Gesture Analysis of Violin Bow Strokes

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1 Introduction

There is an increasing interest of using gestural interfaces to control digital audio processes. One of our current project concerns an "augmented violin", i.e. an acoustic instrument with added gesture capture capabilities in order to control electronic processes. On a fundamental level, our goal is to characterize the various violin playing techniques, on the basis of gestural data. Specifically, our aims are to establish the relationships between the captured data, the bow stroke types and the sound characteristics. This includes the study, on a gestural level, of the variations that occur between players, or between different interpretations of a single player.

2 Related works

The concept of "augmented instruments" is similar to the Hyperinstruments developed by T. Machover and collaborators. Among the first of these instruments was the HyperCello, created in 1991. Particularly, D. Young extended the HyperCello to the violin (the HyperBow [4]). Several other interfaces have been developped, for both fundamental study purposes [1] and artistic purposes (see [3] and references therein). Concerning gesture analysis, Peiper and al [2] used decision tree techniques to classify violin bow strokes based on motion tracking data.

3 Hardware design

The hardware developments were designed with the following constraints: compatible with an acoustic violin, no significant alteration of the instrument, wireless communication, relatively inexpensive. Two types of gesture data are measured, using technology similar to the one described in [4]: bow accelerations (x-y-z) and bow position (distances tip-bridge and frog-bridge).

4 Gesture Analysis

We built a database of three types of bow strokes *Détaché*, *Martelé* and *Spiccato* from recordings of professional and amateur violinists performing scales at two tempi, 60 bpm and 120 bpm, and three nuances *pianissimo*, *mezzo forte*, *fortissimo*.

Four parameters have been derived from the acceleration and velocity curves: a_{max}, a_{min}, v_{max} and v_{min} (first local minimum after v_{max}). Linear discriminant analysis (LDA) on the three bow strokes classes, indicates that class scatter maximization is obtained with two directions. We chose a_{max} and a_{min} for their consistency to model bow strokes. First, using these two parameters, bow strokes cluster according to their types, as shown on Fig 1(a). Second, each cluster is composed of sub-clusters corresponding to nuance and tempo variations.

Table 1(b) gives the recognition scores using kNN algorithm (1/4 of 1400 points taken as reference, 10 nearest neighbors). The recognition rate is high in such well defined playing situations (scales), even mixing data of two players, different nuances and tempi. Nevertheless, modelling bow strokes in separate classes might be limitating. In the context of more complex musical situations, it can be more powerful to consider a characterization by continuous parameters such as a_{max} and a_{min} (Fig 1(a)). Moreover, these parameters can be related to sound characteristics and/or perceptual features.

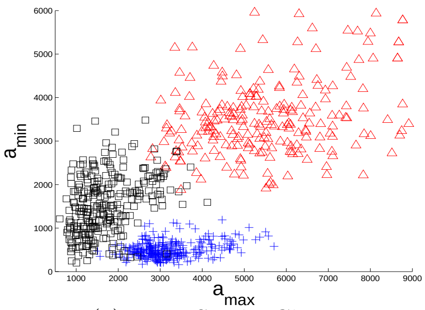

Fig 1(a). Bow Stroke Characterization. Each point corresponds to a single bow stroke (*mf*).

Bowstrokes	*Détaché*	*Martelé*	*Spiccato*
Détaché	**93.4%**	4.3%	2.3%
Martelé	1.0%	**85.8%**	13.2%
Spiccato	6.0%	5.0%	**89.0%**

Table 1(b). kNN recognition results on a database mixing 2 players, 3 nuances and 2 tempi.

References

1. Anders Askenfelt. Measurement of the bowing parameters in violin playing. ii: Bow-bridge distance, dynamic range, and limits of bow force. *J. Acoust. Soc. Am.*, 86(2), 1989.
2. Chad Peiper, David Warden, and Guy Garnett. An interface for real-time classification of articulations produced by violin bowing. In *Proceedings of the Conference on New Instruments for Musical Expression, NIME*, 2003.
3. Cornelius Poepel. Synthesized strings for string players. In *Proceedings of the Conference on New Instruments for Musical Expression, NIME*, 2004.
4. Diana Young. The hyperbow controller: Real-time dynamics measurement of violin performance. In *Proceedings of the Conference on New Instruments for Musical Expression, NIME*, Dublin, Ireland, 2002.