Automatic Detection of Ornamentation in Flamenco

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1 Introduction

Ornamentation is a characteristic feature in the melody of many musical traditions in the world, including flamenco music. There is no universal definition of ornamentation as it is very associated with musical style. In Western classical music, with its long-standing analysis tradition, ornamentation has been studied extensively; consider the ornamentation tables from Baroque to Romanticism, for example. On the contrary, in spite of the always-heard claim that flamenco is very melismatic, scant research have been carried out to define flamenco ornaments. For example, the structural role of flamenco melismas has not been thoroughly described yet, nor its role in style definition.

This paper is concerned with the study of ornamentation in flamenco music. As a starting point, we defined a set of ornaments, mainly taken or adapted from classical music. The next step was to select a flamenco corpus -formed by audio recordings- where the selected set of ornaments would be looked up. In order to do this in an automatic way we had to design an appropriate pattern detection algorithm. The algorithm of Smith-Waterman [4] was adapted to our purposes. The obtained results were promising and they constituted a first step toward a systematic study of ornamentation in flamenco music.

2 Ornamentation in Flamenco Singing

In a melodic phrase notes can be classified as main notes, which are essential components of the melody, and ornamentation notes, whose role is the embellishment of the melody. Main notes belong to the established scale, whereas the ornaments not necessarily belong to the scale or the harmony of the piece. However, the presence of ornaments and embellishments often renders the piece its mood or sense. As mentioned before, little study has been carried out of ornaments in flamenco music. Some authors [3, 1] have study flamenco singing styles in-depth, but unaccountably they mention the existence of ornamentation without undertaking an analytical study. In general, ornaments in flamenco styles strongly depends on the style itself, the vocal technique of the particular *cantaor* (singer), and the singing school (compare, for example, Mairena (Seville) to Agujetas (Jerez)).

For this work a total of 30 different ornaments were defined. Selection criteria were mainly grounded on melodic movement and interval type. The selected ornaments can be classified in the following broad categories: mordents, double mordents, trills, turns, 3-note movements, and 4-note movements. For example, within the category of mordents, we can find upper and lower mordents; depending on the type of scale, the ornament can be at a distance of a tone or half-tone. The 3-note movement consists of three consecutive notes in the established scale; the 4-note ornaments are defined similarly. These ornaments can be regarded as the building blocks of more complicated, longer ornaments occurring in flamenco music.

3 Ornament Detection Method

The next step was to locate the defined melismas in a given corpus. The corpus was formed by pieces belonging to the *tonás* style. These are flamenco a cappella *cantes* (songs). The corpus contains three

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very well defined substyles: *deblas*, *martinetes 1*, and *martinetes 2*; see [2] for a description of these styles. The total number of songs used in our study was 72, where 16 corresponded to *deblas*, and 56 to both kind of *martinetes*. These *cantes* were also chosen because of the high number of ornaments they contain.

Now let us summarize the algorithm used in locating the ornaments in the corpus. The music recordings are first processed to compute a melodic representation in terms of note onset, duration and pitch. We then obtain the melodic contour by converting pitch into interval values and build a similarity grid. This grid is subsequently processed by a sequence alignment algorithm to reveal possible occurrences of the pattern (ornament) in question. Due to lack of space, we cannot describe all the details of the algorithm in full generality. However, it is important to notice that the algorithm uses three user-defined parameters or thresholds worth elaborating upon. Those three parameters are: T_p, T_{int}, and T_{ldur}. Parameter T_p is the penalty term introduced in the definition of the local similarity measure; T_{int} is a threshold to control the absolute difference of music intervals; T_{ldur} is a threshold to manage the difference in time duration between two notes. This last parameter allows the algorithm to recognize the occurrence of an ornament sung with different tempi or with severe distortion of its durations.

The final step of our algorithm proceeds in the light of the standard Smith-Waterman algorithm; see [4]. This algorithm computes the accumulated costs associated with the nodes of the similarity grid. As a last safety measure against irrelevant results, the degree of time warping between the pattern and the detected instance is also examined. To this end, we compute the absolute difference of the respective durations and divide it by the duration of the pattern. If the ratio exceeds a user-defined threshold T_{warp}, then the path is rejected. Equivalently, this is a means to control the amount of stretching/compression of the detected instance with respect to the duration of the pattern that serves as the query.

4 Results and Concluding Remarks

Our preliminary results showed that fine-tuning the algorithm was somehow delicate. Several combinations of threshold were tested, ranging from values allowing strict matches or allowing looser matches. We are still exploring more combinations to determine the best trade-off among the parameters. Location of ornaments was good in general, although they can substantially improved in several directions, one of the most important being the adequate discrimination between ornaments and melody itself in certain cases.

The study of the distribution of ornaments across styles revealed very interesting facts. It can be noticed a tendency to use some ornaments in certain styles. For example, ornaments *lower-4-notes-1* and *lower-4-notes-3*, two ornaments belonging to category 4-note movement, often appear in styles of *debla* and *martinete 2*, which are closely related. On the other hand, some ornaments mostly appear in *martinete 1*. Finally, other ornaments, even when the threshold are looser, barely appear or not at all. We are still interpreting the meaning of this results and how to integrate them into a theory of the flamenco ornamentation.

The goal of this ongoing research is to carry out a systematic study of ornamentation in flamenco music. That study will include both its musicological and computational study. The results presented here are a first step in both directions.

References

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