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Image matching with multi medium Delaunay triangulation

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Abstract

The Delaunay triangulation is well-known in the field of computational geometry, holography, networking and fingerprint matching. In our case, a matching image from the image database is proposed by using the Delaunay triangulation, which has the ability to perform multidimensional in matching. To prevent problems on the complexity of the dimensions, we proposed a method for the Delaunay triangulation matching with several medium dimensions from all feature vectors. Then, apply to match all the image's databases. In this paper, we use the color histogram as a representation of multidimensional feature vectors to test the matching in several environments and illustrate the main issues. The results in matching accuracy are satisfactory.

Keywords: Delaunay triangulation, Image matching, Multidimensional, Image processing

1. Introduction

The Delaunay triangulation approach has been interested in various areas of research, such as computational geometry, network topology especially in images matching. The image matching is mainly applied in biometrics whether face recognition, iris synthesis, hand geometry detection, fingerprint detection, and signature recognition most of which as one-to-one matching [1-2]. And also for a variety of advancement of digital image technological evolutions, such as image retrieval [3].

The Delaunay triangulation brings dimension challenges and advantages, it is ideal to be used in images matching. Since adding up feature vectors, which makes the result even more effective. While dimension increases, the several facets and ridges in a convex hull grow rapidly for the identical number of vertices, including time and memory requirements.

This paper attempts to propose the construction the multiple of medium dimensional Delaunay triangulation that extends to higher dimensions for the structure of image feature vectors. For the present the ability of this method, we use the color histogram, which is well known to extract color features of images for a representation of multidimensional feature vectors.

2. Materials and methods

2.1 Delaunay triangulation

The Delaunay triangulation (DT) introduced by Boris Nikolaevich Delaunay in 1934, is characterized by the empty circum disk property, it is no point in set P lies in the interior of any triangle circumscribing disk. Each scattered points of the triangle are vertex and the segment connecting the two vertices is an edge of a DT. Each triangle of the DT of a set of vertices in multidimensional spaces corresponds to a facet. The circumcircle of each Delaunay triangle does not contain any other vertex in the plane, which is a special characteristic for constructing a DT. Incidentally, property maximizes the minimum angle. Among the triangular the smallest angle in the DT is at least as large as the smallest angle in any other [4], as shown in Figure 1.

Figure 1 Left is scattered points, the center is Delaunay triangulate and right is circumcircle.

The DT has a good simple structure, minimal data redundancy, and high storage efficiency. These properties ensure that are stable and the accurate geometric relationship of the vertices extracted could be constructed in triangles, even when the amount and position of vertex varies.

2.2 Multidimensional Delaunay triangulation

The Qhull library is an extensively used high-dimensional convex hulls and Delaunay implementation [5]. These structures have applications in science, engineering, mathematics, and statistics. It can approximate a convex hull and construct the DT by all vertices are within roundoff error of a paraboloid and triangulated output should produce good

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results. The Qhull library is used to construct for illustrating the dimensions and limit the ability of the DT. Firstly, extract the color histogram of each channel of RGB image. Secondly, determine to each vertex on the DT is the vector from the feature extraction. Thirdly, construct a DT by bringing the feature vectors of all images in the database. The last step is matching (See also 2.4). The results show that, when the number of dimensions increases, the factors, memory and time of the execution are exponentially increased as shown in Figure 2.

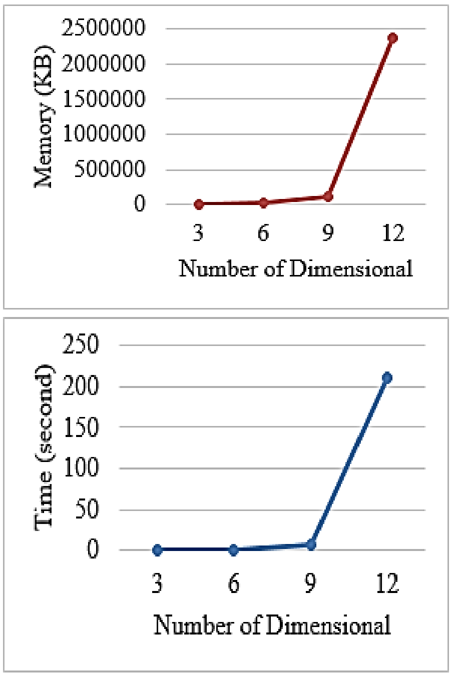

Figure 2 Comparison constructing multidimensional Delaunay triangulation (64 images)

In the dimension refers to the characteristics of DT. Each dimension represents the histogram RGB color space extracted from images, such as DT 3-D. Each vertex is (R,G,B). It demonstrates the effectiveness of high-dimensional DT construction. It brings to the method which we are present.

2.3 Multi medium Delaunay triangulation

To reduce the limitation of multidimensional DT as described, we propose the multiple of medium dimensional DT (MMDT) for image matching. The MMDT is constructed by dividing features (the values of the color histogram) into small groups for the construction of medium dimensions DT as shown in Figure 3.

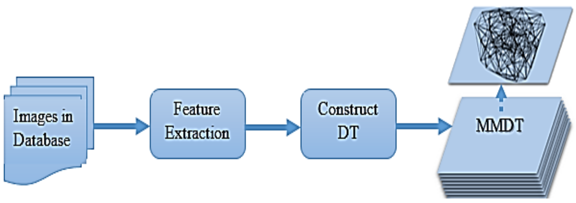

Figure 3 Multi medium Delaunay triangulation process

2.4 Multi medium Delaunay triangulation matching algorithm

After generating MMDT, the matching process is a scoring and sorting the best matched as described follow. The matching method is carried out by four steps.

The first step is finding the nearest vertex in all MMDT, it is a function that identifies the nearest point on each DT to the feature vectors of a query image. The result is the facet, nearest neighbor vertices to a vertex. Repeat all of the DT constructed with query feature vector image of each DT.

The second step is to compute each nearest MMDT Euclidean distance, the result representing the distance of vertex (query image vector) and vertices of facet from step 1.

The third step is summary distance all vertices in step 2. And the last step, sorting distance and show results, when it is nearest to zero, that image is the best matched.

3. Results

Experiments for performance evaluation of the proposed method are run on the Intel® Core™ i5@2.50GHz, RAM 8GB. The test images in the database are from the Corel Image Gallery [6] consists of randomly selected 1,000 images from all categories. The sample images are shown in Figure 4. The test query images also are randomly selected 100 images from the database.

Figure 4 Typical images from the test database

In our experiments, MMDT is constructed. Firstly the feature was extracted three 256-bin color histogram from each image in the RGB color space. Secondly, MMDT were constructed by the proposed method in section 2.3. So, MMDT is a three-dimensional DT as color histogram are red, green and blue of 1000 images in a database according to the bin. For each test query image was extracted feature by three color histogram matching by the proposed method in section 2.4. The number of DT that tests are the bin of color histogram extracted.

To evaluate the overall performance of the proposed image matching, a number of experiments were performed on various size of MMDT. The average results of memory and time usage over 100 test query images matching is shown in Figure 5.

From above experiments, we have presented an image matching MMDT of different sizes. In all experiments, the results are always accurate. But there are significantly difference in terms of memory and time spent in the operation will vary depending on the number of MMDT used.

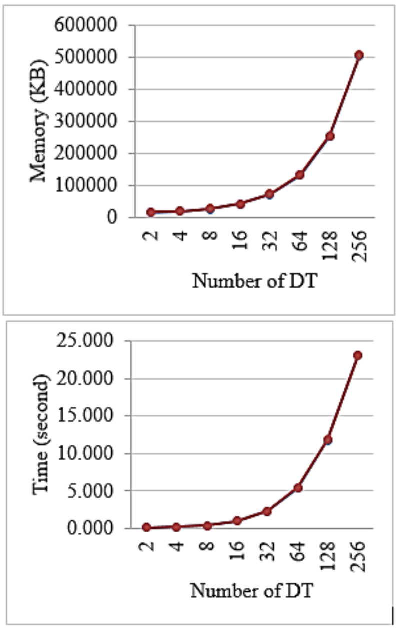

Figure 5 The cost of the construct and matching execution

4. Discussion

We have presented such a way as to match the image. The results have shown that the time to perform is satisfied, but the constructing still requires a lot of memory in higher dimensions. Our proposed method can be applied to increase the number of dimensions.

5. Conclusions

In this paper, we proposed an image matching method that is called the MMDT. This method has proposed the reduction of dimensions of the DT by multiple medium dimensions DT. The experiments were conducted using a color histogram which is well-known to perform feature extraction images to construct MMDT for matching. In all experiments, the results are shown that our method can reduce memory and time and can construct higher dimensions. However, significant differences in terms of memory and time spent in the operation will vary depending on the number of MMDT used.

6. Acknowledgements

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