Melodic Similarity
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Assignment 4
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Similarity in melodic content is an interesting topic of research, which has experienced increased popularity over the course of the past decade, being reinforced by the advancements in computer music technology. A number of different systems and approaches to melodic similarity processing have been implemented over the past years. A summary of publications relevant to the advancements in the field of melodic similarity is presented in this paper.

A publication by Selfridge-Field (1998) introduces a number of important concepts in relation to melodic representation. It describes melodic material that can be compound, self-accompanying, submerged, roving and distributed. The concept of a theme is defined as a shorter sample from longer melodic materials that can be isolated and classified.

Components of melodic representation are classified as representative—pitch, duration, derivable—intervallic motion, accents, and non-derivable—articulation, dynamics. Some of the methods for labeling of pitch as part of preprocessing that are mentioned in the publication include organizing the pitch values into base 7 (diatonic scale), base 12 (chromatic scale), base 21 (with flats/sharps) or base 40 (double flats/sharps) systems.

According to the paper, the main approaches to melodic pitch representation are profiles of pitch direction (up-down-repeat), pitch contours, also known as melodic contours (sonographic data, shapes of melodies), pitch-event strings (which employ base-system representation), and intervallic contours (intervallic profiles).

Some of the models used for multi-dimensional data comparison mentioned in the paper are a kernel-filling model (where melody is considered to evolve from a kernel consisting of outer note of a phrase), an accented-note model, a synthetic data model, and a parallel processing model.

Another approach is described by Maidin (1998). A geometric algorithm for melodic difference is used to identify similarities in one- and eight-bar segments in Irish folk-dance music segments. The algorithm is based on evaluations of such parameters as juxtapositioning of notes in two melodic segments, pitch differences (using base-12 or base-7 pitch labelling), note durations, metrical stress, and transpositions (implementing a set of transpositions and taking the minimum difference value).

A work by Crawford, Iliopoulos and Raman (1998) describes a number of string-matching techniques for musical similarity and melodic recognition. The string-matching algorithms are classified into approaches with known solutions and approaches with unknown solutions. The work also discusses notions of themes, motifs and characteristic signatures. According to the paper, motifs can be considered to have melodic similarity if it has been established that they have matching signatures. All of the algorithms described in the paper use a two-dimensional mode, taking pitch and duration values as parameters.

According to the paper, the pattern matches can be defined as exact, where pitch data is matched, and transposed, where intervallic information is matched. Exact-match algorithms described in the paper include exact matching, matching with deletions (with no duration patterns preserved), repetition identification (with non-overlapping patterns in different voices or the same voice), overlapping repetition identification, transformed matching (retrograde, inversion), distributed matching (across voices), chord recognition, approximate matching (Hamming distance) and evolution detection. Inexact-match algorithms are unstructured exact matching (finding a pattern in voice-unspecified mixture of notes), unstructured repetitions (identified repeating patterns that may or may not overlap) and unstructured approximate matching.

Another approach to melodic similarity problem is presented by Smith, McNab and Witten (1998). It describes a dynamic programming (string matching) algorithm that is applied to a database of 9400 folk songs. The algorithm is based on edit distance, which can be defined as a cost of changing one string into another using replacement, insertion and deletion edit operators. A cost is assigned to each operation, based on the input string components. The algorithm uses a local score matrix, consisting of scores for each element of the two strings, and a global score matrix, that represents the score of a complete match between two strings. The paper also mentions the importance of the techniques of fragmentation and consolidation, which state that several shorter notes can be considered a match for a single longer note of the same duration as the combined duration of the shorter notes, and vice versa.

A publication by Cope (1998) describes creating new scores based on original compositions using 'Experiments in Musical Intelligence' (EMI) system. It discusses a concept of a musical signature, defined as a motif common to two or more works of a given composer, two to five beats in length and a composite of melodic, rhythmic, and harmonic components. The experiment uses a base-12 system, and implements a number of controllers to calculate the similarity value. It also mentions a concept of an earmark, which is more generalized than a signature, and refers to a specific location in the structure of a musical score.

Another work conducted on melodic similarity is presented by Hornel (1998). The style is learned from musical pieces of baroque composers (Bach, Pachelbel), and new pieces are produced based on the learned data. According to the paper, the system is able to learn and reproduce higher-order elements of harmonic, motivic and phrase structure. The learning is done using two mutually interacting neural networks, operating on different time scales, also using an unsupervised learning algorithm to classify and recognize structural elements. Given a chorale melody, a chorale harmonization of the melody is invented, and one of the voices of harmonization is selected and provided with melodic variations

Another work that deals with melodic similarity issue is implemented by Dahlig and

Schaffrath (1998). In the experiment described in the paper, the listeners are presented with series of original and artificially created folksongs and are asked to identify the original songs. The experiment showed that the perception of the nature of composition varied with perception of the music itself—the songs that were identified by the listeners as more perceptually pleasing were also more likely to be identified as the originals. Some of the melodic characteristics that were associated with the originals were rhythmic similarity of phrases, final cadence on the 1st degree, and intermediate phrase beginning that did not start on the 1st degree.

A publication by Bainbridge (1998) presents a web-based query by humming system that works using four databases—North-American/British, German, Chinese, Irish folksongs—which combine to 9400 melodies. The system uses two alternative algorithms: a simple, fast, state matching algorithm, and a slower, sophisticated dynamic programming algorithm.

Another implementation of a web-based music similarity search system is presented by Kornstadt (1998). The system searches a database of 2000 monophonic theme representations for instrumental works from 18th-19th centuries. The search parameters include pitch direction (gross contour or refined contour), letter name of pitch, pitch class, intervallic name, intervallic size and scale degree.

A publication by Hu, Dannenberg and Lewis (2002), describes an experiment that compares dynamic programming to probabilistic approach in sequence matching. The system used query by humming as input, and collected and processed 598 popular song files. The processing was done using MUSART thematic extractor, collecting 10 themes per song, which resulted in 5980 entries with an average of 22 notes per song. The dynamic programming algorithms included edit distance and frame-based (pitch contour) matching, and probabilistic approach implemented similarity matching using a probabilistic distribution histogram. According to the results, the probabilistic model outperformed dynamic programming algorithms by a narrow margin.

A paper by Pardo, Shifrin and Birmingham (1998) describes a query by humming system that uses two-dimensional processing for pitch and rhythm. A comparison between string-alignment (edit cost) dynamic programming and HMM algorithms (where each theme is represented as a model) is made. The results showed that the string-alignment algorithm slightly outperformed the HMM-based approach.

The work by Hoffman-Engl (2004) reviewed here is the latest of the set of publications that have been written by the author on the subject of melodic similarity in 1998-2004. The paper reviews a number of techniques implemented in melodic similarity up to date, including string comparison-based algorithms, geometric measure, transportation distances, musical artist similarity, probabilistic similarity, statistical similarity measures, transformational models and transition matrices. It also discusses the importance of using dynamics as a separate dimension, in addition to pitch and score dimensions, which can significantly ameliorate the results. Furthermore, the work discusses the problem of melodic similarity from a different point of view—instead of considering physical values as dimensions for melodic similarity processing, it suggests that the similarity processing must be implemented based on psychological dimensions. Concepts of meloton, chronoton and dynamon are introduced as perceptual counterparts to pitch, rhythm and dynamics values.

The paper presents a cognitive model based on those three dimensions, that uses a number of factors to determine similarity, including melotonic distance (pitch value difference), melotonic interval distance (distance between pitch intervals), chrontonic distance (difference between durations), tempo distance, dynamic distance (difference between dynamic values), and dynamic interval distance (between relative dynamic values).

A number of different techniques and approaches to the subject of melodic similarity have been presented in this paper. Melodic similarity search and its applications continue to be an interesting field for future research in music technology.

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