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Fast Algorithm of Two Dimensional DP Warping Pattern Matching using Composite mapping

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1 Introduction

Two dimensional DP warping (2D-DP) is used for pattern matching with nonlinearly deformed image such as hand written character. However, 2D-DP needs large computational complexity. In this paper, I propose Fast Algorithm of pattern matching with 2D-DP.

2 pixel-wise 2D-DP

In this paper, I use 2D-DP as a method of calculating the distance between two patterns.

2D-DP is a problem of deciding the map function f which minimizes the following criterion function.

$$D(A, B) = \sum_{j=1}^N \sum_{i=1}^N d(a(i, j), b(f(i, j))) + P_{ij} \quad (1)$$

When d is the distance function between feature amounts
 P_{ij} is the penalty to amount of transformation

When using it for recognition, the P_{ij} will be designed correctly and 2D-DP can't make map with big transformation such as transforming some pattern into other class's pattern. And it helps improving recognition rate.

3 Proposed method

There is already many proposed method to speed up 2D-DP algorithm. So I propose the method which reduce number of times of 2D-DP calculation in pattern matching. In particular I use composite mapping method which was used in one dimensional DP(DTW).

3.1 Fast algorithm with composite mapping

Following is how to recognize the patterns with composite mapping method.

1. Do 2D-DP between Input and Medium pattern and make Input-Medium map g .
2. Synthesize composite map f' from map g and pre-calculated Medium-Reference map h .
3. Use Composite map as approximate map of Input-Reference and calculate distance of patterns with D .
4. Select minimum distance pattern.

In this procedure, Only one 2D-DP calculation is required. So it can run very fast.

3.2 Simply apply

I ran character recognition experiment with ETL-9b database 'HIRAGANA' 30class, 90 reference patterns, 270 input patterns.

Simply use of above composite mapping method makes 54 times faster result. However the recognition rate was down to 78.9% from 89.6%.

3.3 Mismatch of mapping

One of big reasons decreasing recognition rate is 'mismatch of mapping'. Mismatch of mapping means that a white pixel isn't mapped to a white pixel, a black pixel isn't mapped to a black pixel. As a result of these mismatch, calculation result of pattern distance D will be large even if input pattern and reference pattern are completely same.

I propose a path mix method for patching up mismatch of mapping. Following is path mix method procedure.

1. Overlaps composite maps with some Medium patterns.
2. Pick up correct map from overlapped map.

As a result, a mismatch of map will be patched up with other composite maps which generated with other medium patterns.

In this paper, 2D-DP is used as the method of picking up correct map. As above, 2D-DP have very large computational complexity in general use. However, in this case. The search domain is only in overlapped map. It's very narrow domain. So you can use very narrow beam-width. As a result, computational complexity of composite mapping method will be very smaller than conventional 2D-DP pattern matching method's one.

3.4 Transformation penalty and Mismatch of map

As a reducing mismatch method, there is a method to reduce mismatch at running 2D-DP between Input and Medium pattern.

It will be done by using weaker transformation penalty or changing algorithm of the penalty.

Additionally, 2D-DP decide the map f with raster scan method. So, it does not search well vertical direction. To solve this, the method which blurs image little in vertical direction is used. Both methods are same in meaning of expanding transformation range. As a result of expanding transformation range, the map will be different from the map with conventional directly method.. It means the criterion function D may not be good for calculating pattern distance. So in following experiment, I use different transformation parameter of D in mapping phase and calculating pattern distance.

4 experiment

I ran experiments like in section 3.2 with whole method in above. At number of path mix is 5,I got 90.7% recognition rate. It's better than 89.6% as conventional method's result. Moreover,It runs 12.5 times faster.

5 conclusion

As result of applying composite mapping method to 2D-DP pattern matching,12.5 times speed-up were achieved with no recognition rate drop.

And the application in the field of medical imaging and k-means clustering with 2D-DP etc.will be expected in the future.

Moreover,the idea of path mix method will be effective if following conditions are met.

- Composite map can be a approximation of directly calculated map.
- Searching domain is very large to needs beam-search method.

So,this idea will be expected to use for other method in the future.