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Measuring swing in Irish traditional fiddle music

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ABSTRACT

We have endeavoured to analyse audio recordings of solo Irish fiddle players with the objective of measuring micro rythmic deviations, and in particular the presence of swing. In the scope of our study, the autocorrelation methods have yielded good results in both pitch and tempo extraction.

BACKGROUND

As in blues, country and jazz music, Irish traditional fiddle music is often played with swing rhythm, which consists in performing eighth notes where downbeats and upbeats receive approximately 2/3 and 1/3 of the beat, respectively, giving a triplet feel and providing a rhythmic lift to the music. Swing ratio can be defined as the ratio of the two successive beats durations (long/short). The amount of swing varies among performers and repertoires, from no swing (1:1) to hard swing (3:1). Usual swing ratio in Irish traditional fiddle music is around 2:1 (triple meter). Although swing can be clearly perceived by experienced performers, it is a very subtle rhythmic variation that can not be easily quantified perceptually and that provokes many debates among musicians.

AIM

The aim of this study was to quantify the amount of swing through the analysis of audio recordings of Irish fiddle performances. The subject of swing has been of interest for many years in the scientific community, and a considerable amount of work has been done (Gouyon 2005) As in the case of the violin, the attacks are not well defined, we decided to avoid techniques based on measuring the energy of the signal such as the ones used by Bilmes (1993). We decided to base our approach on pitch detection, making

use of autocorrelation methods (Brown 1990, 1993)

METHOD

Extraction of fundamentals

The violin is an instrument that produces harmonic sounds.

The autocorrelation is a mathematical tool that can be used to extract the fundamental frequency of a harmonic signal. Brown (1990) has used it successfully to extract the fundamental frequencies of the sound produced by a harmonic instruments. We have devided our signal in a series or overlapping windows. For each one of those, we have determined a fundamental frequency, and thus obtained a vector of fundamental frequencies corresponding to the center of the windows used.

The time gap between two consecutive fundamental frequencies is function of the width of the window used and the percentage of overlap between two consecutive windows. We have used window size and overlap as parameters to fine tune our results in the next steps of the analysis.

Onset detection

We have chosen to detect the change of notes in the music by detecting changes in fundamental frequency. This is a sufficient condition but not a necessary one. Indeed our method could be considered to be flawed when two notes of the same pitch follow each other. Howether this issue is not important in the case of our study. If there are two consecutive quarter notes with the same pitch in the music, our method will consider them as a unique half note. This has little impact on our study of swing. We will just base our calculations on two quarter note less but the calculations themselves won't be flawed. So we'll live with that limitation. The precision of the onset detection is a function of the size of the window and the step.

Tempo extraction

The tempo of music is itself a periodic phenomenon, and can consequently be estimated by using autocorrelation methods (Brown 1993). In the case of danse music, the tempo can be assumed to be stable through the piece, or it would be difficult to dance to it. Furthermore Itraditional Irish music posesses clearly marked rythmic features (like a strong off-beat ion the case of reels) which help the dancer, and which will as a matter of fact enhance the periodic nature of the audio signal. So we have decided to use the autocorrelation of the envelope of the music signal to determine the tempo of the music. Of course, there is often an ambiguity of a factor two when determining a tempo (it is a difficulty experienced by tempo extraction tools but also by music listeners). We have decided to avoid the question altogether by asking the user of our tool to provide an approximate tempo. Of the series of possible tempi we obtain (all differing by a factor of two) we simply chose the closest to the one provided by the user of the tool.

Micro rythmic deviations

Having determined the onset times, we calculated a vector of durations. We sorted this vector and chose a criterion to distinguish the quarter notes from the rest of the durations. The theoretical quarter note duration can easily be calculated from the tempo. Howether, as we are studying swing, we know that the length of a quarter note is not fixed and can vary considerably. We have had to chose the deviation from the theoretical duration within which we would still consider a quarter note to be a "swinged" quarter note. Musicians consider that the most exagerated swing you can get is when your fisrt quarter not becomes a quarter note and a half, and the following one becomes an eigth note, and that most swings are in fact more subtle than that, in the sense that the deviation is less than an eigth note worth So we considered to be quarter notes all duration within the [theoretical quarter note – eight note, theoretical quarter note + eigth note] boundary. Note that that corpus of durations is likely to be symetrical since any lengthening of a fisrt quarter note has to be followed by an equal shortening of the next one (otherwise we distort the tempo). Having delimited our corpus of quarter notes we can obtain a vector of quarter- note deviations.

Swing ratio calculations

Finaly we used this vector of deviations to calculate a global swing percentage for the whole audio extract. The formula we chose for swing calculation is the following :

$$Swing\ percentage = 100 * \frac{long\ quarter\ note}{half\ note}$$

We calculated the avarage of this value accross all the values of our vector of deviations. We also calculated the error associated to that calculation using the following formula :

$$Error\ percentage\ =\ 100 * \frac{window * overlap}{halfnote * sampling\ rate}$$

RESULTS

We had the opportunity to work closely with Vincent Blin, a professional musician and Irish music teatcher. So we started by analysing a recording he made of a tune called "Morning dew". We first transcribed the version he plays :

Figure 1. the version of the Mountain dew reel, as played by Vincent Blin

Synthetic extracts

Before applying our treatments on this real recording, we tested them on a synthesized version of that tune, that we generated ourselves with Matlab. Having this synthesized version allowed us to check the results we obtained (onsets, deviations, swing) against the real values we programmed into the music. These are the results we obtained :

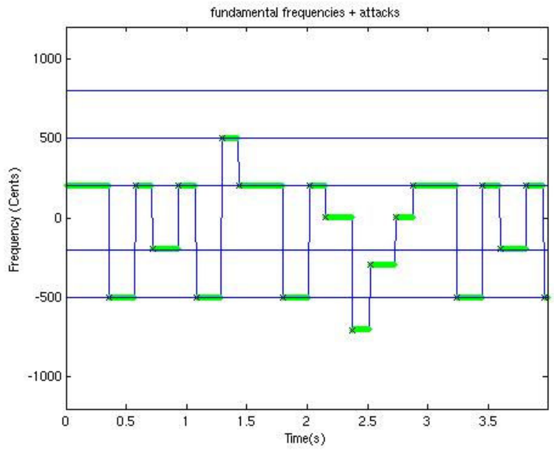

Figure 2. In this graph you can see the fundamental frequencies in Cents as a function of time. We have purposefully added horizontal lines for values in Cents of E G B D F, as to materialize a staff, ans make visual checking easier to people who read music. We have also added crosses at each onset detected.

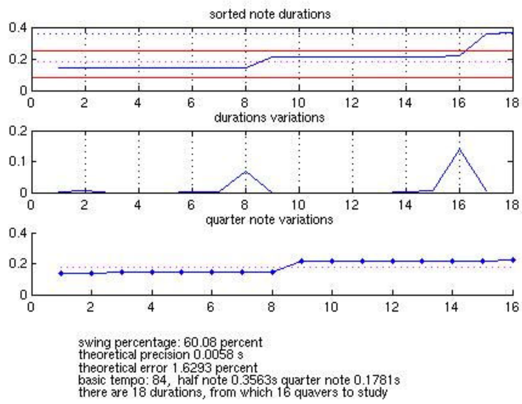

Figure 3. The fisrt graph represents the sorted durations (in seconds) of the extract. We added two red lines corresponding to the upper and lower limit of the corpus of quarter notes.

On the second graph we displayed the time variations of the values of the fisrt. They show that the extremi at the boundaries of the corpus.

The third graph dsiplays the sorted quarter note durations.

We also display the swing percentage calculated and various precisionn indicators.

Audio recordings

Of course in real life recordings, we don't expect results to be as good as this. To just give one reason, a sound produced by a mecanical instrument begins with an attack during which the sound is not yet harmonic (Brown 1990). So at each new onset, our tool will have to deal with a certain amount of noise. Still our first results were very encouraging. We can clearly recognize the tune, and the errors, although numerous, are mainly localized at the change of notes.

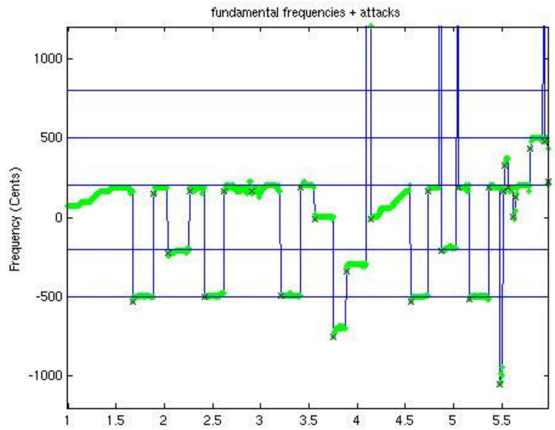

Figure 4. analysis of Morning Dew played by Vincent Blin. We can clearly recognize the score even if there is still a certain amount of noise. The "slope" of the B half notes can be explained by the fact that Vincent Blin slides his finger on the string while playing the note.

We improved these results by selecting carefully the parts of the extract we wanted to analyse, avoiding features in the music that would cause problems, like tremoli of timbre, double stoppings (the action of playing two strings simultaneously on the violin). We also tried a few corrective algorythms, focused on getting rid of erroneously detected onsets.

We tried three types of corrections :

• Smoothing : we tried a standard smoothing tool, replacing each value by the median value of an interval around it. This method proved to be problematic since it tended to "smear" the results, adding intermediate points at each change of the fundamental. So we decided not to use it.

• Octaviation : we noticed that many errors were octave errors. This kind of error is not unexpected since the autocorrelation works on peridicity. We developped a treatment that changed any frequency above or below the Irish tessiture to the corresponding note within it. This treatment was not completely satisfactory in the long run, as it would deal with a very specific type of error.

• Assimilation : we applied an agorithm which would assimilate each isolated point (a frequency value different by more than a semi tone from its previous and next value) to the frequency of the previous point. This method proved to be very efficient in removing the few errors we had.

After having tried these various methods and evaluated their cost in terms of precision degradation, we arrived at the following results, on a recording from Maeve Donelly, Irish fiddle palyer fron County Clare :

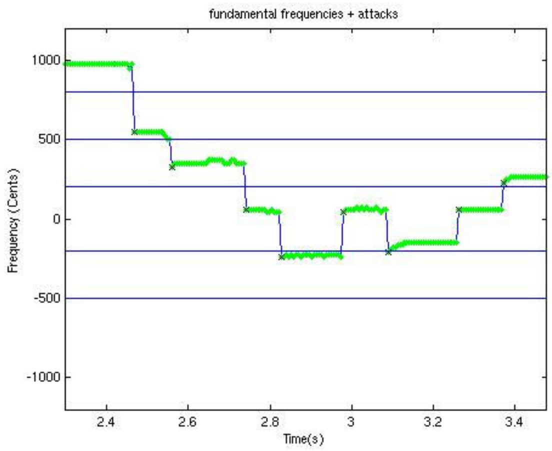

Figure 5. analysis of an extract played by Maeve Donelly. We obtained this result by using windows of 512 samples, overlapped by 50%. The swing percentage we calculated is 63% +/- 2%. The tempo is 116 to the half note.

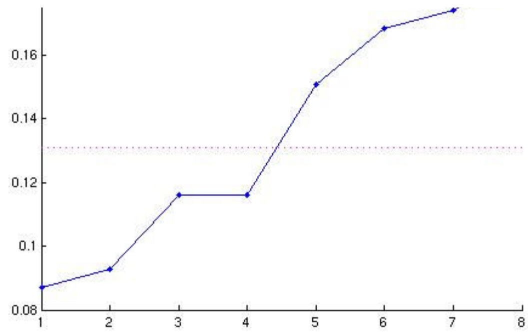

Figure 6. Detail of the quarter note durations, of the extract from Maeve Donelly, sorted in ascending order.

We can see from figures 5 that we have obtained a clean analysis of the sample, that the quarter notes corpus is clearly split in two. We can even guess the symetrc nature of the quarter note duration curve, eas xplained earlier in this article.

CONCLUSION

We can see that our simple methods, which we first tested on synthesized audio samples, gave good results. They gave us the notes of the extract with pitch and durations. They gave us graphical cues of personal intepretation like variations. They finally gave us a swing percentage with its associated calculation error percentage. These results prove that there is swing in some of the recordings studied, which is a conclusion of importance for the field of musicology. In a future effort, we will try to futher improve the precision and robustness of our treatments, in order to use them for comparative analysis of different sound extracts. This would help us to better understand the musical style of different musicians.

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