QUERY BY SINGING/HUMMING (MIREX 2013)
THE TUNE FOLLOWER

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ABSTRACT

This extended abstract presents a solution to the QbSH (Query by Singing/Humming) problem, submitted to MIREX 2013 QbSH evaluation contest. The solution is based on the well-known DTW (Dynamic Time Warping) approach, modified by the use of *tune-following* procedure. In this way it is possible to alleviate the problem – resulting i.a. from imprecision in sung queries – of fitting absolute pitch values between a query and a template.

1. INTRODUCTION

Dynamic Time Warping is a standard tool used in QbSH tasks. It is often considered more robust and precise, yet considerably slower, than note-based approaches, with the best results being obtained by combination of the two [4]. One of the problems of direct DTW application is that it is basically not robust to transpositions (both fixed and occurring in the course of a query), while in melody matching only the relative pitch changes between consecutive pitch values are of importance. The solution may be searched for in e.g. mean value subtraction, using delta sequences or trying several transpositions of one of the sequences [3] [5]. An alternative to those approaches is presented in the following section.

2. SYSTEM DESCRIPTION

A solution proposed in this extended abstract is to try to follow the melody of the template by gradually decreasing the difference between the query and the template. This is intended to resemble the way in which humans follow the known melody irrespective of pitch inaccuracies and key changes.

The detailed description of the method is presented in [1]. Basically, for any query-template pair of pitch vectors being compared, the optimal warping path is found with the DTW algorithm. Then, the consecutive pitch values q_i of the time-warped query are compared to the corresponding pitch values t_i in the template, in order to produce a modified query sequence $\hat{q}$. The modification aims at making
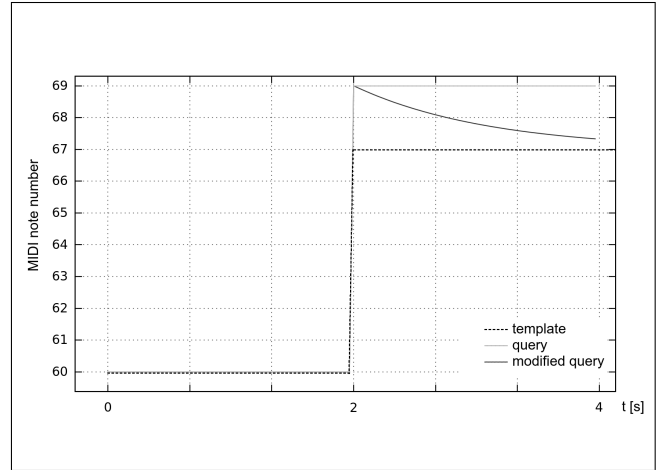
Figure 1. Effect of the tune following procedure (the last two seconds).

the $\hat{q}$ sequence closer to the template t by gradually "tuning" it to the right pitch values. An example, in which a template fragment contains a perfect fifth while the user sings a major sixth instead, is presented in Fig. 1. Finally, the $\text{DTW}(t, \hat{q})$ value is used as a similarity measure instead of $\text{DTW}(t, q)$.

Several additional pre/postprocessing operations are involved to optimize the solution. Median filter is used to remove impulse noise from the pitch vectors. The basic DTW algorithm is based on the original work by Sakoe and Chiba [2] with slope constraint parameter $P = 1/2$. Preliminary alignment of the absolute pitch values between the query and the template (transposition) is performed on the basis of the mean value of the first half of the query, after rejecting some initial values (<500 ms).

Reduction of computation time is achieved be means of indexing the template sequences in R*-tree structure [6]. Every template is represented by 20 points in 16-dimensional search space, where each point is obtained with piecewise aggregate approximation (PAA, [6]) of a different part cut from the template sequence.

3. RATIONALE

It has been shown [1] that the tune-following procedure has a positive influence on the DTW-based melody search. Although it generally makes the matching cost smaller for

most of the templates, both matching and non-matching ones, it can be expected that this decrease will be more significant in the case of the correct (matching) template.

This may result from the effect of accumulation of the corrections for consecutive notes. For example, when the pitch of a note sung by a user is too low with respect to the correct template then it is gradually increased until it reaches the right tune, provided that the note is long enough. If it is relatively short, it is at least partially corrected. In either case, if the note was sung too low, then it is probable that the pitch of the next note will also be too low in which case it will get corrected immediately or – at least – faster. This type of correspondence between the signs of the pitch differences in consecutive notes cannot be generally expected when comparing a query with a non-matching template. Correcting one note may result in increasing the initial difference between the next note and the template. This may even result in increasing the total matching cost, although for long notes and infrequent pitch changes the tune follower will usually make the query closer to most of the templates.

4. REFERENCES

[1] B. Stasiak. *Follow That Tune - Dynamic Time Warping Refinement for Query by Humming*. Proc. of Joint Conference NTAV/SPA'12, pp. 109 – 114, 2012

[2] H. Sakoe, and S. Chiba, *Dynamic programming algorithm optimization for spoken word recognition*. IEEE Trans. on Acoustics, Speech and Signal Processing, pp. 43–49, 1978

[3] H.-M Yu, W.-H. Tsai, and H.-M. Wang, *A Query-by-Singing System for Retrieving Karaoke Music*. IEEE Transactions on Multimedia, Vol. 10 (8), pp. 1626–1637, 2008

[4] L. Wang, S. Huang, S. Hu, J. Laing, and B. Xu, *An effective and efficient method for query by humming system based on multi-similarity measurement fusion*. Int. Conf. on Audio, Language and Image Processing, pp. 471–475, 2008

[5] www.music-ir.org/mirex/abstracts/2011/JSSLP1.pdf

[6] E. Keogh, *Exact indexing of dynamic time warping*. In 28th International Conference on Very Large Data Bases, pp. 406–417, 2002