LIMITATION OF ACCUATE TEMPO TO IMPROVE DYNAMIC-PROGRAMMING-BASED BEAT TRACKER

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ABSTRACT

For our dynamic programming (DP) based beat tracker, we try to identify the factors to improve accuracy. For the specified algorithm, it has merit to handle time-varying-tempo excerpts. In contrast to the effectiveness, the algorithm is not good enough for musical audio with stable tempo. One of the reason to cause poor accuracy is due to inaccurate tempo estimation. This study adopts the research result of our tempo estimation to improve beat tracking accuracy. Unfortunately, the improved accuracy, 1.5% dataset average, of tempo estimation is not enough to let the DP-based beat tracker be competitive.

1. INTRODUCTION

There are many families of beat tracker. One among them is dynamic programming (DP) based algorithm, which highly depend on accuracy of tempo estimation. We conduct improve of tempo estimation two consequent years – 2014 and 2015. Comparing with the results of MRIREX 2014 and 2015 audio beat tracking (abt), we conclude there is bottle neck to improve accuracy only depending on improving tempo estimation.

As the previous years, we have three submissions. One [1] is for time-varying-tempo (TVT, highly dynamic tempo) excerpts; another is for stable-tempo (ST); the other 'Universal' is combined version for previous two. We devise a stable-tempo beat tracker, derived from TVT beat tracker, with multi-paths and a selector to decide only one beat sequence. The last category, named as universal beat tracker, contains the arbitration mechanism to select the best between time-varying-tempo beat tracker and stable-tempo beat tracker for the specified excerpt.

In this evaluation, we have approved the benefit of accurate tempo estimation algorithm. Most of all, the F-measure of MAZ dataset for ST beat tracker has 4.5% increase. On the other hand, out of expectation, the accuracy for MCK has less accuracy around 0.66 %. The reason could be worst tempo estimation. To sum up, only tempo estimation improvement is not enough to compete with the first-place algorithms.

Although we didn't have any effort to improve beat tracking except introduction more accurate tempo estimation this year. We also describe the major blocks of the universal beat tracker in the next section. More specifically, we explain the notion of tempo-guided tempo curve and the TSV feature in following section.

2. IMPORTANT FACTORS TO APPROACH UNIVERSAL BEAT TRACKER

In order to build a beat tracker for public usage, the beat tracker should be suitable for all kinds of music. For our algorithm, the stable-tempo-tracking ability seems to have some room to improve. So we provide the ST beat tracker with tempo guided. Another important factor is how to combine the presumed best beat tracking algorithms, the first step is to discriminate which the excerpts to the specified type of tempo. TSV is borrowed from our previous work to approach this. In short, Figure 1 is shown to illustrate the role of these two major factors. The audio is processed by ST beat tracker and TVT beat tracker simultaneously; then, the tempogram is analyzed to produce TSV, which is input

Table 1 MIREX evaluation result of audio beat tracking for years of 2013 and 2014

Beat tracker type	MIREX 2014				MIREX 2015			
	Submission code	F-MEASURE			Submission code	F-MEASURE		
		DAV(SMC)	MAZ	MCK		SMC	MAZ	MCK
Time-varying-tempo	FW3	35.4572	67.1690	44.2559	FW6	35.9999	66.5267	44.2933
Stable-tempo	FW4	36.9533	53.2305	51.2939	FW7	37.5266	57.8285	50.6318
Universal	FW5	37.5585	54.4881	50.9856	FW8	37.7681	58.6296	50.3989

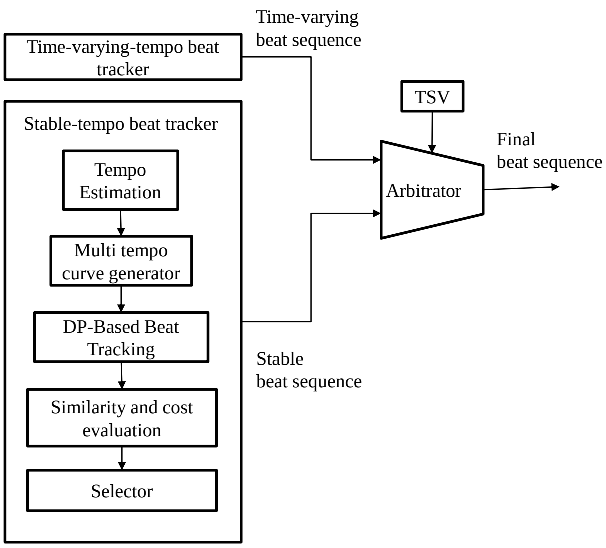

Figure 1. Flowchart of proposed method

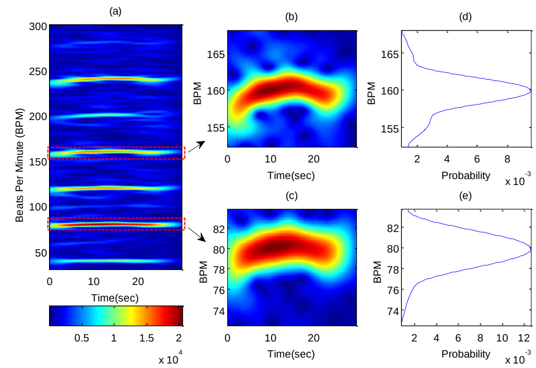

Figure 2 Typical example of LTP derivation: (a) Tempogram; (b) tempogram strip around tempo2 (c) tempogram strip around tempo1 (d) LTP of tempo2 tempogram strip (e) LTP of tempo1 tempogram strip.

feature of a classifier. Finally, the last beat sequence is selected by the results of the arbitrator, which is the classifier to discriminate the time-varying beat sequence and stable beat sequence.

2.1 Stable-Tempo Beat Tracker with Tempo-Guided Multipath

From theoretical and empirical perspective, more accurate tempo could improve our DP-based beat tracker. So we put constrains on the tempogram with the weighting function centered at the estimated tempo pair to lead the derivation of tempo curve. After we acquire the tempo curve, we create more reference tempo curves. Therefore for each tempo curve, we create beat sequence for it. Then the beats could be derived by DP likely to constitute tempo curve. Finally, the decision of final beat sequence depend on the factors: the similarity of those beat sequences, the cost of beat sequence, and the frequency of beat sequence.

2.2 Tempogram Shape Vector (TSV)

The TSV contains the features computed from tempogram, where the features are tempogram mean (μ_T), tempogram standard deviation (σ_T), tempogram coefficient of variation (cv_T), tempogram skewness (γ_T) and tempogram kurtosis(κ_T). The statistical quantities are calculated from the whole and the stripes of tempogram to generate low-level features.

In term of the statistics of tempogram stripe, the long-term-periodicity (LTP), as Figure 2 shown, is regarded as probability mass function and the statistical quantities are calculated as the components of the TSV. The detail derivation of the vector could be referenced in the work [2].

3. REFERENCES

[1] Fu-Hai Frank Wu, Tsung-Chi Lee, Jyh-Shing Roger Jang, Kaichun K. Chang, Chun Hung Lu, Wen Nan Wang, “A Two-Fold Dynamic Programming Approach to Beat Tracking For Audio Music with Time-Varying Tempo“ in *Proc. ISMIR*, Florida, USA, 2011

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