INDIRECT ACQUISITION OF FINGERINGS OF HARMONIC NOTES ON THE FLUTE

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Abstract

We present an approach for the indirect acquisition of specific fingerings that produce harmonic notes on the flute. We analyse both the temporal and spectral characteristics of the attack of harmonic notes which are produced by specific control gestures involving fingering and potentially overblowing. We then show that it is possible to acquire this effect using a principal component analysis (PCA) on the spectral data. An 8-fold cross-validation showed this approach to be successful for a single performer playing isolated notes.

Score

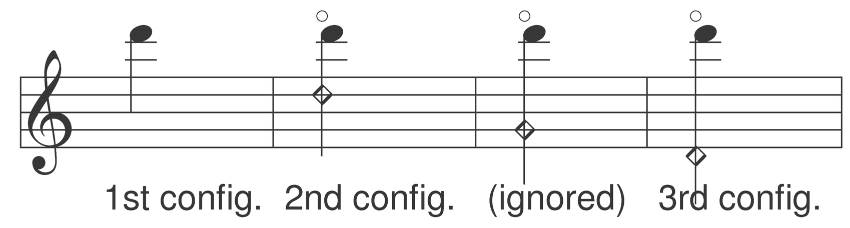

Figure 1: Score showing four fingering configurations of D6. A diamond denotes the required fingering and a note with a circle above denotes the desired pitch. We chose to focus on fingerings separated at octave intervals only.

Fingering Diagrams

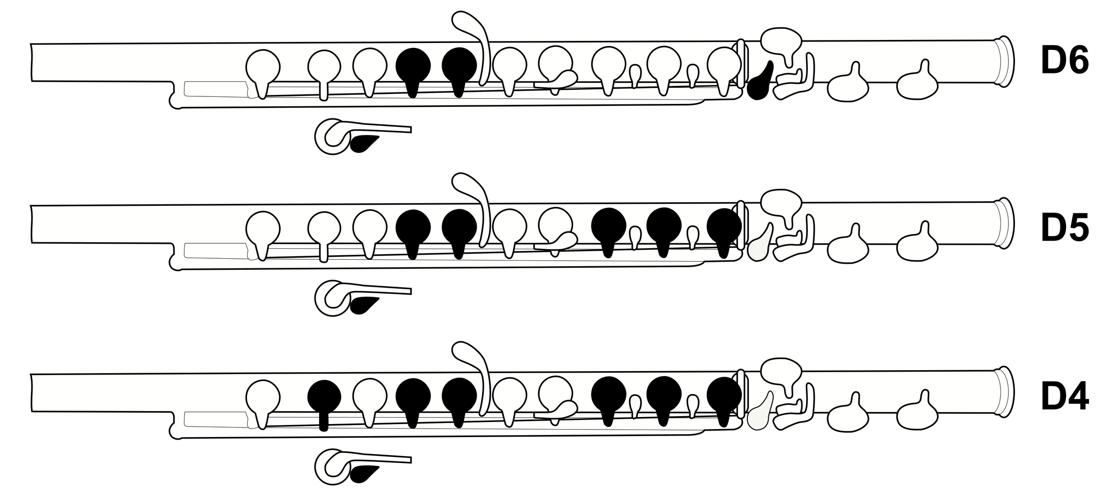

Figure 2: Fingering diagrams for D6, D5 and D4 (adapted from [13]).

Strategy

- When a flutist plays a harmonic note using a given fingering and overblowing (Fig. 1, 2) changes appear in:
  - The spectral envelope of the harmonic and residual components of the sustained sound.
  - The spectral content and time evolution of the attack.

➤ We chose to focus on the *temporal* and *spectral* structures of the attack since these features are most amiable to realtime analysis.

Temporal Analysis

RMS Profile

- We examined the evolution of the short-time energy of the signal during the attack via the RMS profile (Fig. 3).

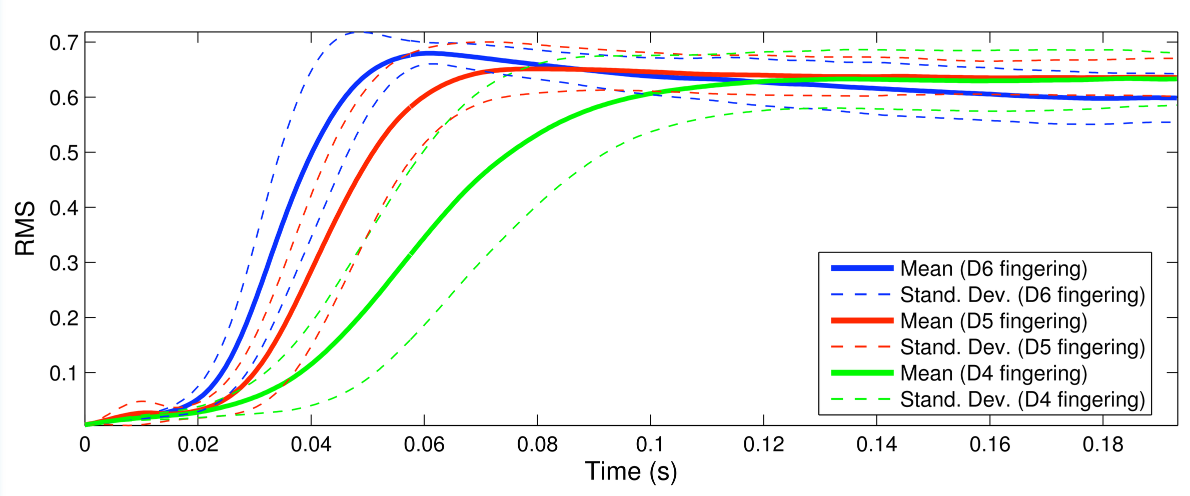

Figure 3: Mean and standard deviation of RMS profile for fingering configurations in Fig. 1.

Inflexion Point

- Notice that the RMS profile, on average, increases at different rates for the different fingering configurations.
- We collected the inflexion point (time, slope) of the RMS profiles for all the sounds in our data set (Fig. 4).

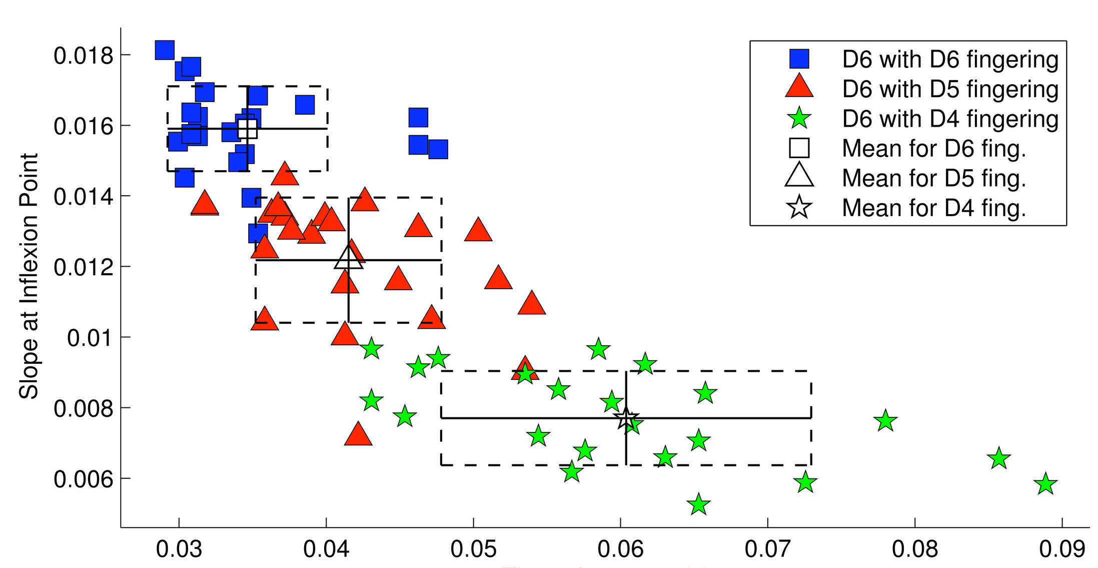

Figure 4: Slope vs. time of inflexion.

Results

- The RMS profiles of the different fingerings cluster in different regions of this 2-d representation.
- But, there is a lot of overlap between the different fingerings.

➤ We need to examine other features to better distinguish harmonic note fingerings.

Spectral Analysis

Spectrogram

- Fig. 5 shows the spectrograms for the notes depicted in Fig. 1.
- As the fingering changes from D6 to D5 and then to D4, energy begins to emerge at frequencies that are not in the harmonic series of D6.
- These secondary peaks correspond to the minima of acoustic impedance for the given fingering (Fig. 6).

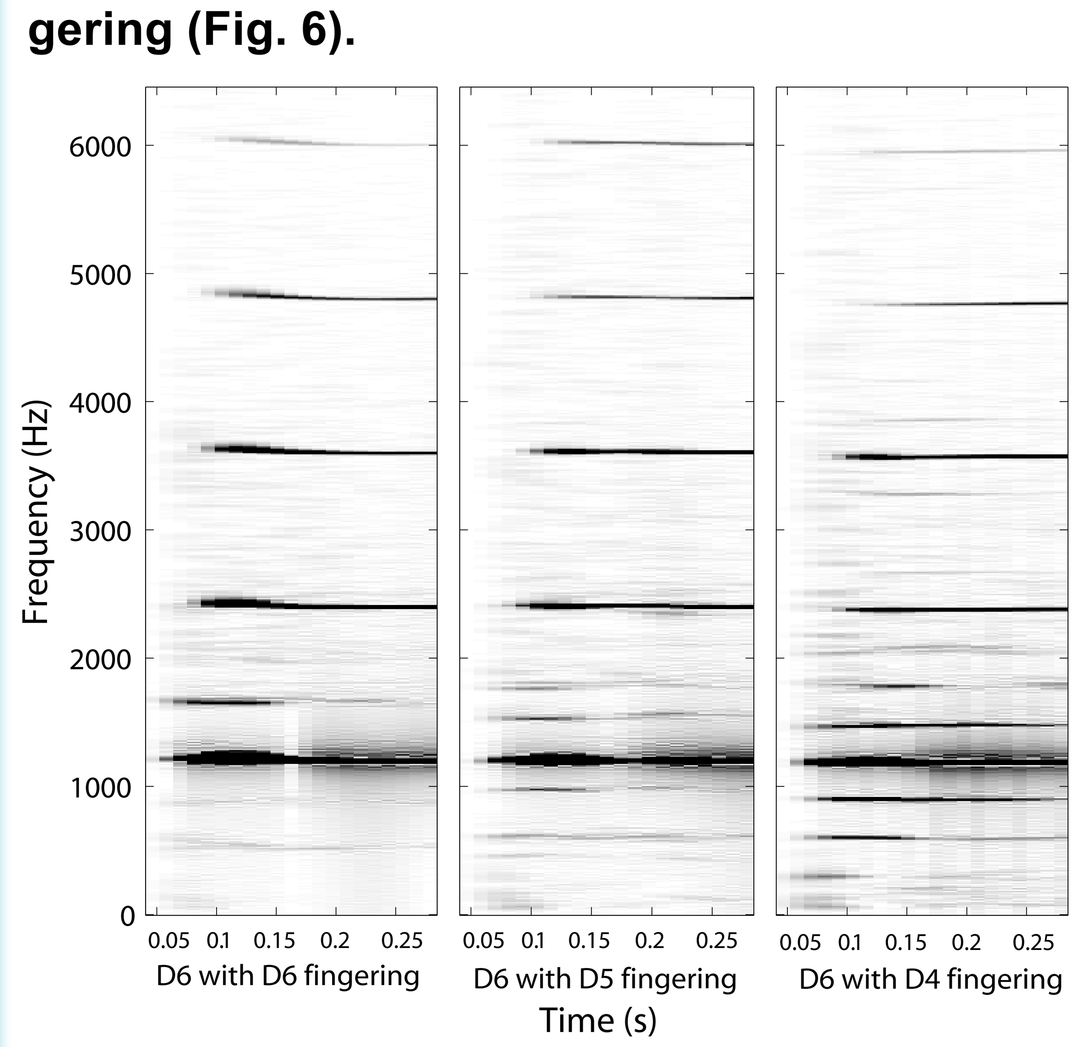

Figure 5: Spectrograms of D6 fingerings.

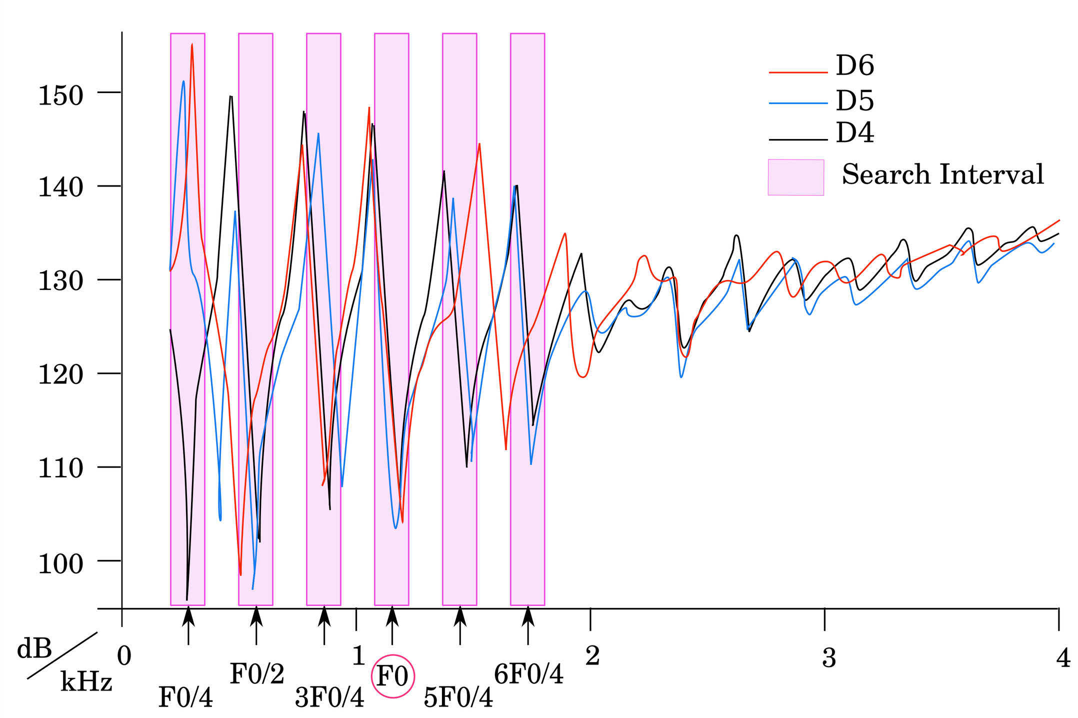

Figure 6: Acoustic impedence of D6, D5 and D4 fingerings on the transverse flute (adapted from [8]).

Feature Vector

- We performed an FFT on each flute sample.
- We extracted the maximum magnitude peaks from each frame in frequency bands centered at $kf_0/4$, $k=[1,..,6]$ (f_0 obtained a priori).
- We then averaged the peaks over the duration of the attack.

Principal Component Analysis

- A principal component analysis (PCA) was performed on the feature vector.
- The first 2 principal components were found to account for over 90% of the variance in the data.
- Each configuration forms a distinct cluster in the principal component space (Fig. 7).

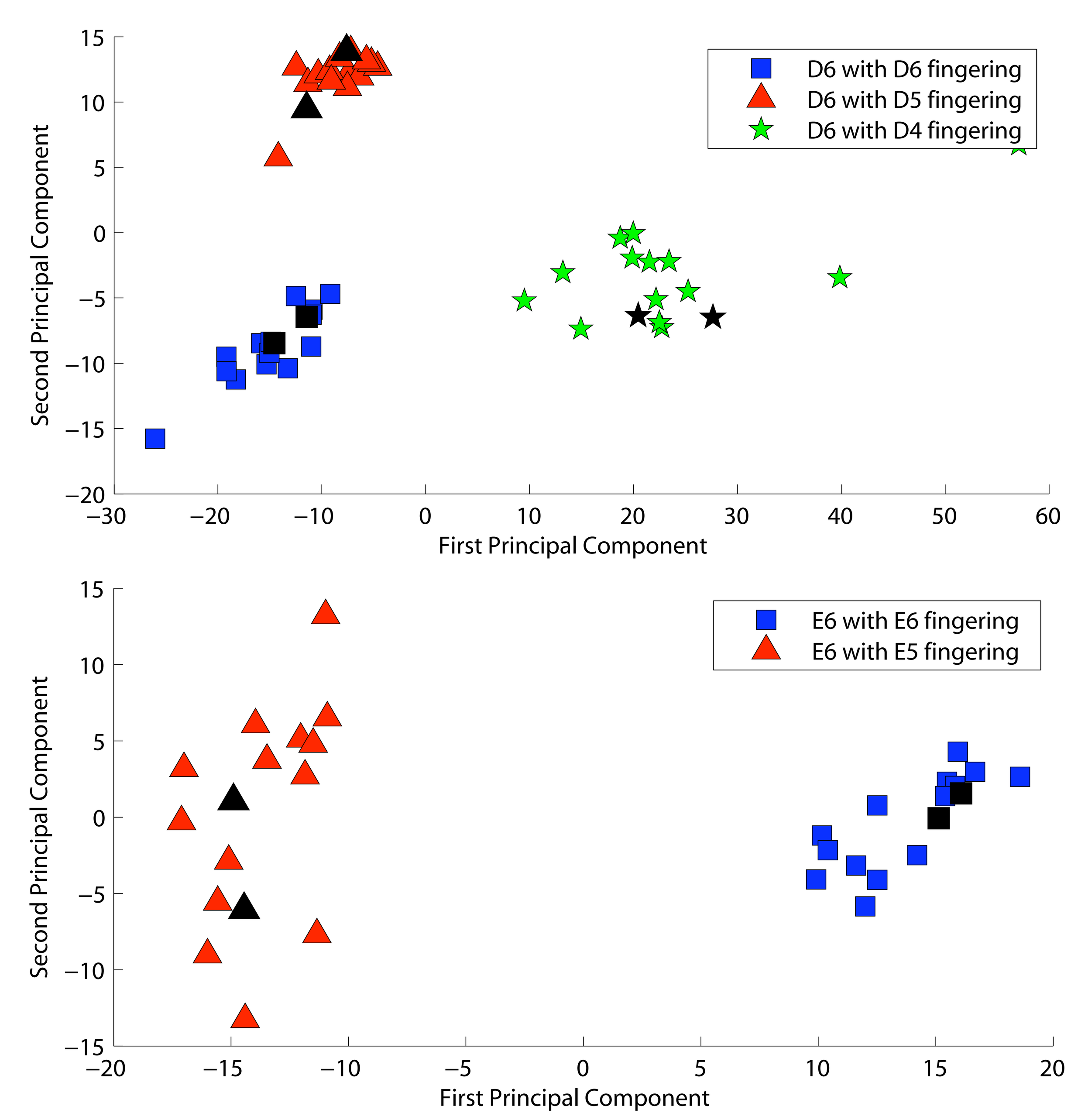

Figure 7: First 2 principal components for D6 (top) and E6 (bottom). Colored shapes indicates training samples; black shapes indicates test samples.

Results

- We used a Euclidean distance measure to classify harmonic note fingerings by cluster.

➤ All of the test samples from our data set were correctly classified (an 8-fold cross-validation was used).

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