

Dynamic Programming Algorithms in Speech Recognition

Titus Felix FURTUNĂ

Academy of Economic Studies, Bucharest

titus@ase.ro

In a system of speech recognition containing words, the recognition requires the comparison between the entry signal of the word and the various words of the dictionary. The problem can be solved efficiently by a dynamic comparison algorithm whose goal is to put in optimal correspondence the temporal scales of the two words. An algorithm of this type is Dynamic Time Warping. This paper presents two alternatives for implementation of the algorithm designed for recognition of the isolated words.

Keywords: dynamic programming, speech recognition, word detection.

Introduction

Studies in speaking recognition field, as well as studies in other fields, follow two trends: fundamental research whose goal is to devise and test new methods, algorithms and concepts in a non-commercial manner and applied research whose goal is to improve existing methods, following specific criteria. This article deals with isolated words recognition within applied research trend.

The fundamental research aims at medium and especially long term benefits, while applied research aims at quick performances improvements of existing methods or extending their use in domains where they have less been used so far.

Improving performances in voice recognition can be done taking into account the following criteria:

- dimension of recognizable vocabulary;
- spontaneous ness degree of speaking to be recognized
- dependence/independence on the speaker;
- time to put in motion the system
- system accommodating time at new speakers;
- decision and recognition time;
- recognition rate (expressed by word or by sentence).

Today's vocal recognition systems are based on the general principles of forms' recognition [3][7]. The methods and algorithms that have been used so far can be divided into four large classes:

- Discriminant Analysis Methods based on Bayesian discrimination;

- Hidden Markov Models;
- Dynamic Programming –Dynamic Time Warping algorithm (DTW) [8];
- Neuronal Networks.

This article presents an example/alternative of dynamic programming DTW algorithm implementation in speech recognition.

1. Dynamic Time Warping Algorithm (DTW)

Dynamic Time Warping algorithm (DTW) [Sakoe, H. & S. Chiba-8] is an algorithm that calculates an optimal warping path between two time series. The algorithm calculates both warping path values between the two series and the distance between them.

Suppose we have two numerical sequences (a_1, a_2, \dots, a_n) and (b_1, b_2, \dots, b_m) . As we can see, the length of the two sequences can be different. The algorithm starts with local distances calculation between the elements of the two sequences using different types of distances. The most frequent used method for distance calculation is the absolute distance between the values of the two elements (Euclidian distance). That results in a matrix of distances having n lines and m columns of general term:

$$d_{ij} = |a_i - b_j|, \quad i = \overline{1, n}, \quad j = \overline{1, m}.$$

Starting with local distances matrix, then the minimal distance matrix between sequences is determined using a dynamic programming algorithm and the following optimization criterion:

$$a_{ij} = d_{ij} + \min(a_{i-1, j-1}, a_{i-1, j}, a_{i, j-1}).$$

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