ALGORITHM FOR QUERY BY TAPPING

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***Abstract*—A query-by-tapping (QBT) system is a content-based music retrieval system that can retrieve a song by taking the user's tapping or clapping at the note onsets of the song for database comparison. This paper proposes a new query-by-tapping algorithm that shifts the query sequence and builds an IOI (inter-onset interval) ratio matrix, and then applies a dynamic programming (DP) method to compute the optimum path with minimum cost.**

I. INTRODUCTION

QBT is a mechanism for content-based music retrieval which extracts the note onset time from recordings of users' input tapping or symbolic signals, which it then compares against a song database to retrieve the correct song. Unlike query-by-singing/humming (QBSH) [1, 2], which takes the user's melody pitch for comparison, QBT only uses the note duration for comparison, with no pitch information. This makes QBT more difficult to implement than QBSH, be-cause the note onset in QBT contains less information than the musical pitch in QBSH, raising the likelihood of collision. For example, musical pieces with different melodies but similar rhythmic patterns may be characterized by the same onset sequence.

QBT system algorithms are based on the estimation of the similarity between two onset sequences. For example, G. Eisenberg proposed a simple algorithm called "Direct Measure" to accomplish such comparisons [3]. R. Typke presented a variant of the earth mover's distance appropriate for searching rhythmic patterns [4]. Among these algorithms, the techniques of dynamic programming (DP) have been widely used, such as R. Jang's Dynamic Time Warping (DTW) [5], G. Peters's edit distance algorithm [6], and P. Hanna's adaptation of local alignment algorithm [7].

II. QBT ALGORITHM

This section presents the proposed method to QBT. The method can be divided into two stages of IOI normalization and similarity comparison. We shall describe these two steps and explain the advantages over the state-of-art QBT methods.

Normalization: For each matched element pair, we divide the query IOI by its mapping reference IOI to construct an IOI ratio matrix M according to the following formula:

$$M_{i,j} = \begin{cases} q_{i_s - i + j + 1} / r_j & \text{, if } 1 \le i_s - i + j + 1 \le \min(m,n) \\ 0 & \text{, otherwise} \end{cases} \quad (3)$$

where the size of the matrix M is $\min(m,n)*(i_s + i_e +1)$. i_s and i_e are the left- and right-shift amount of the query IOI vector, respectively.

Similarity comparison: In order to handle insertions and deletions in a flexible yet robust manner, we propose a dynamic programming method to compute the similarity between the query and the reference IOI vectors.

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