# QUERY BY SINGING/HUMMING (MIREX 2014) 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 2014 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

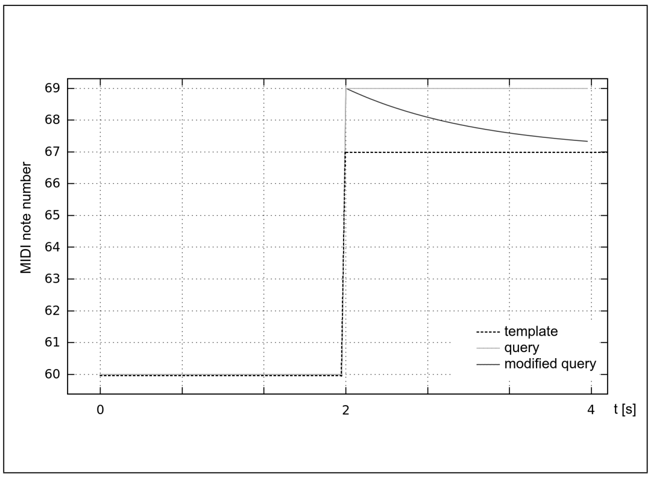


**Figure 1**. Effect of the tune following procedure (the last two seconds).

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 $\mathrm{DTW}(t, \hat{q})$ value is used as a similarity measure instead of $\mathrm{DTW}(t, q)$.

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. CHANGES FROM MIREX 2013

A severe bug concerning the time resolution of the templates have been fixed, which led to significant increase of the recognition rate. Also, the parameters of the pitchtracker, which is the author's own implementation of Paul Boersma's autocorrelation-based algorithm [7], have been adjusted appropriately.

In order to enhance the recognition in the cases where several consecutive notes have the same pitch (repetitions), the elements of rhythm analysis have been introduced. The note onsets are detected both in the templates and in the queries and they are involved in the computation of the DTW cost. The onset detection is straightforward in the case of the templates, as they are given as MIDI files, while for queries a novel aproach, based on monitoring the spectral flux [8] and pitch changes in consecutive frames, is adopted.

## 4. 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 in the first case (the matching templates) this decrease will be more significant.

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 high with respect to the matching template, then it is gradually decreased until it reaches the right tune (provided that the note is long enough – otherwise it will get at least *partially* corrected). Generally, if the note was sung too high, then it is probable that the pitch of the next note will also be too high, in which case it will get corrected immediately or – at least – faster. Similar observations may be made if a part of a query is sung too low with respect to the template. In either case, the total cost of matching a query with the corresponding (correct) template will most probably get significantly reduced.

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. In this case, correcting one note may as well result in *increasing* the initial difference between the next note and the template. In some cases, this may even lead to increasing the total matching cost for the incorrect templates.

## 5. REFERENCES


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