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UNAMBIGUOUS CONTROL POINT SELECTION IN AUTOMATIC IMAGE REGISTRATION USING EDGE DETECTED IMAGE ENERGY CROSS CORRELATION

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Abstract - *This paper is about how to decide unambiguous control points for automatic image registration. The basic algorithm is depending on cross-correlation similarity measure. But due to geometrically distorted images this similarity measure need some good decision capability. So this paper explores the integrity of other parameters for correct points. The image is first divided into sub images and calculates the energy of each sub image. Based on those values it can be sort out from low energy to high energy sub image. It also considers the similarity of points using edge detection like canny edge detector. Instead of operating on gray scale image this algorithm tells to operate on edge image which is opted using canny edge detection method. Both reference and geometrically distorted images now have only high frequency information which is helpful to find control points matching using energy of sub images between these two images. once control points match correctly it is very easy to perform transformation on distorted image.*

Key Words- *Cross-correlation, canny edge, less unambiguous correlated points, mean square,energy of sub images*

I. INTRODUCTION

Various methods are available for Automatic Image registration. Many methods are based on control points [1], [2]. When you are developing control point selection algorithm based on cross-correlation, then due to geometrically variant of the image a robust algorithm is required to be developed. One may develop feature extraction algorithm for control point selection. In this paper we are selecting features which are less ambiguous by using cross correlated images' energy, edge detection and end point detection respectively. For robustness a several parameters need to be observed automatically and take a decision of final control points, which are need to be matched with reference image based on it correlation value. One may use another independent method for matching. Decision capability of this algorithm is also dependent on histogram of image. A discrete histogram have more edges, more features but at the same time it may create ambiguity. A continuous tone histogram has chance to get wrong control point due to more local maxima are present. So for perfect feature, perfect control point should be decided which has a less chance to get more number of maxima in correlated image. Here I have used template 64X64, 32X32, 16X16 as per decision. These templates are extracted from input image with non-overlapping. Energy is taken into account to keep an eye on more number of maxima. Decision of highest correlation cut off, at which all points below this cut-off are neglected, is decided by histogram of image and its local maxima of cross-correlated image of template n reference image. Canny edge detector is used to detect a very sharp edge. Its threshold value varies from 0.8 to 0.9. Those edges have endpoints which are extracted by morphological end point extraction. Those points may eligible for control points. All images that I have taken are resized to 256X256. The number of blocks needs to be consider for control point selection from input image are depend upon the cross correlation cut-off. The next sessions contain each process in detail.

II. Selection of blocks from input image

Input image is divided into each 32X32 size of no overlapping blocks. Those blocks are cross correlated with reference image. We have taken image size as 256X256 so maximum 64 normalized cross-correlated images available. Blocks having standard deviation 0 should be discarded. Normalized cross-correlation is calculated with following equation [3].

$$\gamma(u,v) = \frac{\sum_{x,y}\left[f(x,y)-\bar{f}_{u,v}\right]\left[t(x-u,y-v)-\bar{t}\right]}{\left\{\sum_{x,y}\left[f(x,y)-\bar{f}_{u,v}\right]^2\sum_{x,y}\left[t(x-u,y-v)-\bar{t}\right]^2\right\}^{0.5}} \qquad (1)$$

Here f will be reference image. Template t is block extracted from input image $\bar{f}$ and $\bar{t}$ are mean of local image region in reference image and template respectively. Energy of each normalized cross correlated image will tell about more number of maxima present in one correlated image. Energy can be found in mean square manner. So we get N values, if we have N number of cross-correlated images. Sort all values in ascending order. Choose blocks which have lower energies.

Figure 2.1 first 10 blocks of lower energy

Those first 10 blocks may not have good maxima. Next 10 blocks are shown below.

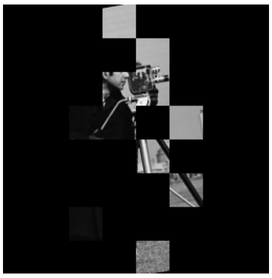

Figure 2.2 Next 10 blocks of lower energy

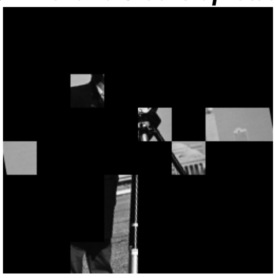

Figure 2.3 Next 10 blocks of lower energy

At higher blocks number will have more ambiguous blocks. So we start from lower blocks. We may move to the higher blocks to match exactly with cut-off.

III. CANNY EDGE DETECTION AND END POINT.

A.Canny edge detection

After extraction of blocks, find out canny edge with threshold 0.8 to 0.9. Those strong edges are capable for giving us control points.

B.End points

In each edge we are finding end points using maximum connected pixels. If it has only one connected pixel or void then it said to be end point. Those end points will now act as a control points for current iteration. If those points' cross-correlation matches to our current cut-off, then it will give us match point in reference image.

In main algorithm, if those control points are not matched then next iteration will take next 10 blocks and again find edges and end points. Next figures will show first, second and third 10 blocks.

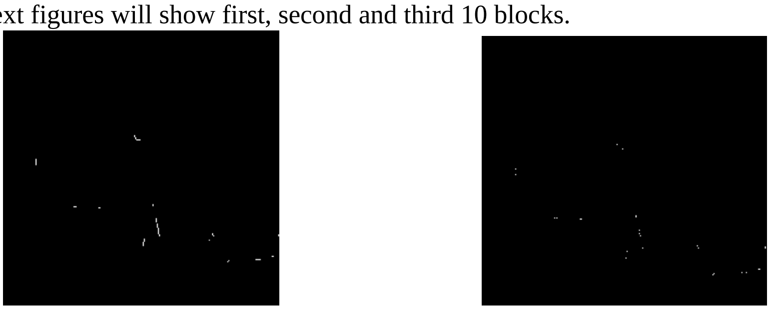

Figure 3.1 Edges and End points for first 10 blocks.

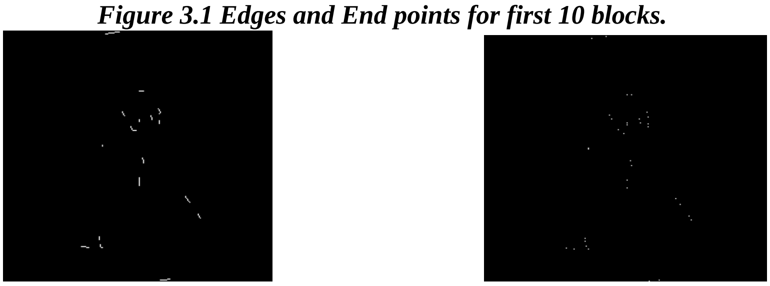

Figure 3.1 Edges and End points for next 10 blocks.

IV. Use of control points

Control points are shown in figure 6. Now each control point putting at centre and creating a template of 9x9, 17x17, 31x31. Those templates sizes are also decide by decision algorithm. In general if continuous tone image then Template size is possible to be lower, and if discrete image then higher size is good. Main parameter correlation cut-off is decided by the highest maximum value present in all cross-correlated images. The value should be around 80% of this maximum value. Here in this example cut-off is set to 0.9605. In first iteration first 10 sorted blocks are taken. But each cross-correlated image maximum value doesn't match our cut –off criteria. So we take next 10 blocks. For these points, cut-off criteria are not satisfied. But this time it will change control points template size and trying to match. If not satisfied, it will check maximum value of those blocks. If these values are quite lower than the cut-off then it will lower down the cut off by 10%. This is again an iterative procedure. Next 10 blocks or 20 blocks are now considered if 3 iterations are failed in previous session. Again same procedure follows. Once it matches then it will give correct match points set.

Figure 4.1 Control point set of blocks no.21 to 30

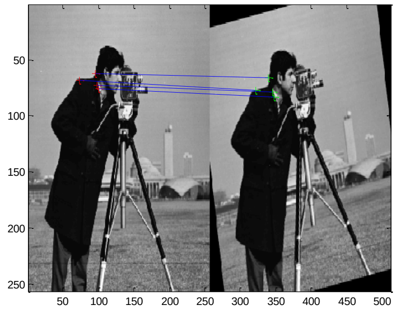

Figure 4.2 final match points

Figure 4.2 shows control points and out of which 4 points are matched. It will also keep track of previous points. When numbers of match points are greater than 3 then loop will be terminated. 3 points are necessary to solve mapping of points using affine transform in later stage. Final values of parameters are:

- Cut-off is reduced to 0.7050.
- Block size 32X32
- Control-point template size 64X64

We may reduce the template size to increase cut-off value.

V. Result

For results to be shown here, two images have been taken. One image has continuous tone and another one has discrete one and those result are compared with the conventional cross-correlation matching. So next 2 figures will show efficiency of this decision algorithm.

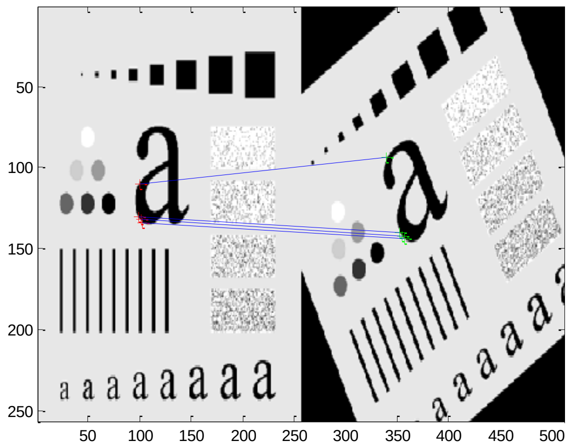

Figure 5.1 ambiguous matching of control points with cutoff 0.8800 and blocks number from 44 to 53 (these blocks have highest energy cross-correlated points) Gives wrong matching of the points.

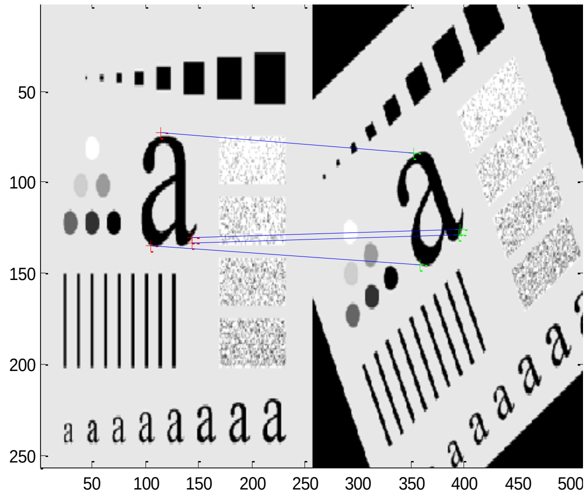

Figure 5.2 Unambiguous matching of control points.
With cut-off 0.806 and blocks 30 to 41.

Here template size is 32X32 and block size is 16X16. Block number indicates the energy of cross correlated image in ascending order. Block 1 indicates lowest energy and highest block number indicates highest energy. We can observe here even though cut-off is set to lower value, we get correct match points due to block number 30 to 41 as shown in figure 9. In this image due to more objects there is more chance to have ambiguity in selection of control points. Here we have no problem of this ambiguity due to less energy points. Blocks 30 to 41 indicate neither lowest energy nor maximum energy of cross-correlated images. Total we have 53 blocks.
Next image has continuous tone. So by prediction this image has to match with lower energy blocks. here note that figure 10 has block size and template size is different than the figure 11. Due to no match found in 32x32 block size it will reduced to 16x16 with only centre portion of the image. And template size startup is 32x32. If it doesn't match with 32x32 then template size will be reduced to 16x16. Here we require more number of iteration to get correct result.

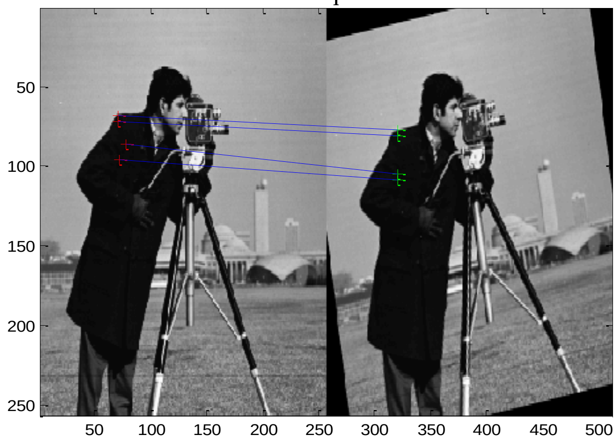

Figure 5.3 False matching with higher energy blocks. Cut-off is reached to 0.9440 with all block. Block size is set to 32x32, template size is set to 16x16

Figure 5.4 per fact match of points.with cut-off is reached to 0.8300 where blocks 10 to 32. Block size is 16x16 and template is 32x32.

Table 5.1 Results

Sr. no.	**Original image : Cameraman**		
	Input image	***Cutoff***	***Blocks(64)***
1	Distorted with degree 10	0.8300	10 to 32
2	Distorted with degree 15	0.8540	32 to 52
Sr. no.	**Original image : letter image**		
	Input image	***Cutoff***	***Blocks(64)***
1	Distorted with degree 30	0.806	30 to 41
2	Distorted with degree 25	0.914	20 to 41

Conclusion

The computational complexity is lesser but at the same time decision making algorithm is somewhat complex. If number of iterations are more for matching then it will use previous results to save time. We can use parallelism to compute each block cross-correlation and template cross-correlation. We can also process image histogram before making any decision. Discrete histogram image have fast results compare to continuous tone image. For matching of control points one may use another approach with this decision making algorithm. So we can use other transforms to correlate those points. Wavelet transforms, Discrete Cosine transform can be use in later stage of matching points for improvement in results and reduction in computational complexity.

References

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[3]Lewis, J. P.,"Fast Normalized Cross-correlation," *industrial light & magic*.

