2D Adjacency Matrix Generation using DCT for UWV contents

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Abstract—Since a display device such as TV or signage is getting larger, the types of media is getting changed into wider view one such as UHD, panoramic and jigsaw-like media. Especially, panoramic and jigsaw-like media is realized by stitching video clips, which are captured by different camera or devices. In order to stich those video clips, it is required to find out 2D Adjacency Matrix, which tells spatial relationships among those video clips. Discrete Cosine Transform (DCT), which is used as a compression transform method, can convert the each frame of video source from the spatial domain (2D) into frequency domain. Based on the aforementioned compressed features, 2D adjacency Matrix of images could be found that we can efficiently make the spatial map of the images by using DCT. This paper proposes a new method of generating 2D adjacency matrix by using DCT for producing a panoramic and jigsaw-like media through various individual video clips.

Index Terms— 2D Adjacency Matrix, Discrete Cosine Transform (DCT), panorama.

1. Introduction

In recent years, with the development of the display technology, the use of the images shows an increasing tendency. Thus, the size of image, which is exhibited in the display, is also expected to be enlarged. However, the view of normal camera is only 60 degree which makes the difficulty in conveying the realistic feeling to users in some vast areas, such as stage and stadium. To solve this problem, the method, which uses several cameras to generate a large image from multiple angle and multiple viewpoint, is proposed.

There exist lots of algorithms, taking the SIFT for example, which is the most frequently used method, it take the advantages of extracting the invariant feature points or shapes to composite images. By using feature points to combine the image is benefit to the synthesis part, since it can calculate the exact combination position and is also robust for image distortion. However, due to the mass of compared feature points and processing information, the computation is relatively large along with the low speed.

In present work, several parts are involved, namely, the description of the DCT matching contains DCT algorithm and DCT block similarity detection method (section 2), the 2D Adjacency Matrix Generation based on SURF (see section 3), and section 4 presents the implementation and results are contained. Finally, the conclusion of the proposed system and the view of future work on this topic are stated in section 5.

2. DCT Matching

2.1 DCT algorithm

The DCT (Discrete Cosine Transform), and in particular the DCT-II, is often used in signal and image processing, especially for lossy compression, because it has a strong "energy compaction" property.

DCT-II

$$\mathbf{X_k = \sum_{n=0}^{N-1} x_n \cos\left[\frac{\pi}{N}\left(n+\frac{1}{2}\right)k\right] \qquad k = 0, \ldots, N-1.}$$

Fig. 1. The DCT-II calculating formula

2.2 DCT Block Similarity Detection Method

The transformed DCT images of the similar images possess semblable data distribution, while the DCT images of different images have another data distribution. On account of this point, DCT comparison may be an approach for detecting the similarity of images. The correlation coefficient is used for matching the value of DCT comparison as shown in Fig 2.

$$d(H_1, H_2) = \frac{\sum_I (H_1(I)-\bar{H}_1)(H_2(I)-\bar{H}_2)}{\sqrt{\sum_I (H_1(I)-\bar{H}_1)^2 \sum_I (H_2(I)-\bar{H}_2)^2}} \quad \text{where } \bar{H}_k = \frac{1}{N}\sum_J H_k(J)$$

Fig. 2. The correlation calculating formula

The maximum value of DCT comparison for blocked images would be the standard to determine the location of the images.

In terms of the DCT block similarity detection method, it can be divided into several steps. In brief, two images are firstly input. Subsequently, the DCT comparison is carried out to the whole of input images. When the calculated result exceeds the specified threshold, it can be concluded that these two input images are very similar as well as possess the same position. Otherwise, these images are divided into two parts in the horizontal and vertical direction, respectively. To further determine the relation between two input images, the DCT comparison and analysis on the segmented blocks are performed.

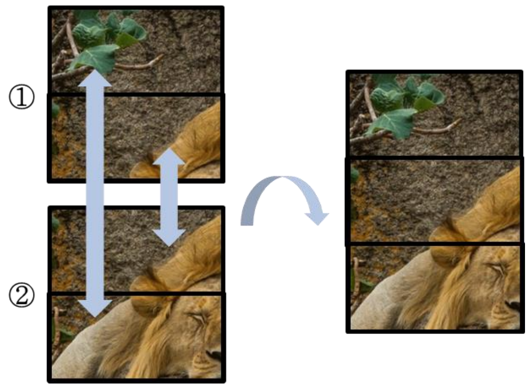

Fig. 3. Segmented images in the horizontal direction and matching result

The comparison of lower part of image 1 and the upper portion of image 2 using DCT block similarity detection method is executed, as demonstrated in Fig. 3. If they were judged as similar, it is reasonable to confirm that image 2 is below image 1 and shows 1/2 overlap with image 1. On the other hand, if the upper portion of image 1 was similar to the lower part of image 2, one obtains that the image 1 is on the up position of image 2.

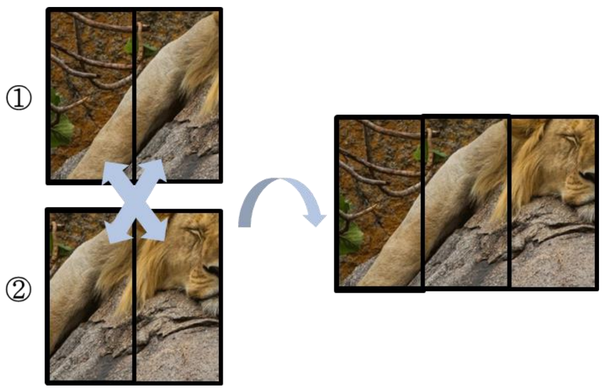

Fig. 4. Segmented images in the vertical direction and matching result

Moreover, by utilizing the DCT block similarity detection method, the similarity result between the right portion of image 1 and the left portion of image 2 is achieved, as shown in Fig. 4. If the similarity was high, it indicates that the image 1 is situated at the left side of image 2 along with 1/2 overlap with image 2. In another case, if the left portion of image 1 and right portion image of 2 was similar, one knows that the image 1 is located at the right side of image 2.

If the similarity of the input images can not be achieved through aforementioned procedure, the image should be divided into 4 parts for further analysis. With the help of DCT comparison, we can know the position relation of segmented images in the diagonal direction.

Fig. 5 illustrates comparison result between the lower right part of image 1 and the upper left part of image 2 by DCT comparison. As presented in Fig. 5, it is evident that image 1 is placed at upper left side of image 2 with the overlap of 1/4 with image 2 in the diagonal direction.

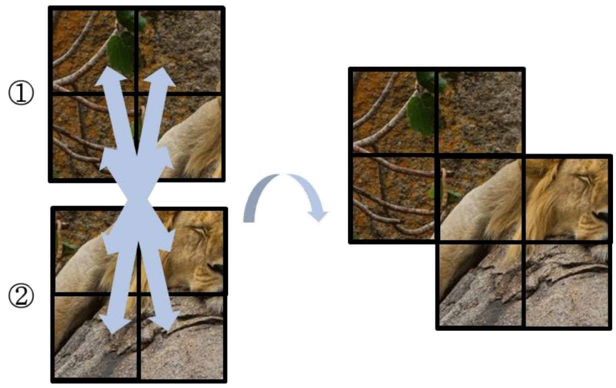

Fig. 5. Segmented images in the diagonal direction and matching result

When two images are compared with each other, the potential confirmed positions are investigated and corresponding results are depicted in Fig. 6. Clearly, eight positions are obtained from an image (see Fig. 6). The schematic diagram for the above algorithm is displayed in Fig. 7.

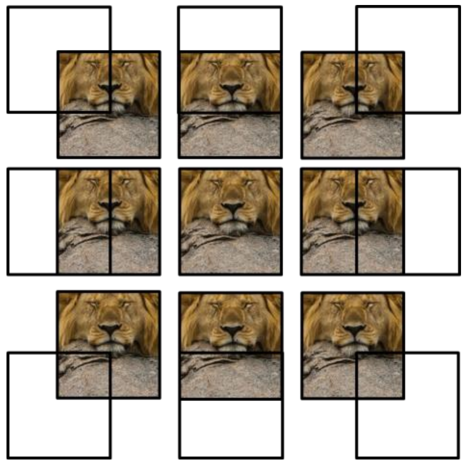

Fig. 6. Possible locations

3. 2D Adjacency Matrix Generation

The operation procedure of the proposed system, which is used in this work, is demonstrated in Fig. 8. In this case, the grayscale images with the resolution of 256 x 256 are firstly inserted. Then, the DCT comparison is implemented to inspect the similarity of input images. On the basis of the similarity of the input images, one knows their 2D Adjacency Matrix. Ultimately, by means of DCT block matching process on the input images, the image map would be created.

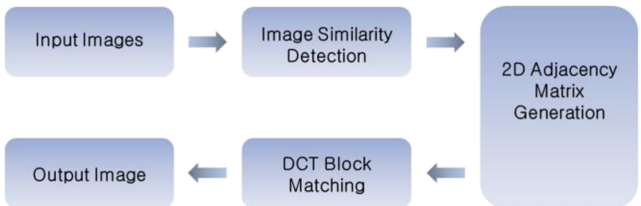

Fig. 8. System block diagram

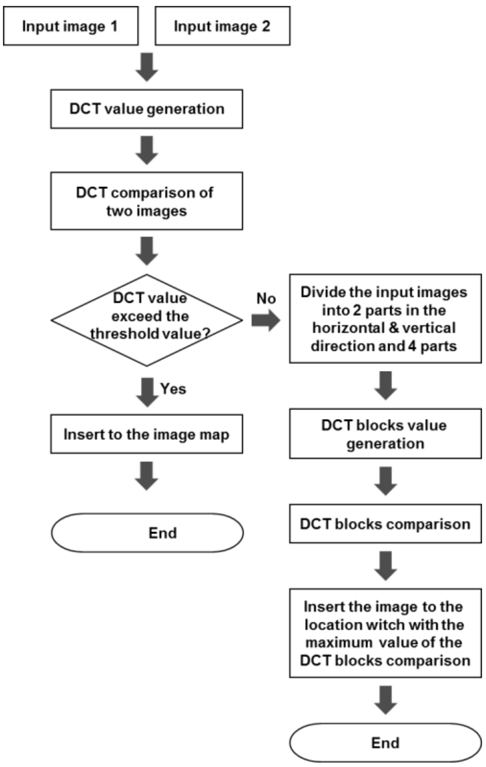

Fig. 7. 2D Adjacency Matrix generation algorithm flow chat

The image position can be gained via the DCT block similarity detection method. Based on the values obtained from DCT comparison, the expression of 2D Adjacency Matrix between the images is achieved and it could be employed to create the image map. As is known, the image map is a collection of images. In general case, if image A was shot at the right side of image B, it would be populated at the right side of image B in the image map.

If we already had an image map and want to do further image mosaic, such as mosaicking panorama and jigsaw-like image, the amount of calculation would be greatly reduced, leading to the enormous enhancement of computing speed.

To produce the image map, the images are initially input into the system. After inputting the images, the DCT comparison method is employed to analyze the similarity among image 1 with other input images. In particular, when the image 1 is located at a certain position, from the similarity result, the position of image 2, which is related to that of image 1, could be determined. After finishing the comparison between the image 1 and other input images, the images, which show the similarity with image 1, will be applied as the reference image to continually compare with other residual images. The detailed processes are illustrated in Fig. 9.

In terms of generation of an image map, the most critical thing is that each image can only occupy a certain position in the image map, that is to say, different images possess different positons. If two images were very similar to each other, one of them should be removed. To realize this purpose, an alignment process is required, as described in Fig. 9. In this case, the image 2 is expected to inset into the image map. Unfortunately, the candidate inserting position, which is related to image 1, is occupied by another image. To figure it out, the insertion of image 2 into the image map is quitted and it is used to detect the similarity with other images.

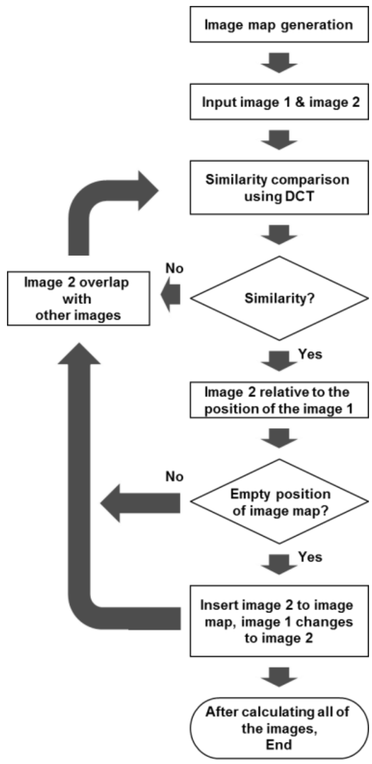

Fig. 9. Image map generation algorithm flow chat

4. Implementation and Results

For the sake of verifying the performance of the proposed algorithm, in present work, images with the resolution of 256 x 256 are employed as the experimental object. The experimental environment consists of Microsoft Visual Studio 2013 from Microsoft Company, OpenCV2.4.10 library and 3.4GHz Intel I7 processor. The test images are shown in Fig. 10.

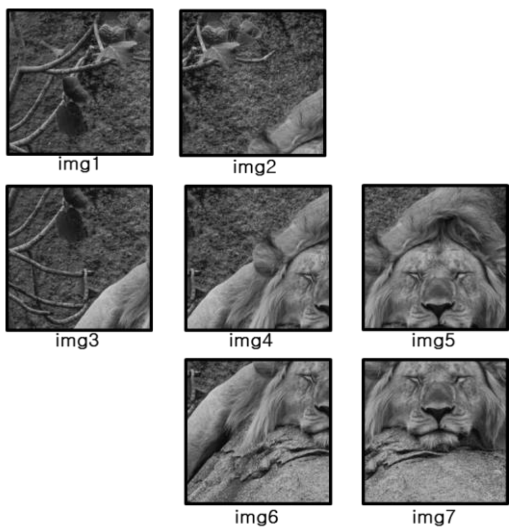

Fig. 10. Test images

Eventually, the image map of input images is generated, as depicted in Fig. 11.

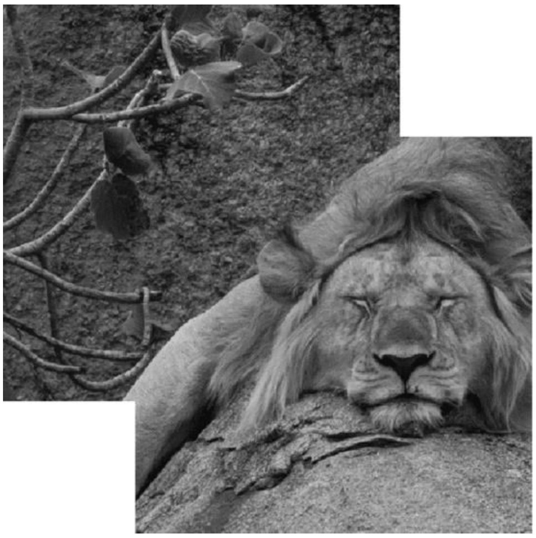

Fig. 11. Image map

The runtime of the proposed system for generation of the image map is 107ms.

5. Conclusion and Future Work

In conclusion, based on the experimental results, it is evident that DCT block similarity detection method is suitable for detecting the similarity between different images. Meanwhile, the proposed method is also an effective approach to deal with these slightly warping images. Furthermore, the system possesses an extremely fast runtime as low as 107ms. However, as for processing the rotated and larger warping images, there still exist some problems. As a consequence, the goal of the future work is to overcome these drawbacks.

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