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Determination of The Satellite Images Orientation Using DCT Coefficients

In this research a new method that determine the difference in orientation between two images (windows) using the DCT coefficients as descriptors is present, where the four operators that may change the orientation between the two images (windows) is studied by analyzing the new distribution of the DCT coefficients after applying each of them or their combinations. To determine the difference in orientation using the new distribution of the DCT coefficients, a new criterion is proposed which uses the sign changing in certain DCT coefficients as a pattern for that difference, and according to the results it success to determine the difference in the orientation between two images (windows) in very fast and accurate manner that invariant to the size and the details of the image (window).

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1. Introduction

In many field of image processing and remote sensing adjusting the orientation between different images or their slide windows to be matched is common issue as pre or post processing step. Adjusting the orientation utilizes testing all possible different directions that may make the images orientation match, this process usually perform using pixel-based distance criteria in which the minimum of the sum squared distances between the images is intend [1].

Adjusting the orientation between different images are rise in many different fields, therefore many researches that deal with that issue are reported and all are aim to perform it with more accurate and efficient way that consume the computer less time and memory. In building 3-dimensional representation for big object, Besl and McKay [2] present iterative closest point (ICP) method to adjust the orientation of range images, the ICP searches corresponding points as the nearest neighbors between two range images. Relative rotation and translation matrices are computed so that the mean square error of the corresponding points is minimized. These steps are iterated until the error falls below the threshold value. Oishi [3] developed a faster model of the ICP method to reduce the computational time by reduce the algorithm to only three or more of the range image. In medical imaging, Bulan and Ozturk [4] present a comparison between a k-dimensional tree based alignment with the standard distance map based alignment algorithm, the k-dimensional based technique uses modified approximate nearest neighbor library, which primate to search in multidimensional space and adjust the orientation in 3D dataset of rodent brain. In remote sensing field Cheng [5] uses a binary image region based method to adjust the orientation between images by a two steps, first determine the overlap regions between the images and then the regions process to binary images, and then the binary images are filtered by mathematic morphologic method. In the appointed binary image region of the former image, feature template is searched and extracted. Through the XOR operation of the feature template and search region, some possible matching positions in the overlapped region of the latter image are obtained. In Image Processing, Dong and Guan [6] used the local binary pattern technique to adjust the images orientation, which is recognized as gray scale and rotation invariant, but this technique is variant for flipping and scaling or their combinations.

In the field of remote sensing, the standard four operations that may produce the difference in orientation between different images or there slide windows are flipping, rotation, scaling, translation, or combinations of these operations. The common way to adjust the orientation is to use the distance criteria to decide which orientation match the other image (window) better than the others orientation, therefore each image (window) should be tested using the four standard operations or there combinations and calculate the difference with the reference images (window).

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2. DCT Coefficients as Descriptors

One of the properties that the DCT transform is possessing the energy compactness [7], which mean that the DCT transform has the ability to describe the image orientation in its coefficients (except the DC coefficient), therefore using the DCT transform as image (window) descriptor will provide a very fast way to detect the orientation of different images (windows) since there is no need for applying the four standard operations or there combinations and measure the distance between the images (windows).

In order to use the DCT transform as a descriptor there is a need to study the new distribution of the coefficients and their alternation to make pattern of changing for each standard operation or there combinations to use them to detect the orientation between the two images (windows).

3. Research Procedures

To maintain the generality and to make the results independent on the used images, random number generator used to generate the test slide windows for different sizes, which used to analyze the DCT coefficients. The coefficients of each generated slide window compared with the coefficients of the same generated slide window but after applying rotation, flipping, scaling, and\or translation operator separately and together (companied). The alteration in the DCT coefficients after applying the operators is detected using the DCT descriptor.

4. Results and Discussions

By comparing the DCT coefficients of the test slide windows before and after applying the operators, the alterations in the DCT coefficients illustrated in Fig. (1) is determined.

In Table (1), summary of the alteration in the DCT coefficients distribution and their signs is presented, in which for each operation(s) there is standard distribution for the new DCT coefficients. For some cases, when applying the operators together it will produced effect on the test slide windows similar to the effect of other operators and this is due to the symmetry effect of these operators.

Table (1) Summery of the changing in the DCT coefficients

Operation	Equal to	Sign Changing	Transpose
Flipping Around Rows (**r**)	**c180**	Yes	No
Flipping Around Columns (**c**)	**r180**	Yes	No
Rotation 90 Counterclockwise (**90**)	**90**	Yes	Yes
Rotation 180 Counterclockwise (**180**)	**180**	Yes	No
Rotation 270 Counterclockwise (**270**)	**270**	Yes	Yes
Flipping Around Rows And Rotation 90 Counterclockwise (**r90**)	**c270**	Yes	Yes
Flipping Around Rows And Rotation 180 Counterclockwise (**r180**)	**C**	Yes	No
Flipping Around Rows And Rotation 270 Counterclockwise (**r270**)	**c9o**	No	Yes
Flipping Around Columns And Rotation 90 Counterclockwise (**c90**)	**r270**	No	Yes
Flipping Around Columns And Rotation 180 Counterclockwise (**c180**)	**r**	Yes	No
Flipping Around Columns And Rotation 270 Counterclockwise (**c270**)	**r90**	Yes	Yes

By examining Fig. (1), it is clear that the DCT coefficient altered with the four operators in two manners either by altering the sign of some coefficients in certain pattern for each operation or altering the coefficients by two steps first by altering the sign and then by transpose the coefficients.

By studying the alteration in the DCT coefficients it is easy to notice that the new distribution of the DCT coefficients after applying the four operators or their combinations is invariant for the size and contain of the original data (image details) as shown in Fig. (1). That's make the determining of which operator(s) that may produce the new distribution of the DCT coefficients is easy by comparing them with the DCT coefficients of the original data. In this research a new criteria is suggested to determine the difference in orientation between two datasets by taking certain coefficients and determine if the signs of them are changed and according to the sign changing pattern the difference in the orientation between the datasets is determine (i.e. which of the four operators or their combinations caused the difference).

After Applying the DCT

The Original Coefficients

a11	a12	a13	a14
a21	a22	a23	a24
a31	a32	a33	a34
a41	a42	a43	a44

1 - Flipping Around Rows

Coefficients After Flipping (Final)

a11	a12	a13	a14
-a21	-a22	-a23	-a24
a31	a32	a33	a34
-a41	-a42	-a43	-a44

2 - Flipping Around Columns

Coefficients After Flipping (Final)

a11	-a12	a13	-a14
a21	-a22	a23	-a24
a31	-a32	a33	-a34
a41	-a42	a43	-a44

3 - Rotation 90 Counterclockwise

1- Changing Coefficients Signs

a11	-a12	a13	-a14
a21	-a22	a23	-a24
a31	-a32	a33	-a34
a41	-a42	a43	-a44

→

2- Transpose Coefficients (Final)

a11	a21	a31	a41
-a12	-a22	-a32	-a42
a13	a23	a33	a43
-a14	-a24	-a34	-a44

4 - Rotation 180 Counterclockwise

Coefficients After Flipping (Final)

a11	-a12	a13	-a14
-a21	a22	-a23	a24
a31	-a32	a33	-a34
-a41	a42	-a43	a44

5 -Rotation 270 Counterclockwise

1- Changing Coefficients Signs

a11	a12	a13	a14
-a21	-a22	-a23	-a24
a31	a32	a33	a34
-a41	-a42	-a43	-a44

→

2- Transpose Coefficients (Final)

a11	-a21	a31	-a41
a12	-a22	a32	-a42
a13	-a23	a33	-a43
a14	-a24	a34	-a44

6 - Flipping Around Rows And Rotation 90 Counterclockwise

1- Changing Coefficients Signs

a11	-a12	a13	-a14
-a21	a22	-a23	a24
a31	-a32	a33	-a34
-a41	a42	-a43	a44

→

2- Transpose Coefficients (Final)

a11	-a21	a31	-a41
-a12	a22	-a32	a42
a13	-a23	a33	-a43
-a14	a24	-a34	a44

7 - Flipping Around Rows And Rotation 180 Counterclockwise

Coefficients After Flipping (Final)

a11	-a12	a13	-a14
a21	-a22	a23	-a24
a31	-a32	a33	-a34
a41	-a42	a43	-a44

8 - Flipping Around Rows And Rotation 270 Counterclockwise

Coefficients After Flipping (Final)

a11	a21	a31	a41
a12	a22	a32	a42
a13	a23	a33	a43
a14	a24	a34	a44

9 - Flipping Around Columns And Rotation 90 Counterclockwise

Coefficients After Flipping (Final)

a11	a21	a31	a41
a12	a22	a32	a42
a13	a23	a33	a43
a14	a24	a34	a44

Coefficients After Flipping (Final)

a11	a12	a13	a14
-a21	-a22	-a23	-a24
a31	a32	a33	a34
-a41	-a42	-a43	-a44

11 - Flipping Around Columns And Rotation 270 Counterclockwise

1- Changing Coefficients Signs

a11	-a12	a13	-a14
-a21	a22	-a23	a24
a31	-a32	a33	-a34
-a41	a42	-a43	a44

→

2- Transpose Coefficients (Final)

a11	-a21	a31	-a41
-a12	a22	-a32	a42
a13	-a23	a33	-a43
-a14	a24	-a34	a44

12 - Scaling By S And Translating By T

After Scaling and Translation

(a11-WxT)/S	S*a12	S*a13	S*a14
S*a21	S*a22	S*a23	S*a24
S*a31	S*a32	S*a33	S*a34
S*a41	S*a42	S*a43	S*a44

*Where W is the length of the slide window Here W=4

Fig. (1) the changing in the DCT coefficients with slide window of size 4x4 pixel

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In this new criteria, the coefficients election is done after a careful study for the new distribution of the DCT coefficients comparing with the original DCT coefficients, which let us elect eight coefficients (which can be reduce to four) that their sign change can be used as a pattern to determine the difference in orientation between any two dataset as shown in Table (2). The changing in sign for any coefficient can be tested by simply multiplying this coefficient with the same coefficient in the original DCT coefficients (has same location) and see if the multiplying result is negative which mean that the sign is changed and vice versa.

Table (2) the changing sign pattern that determine the difference in orientation, where the O means that the two coefficients have the same sign and X mean that the two coefficients have different signs (capital letters mean after applying the operator(s) and small for the original DCT coefficient)

	a21*A21	a32*A32	a12*A21	a23*A23	a21*A12	a41*A14	a24*A24	a43*A34
r	X	O		X			X	
c		X		O			X	
90			X		O	O		O
180	X		X	X			O	
270			O		X	X		X
r90			X		X	X		X
r180	O	X		O			X	
r270			O		O	O		O

5. Conclusions

According to the obtained results, the following conclusions are driven. For each operation of the four operations (or their combinations), the DCT coefficients will be always changed in a certain pattern. The new pattern of the DCT coefficients after applying one or combination of the four operations is invariant with the window size and details. In some cases of combining two of the four operators together, it will produce the same effect when combine other two operators as shown in Table (1), therefore they will produce the same distribution for the DCT coefficients. The suggested criterion success to determine the difference in orientation in very fast and accurate way and it is invariant for dataset size or contained.

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