Parametric modeling of gestural co-articulation effects in music performance

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Introduction. In most human-computer interaction paradigms, the variations in the gesture execution are commonly depicted as noise inside a gesture class. This is not the case for musical performance: each variation should be regarded as possible expression of a musical meaning [1]. Therefore, for music applications, the analysis of a given gesture could be considered as a twofold process: the recognition of a gesture class, and the characterization of the nuance embodied in its execution. In addition to idiosyncratic variation, co-articulation effects occur between adjacent gestural events. This inter-gesture modulation at the boundaries of the events can be explained by different mechanisms. On the one hand, human biomechanics impose constraints, which influence the degree of stiffness of the transitions between sequential units. On the other hand, these transitions are also subordinated to an wider inflection, linked to “musical prosody” at the phrase level.

In this paper we present a method to quantify gesture variations and transitions as performed using different musical articulation and playing techniques. We employed functional data analysis techniques to convert gesture data (sampled over time) into mathematical continuous functions. We then build a parametrical model which accounts for gesture variations with respect to the neighbor's influence.

Similar statistical techniques have been previously used for analyzing synchronized tension judgments in musical context [2], and in articulatory phonetics for time deformation in prosodic boundaries [3]. The analysis and classification on the set of coefficients obtained by the basis expansion has never been used yet for the modeling of co-articulation and playing technique for musical performance.

Results and discussion. We measured the in-mouth air pressure and the force exerted by the lips against the trumpet mouthpiece during trumpet performances. We collected the data on professional musicians playing isolated single notes and notes sequences, under different musical articulatory conditions - staccato and legato. Single note recordings were taken as reference curves. In the longer sequences, each note event - considered as a test curve - was segmented using maximum/minimum detection, and then compared to the reference single notes. We performed time registration between the reference and the test curves in order to align features and estimate the time warping functions.

Fig. 1. Curves of in-mouth pressure measurement during two transitions: from a legato articulated note to a staccato one (left), and from a legato articulated note to a non-legato version (right).

Each time series has been decomposed as a linear combination of equally spaced B-spline basis functions. By means of functional data analysis techniques, the resulting function's third derivative was penalized in order to get a smooth curve along with its first derivative.

The results showed that the test curves systematically undergo both phase and amplitude variations, jointly with boundary deflections as effects of anticipatory conditions. An example of such a deflection effect is illustrated in Fig.1. Moreover, we found that the coefficient vectors of the spline basis expansions can be used to adequately characterize the experimental curves and the co-articulation effects. In particular, the estimated coefficients of the basis expansion allow for the classification of the type of articulation and the quantification of their variations. We are currently extending this method for other playing techniques, either stylistic or functional (velocity).

These first results indicate that the proposed method is promising from the stylistic and functional point of view for the modeling of articulation and co-articulation as measured from gesture data. In a long-term vision, we plan to apply this methodology to the control of sound synthesis. Indeed, this parametric functional approach could be very efficient for the control of physical models.

References

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