm to determine if we could identify these two population simply by their acoustic output.
- The audio recordings were made in a room specially treated for excellent noise isolation and low reverberation time, using condenser microphones placed level at 0.5 m, 1.2 m and 2.0 m away from the player's mouth.

2. Performed Exercise

- Five expert players were tasked to perform musical exercises on three Dízi sizes: Low G, C, and High G for both standard (traditional) and modern (Ng) Dízi.
- The instruments used are professional/concert-grade, and are tuned to a reference pitch of A4 = 442 Hz.
- Diatonic scale at 4 dynamic levels:
  - constant *pp* at soft volume
  - constant *mf* at moderate volume
  - constant *ff* at loud volume
  - *Messa di Voce*. Increasing volume gradually from *pp* to *ff* & back to *pp* while sustaining a single pitch over 6-8 seconds with no vibrato and a stable embouchure
- Overblowing: 'Overblow' and sound the first 4-5 overtones held for 2-3 seconds.
- Pitch Bending: Bend the sounded note as low as possible, and as high as possible.
- Octave Break: Play smoothly (*legato*) over the octave break

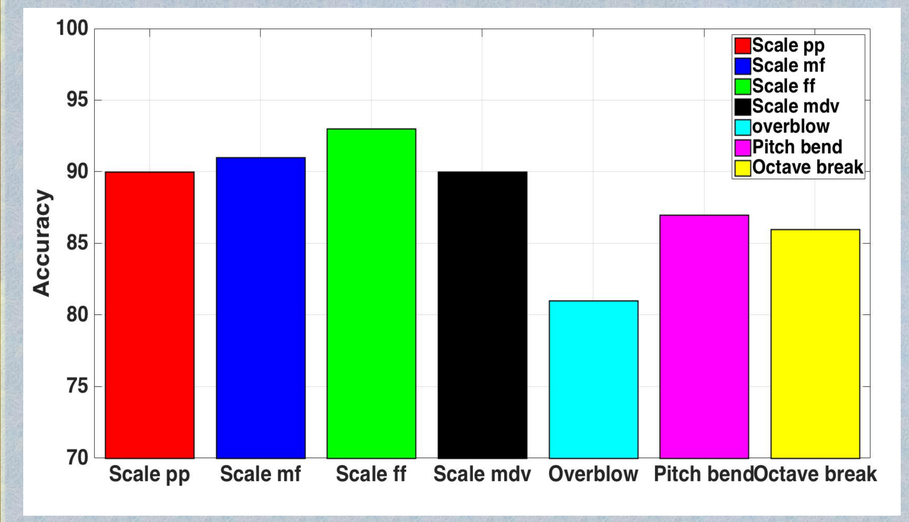
3. Experimental Setup

- The signal from each flute was rendered into mono PCM WAV (44,100 Hz, 16 bits per sample) and python audio analysis library was used to extract audio features for analysis [1].
- The features were labeled with the source instrument (traditional / modern) and the random forest algorithm [2,3,4] was used to model and predict if a given audio sample was produced by the traditional or modern Dízi.



4. Results

- From our experiments, we found that the chosen classifier was able to predict if an audio sample was produced by the traditional or modern Dízi to a high degree of accuracy.
- Scale exercises were found to be achieving the highest accuracy.
  - Among the four dynamic levels performed as part of the scale exercise, constant *ff* was found to be the best differentiator.



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