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# Image Path Searching using Auto and Cross Correlations

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**Abstract—The position detection of overlapping area in the interframe for image stitching using auto and cross correlation function (ACCF) and compounding one image with the stitching algorithm is presented in this paper. ACCF is used by autocorrelation to the featured area to extract the filter mask in the reference (previous) image and the comparing (current) image is used by crosscorrelation. The stitching is detected by the position of high correlation, and aligns and stitches the image in shifting the current image based on the moving vector. The ACCF technique results in a few computations and simplicity because the filter mask is given by the featuring block, and the position is enabled to detect a bit movement. Input image captured from CMOS is used to be compared with the performance between the ACCF and the window correlation. The results of ACCF show that there is no seam and distortion at the joint parts in the stitched image, and the detection performance of the moving vector is improved to 12% in comparison with the window correlation method.**

**Index Terms—ACCF, Auto and cross correlations, image stitching, image filtering**

## I. INTRODUCTION

**IT** is very difficult to acquire images of entire tumor sections in retaining a microscopic resolution in detail. A usual approach to solve is to create a composite image at appropriate overlapped several images acquired by microscope [1-3]. It is similar to capture the documents as well. An image should be taken by capturing at some distance uniformly. In this case, the letter of image is not clear and character recognition is also difficult on scale down image. Thus, the demand to makes one image from several images has been increased gradually. But most technique have used geometric image transform or required complex computation to sleek he composited image visually [4-9].

This paper describes stitching technique that is used to hold the original image by image pixel directly to maintain high resolution and be good at character recognition. First, the filtering technique is expanded to detect features on image and to build the correlation matched filter design to find out the overlapping region and the moving vector in the interframe. Second, the image stitching is expanded by moving vector to composite one frame from the interframe by moving vector. To evaluate the performance of proposed method, the stitched image with ACCF is compared to window correlation method.

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## II. AUTO AND CROSS CORRELATIONS

The correlation function is used to show the similarity between the two images and to compare the correlation based on image pixel as an objective indicator. The ACCF is constructed from image block applied correlation function to previous image. It is possible to search the duplicate pixels in current image using crosscorrelation of ACCF. One of the two images is used to make a filter for the correlation matching and the other image is applied to crosscorrelation with ACCF to find best similar position. The detected position is used to stitch one image from two images. The previous image must be reference and the current image is used to be base image for moving vector detection.

It assumes that the interframe has the same duplicate area and the center position on the previous image is shifted from the current image. The moving vector of the two images is allowed to be shown the affine transform equation. The correlation vector is shown as the relation of the two image with moving displacement. When the $z$ axis is two images correlation value and $x$, $y$-axis is pixel position of image and 3D correlation plane is the same to an elliptic parabola. The second order equation of the moved image to $x'$, $y'$ points are the following as (1).

$$z' = f'(x', y') = q_{20}x'^2 + q_{02}y'^2 \qquad (1)$$

If $q_{20}$, $q_{02} > 0$, the elliptic parabola plane $\{x', y'\} = \{0,0\}$ has uniform minimum $z' = 0$, and x' and y' of elliptic parabolic plane are formed by the intersection of the plane $f'(x', y')$. If $z' = z_0 \equiv \delta$, $\sqrt{z_0/q_{20}}$ and $\sqrt{z_0/q_{02}}$ are represented.

The plane $\{x', y'\}$is enabled to be transformed to the surface $z' = f'(x', y')$by using two-dimensional affine transformation, and the inverse of the transformation can be represented in the Cartesian basis by the matrix expression (2).

$$c = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \quad (2)$$

In the case of a rotation about the z' axis by an angle θ and c is described by the expression (3).

$$c \equiv R(\theta) = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \quad (3)$$

Next, the 2D affine transformation enables to be converted to 3D translation by the vector$\{x_0, y_0, z_0\}$, and the reference frame is specified by the coordinates$\{x, y, z\}$. The original coordinates of the undisturbed correlation surface are produced in terms of the modeling coordinates by inverting both the translation and the affine transformation in order is given by the equations (4) to (6),

$$x' = c_{11}(x - x_0) + c_{12}(y - y_0) \quad (4)$$
$$y' = c_{21}(x - x_0) + c_{22}(y - y_0) \quad (5)$$
$$z' = z - z_0 \quad (6)$$

The coordinate $\{x, y, z\}$ of correlation plane enables to express to second order model function like the following,

$$f(x, y) = a_{00} + a_{10}x + a_{01}y + a_{20}x^2 + a_{11}xy + a_{02}y^2 \quad (7)$$

The equation is rewritten by the coefficient, $a_{mn}x^m y^n$ with six coefficients is represented. Where $\{m, n\} \in \{0,1,2\}$ and $0 \le m + n \le 2$. The two coefficients $a_{10}$ and $a_{01}$ enables to be uniquely expressed in terms of displacements $\{x_0, y_0\}$. The result of inversion is given by the following equation (8) and (9),

$$x_0 = \frac{a_{01}a_{11} - 2a_{10}a_{02}}{4a_{20}a_{02} - a_{11}^2} \quad (8)$$
$$y_0 = \frac{a_{01}a_{11} - 2a_{01}a_{20}}{4a_{20}a_{02} - a_{11}^2} \quad (9)$$

The moving vector for the image stitching is computed by 4 steps. First, the image filtering is processing on the input image. Second process is detecting the reference image in the previous image and third process is detection of overlap position in the comparing image using reference image. The last step is the image stitching of different two image detected overlap information.

*A. Image Filtering*

The image filtering leads to enhancement of image feature, remove noise and DC component in image. The filter size is array 4x4. The larger is filter size, the wider area enables to process at a time. But it has weakness that is increasing computation size and insensitive of the data change. The filter size is set to temporary value. Fig.1 is shown as filter mask. The filter operation is processed to shift filter mask. The filter mask is lied left side and the input image is put upper side, and to operate convolution to the stitching mask area. In next step, the filter shifts one pixel to right side of image. With the same method, the computation to the image and filter mask is repeated until the filter block is arrive to the right end of the image. When the filter mask is located at the right end of image, the computation is restarted to shift one pixel to down side at the left of image.

| | | | |
|---|---|---|---|
| 5 | 2 | -2 | -5 |
| 2 | 1 | -1 | -2 |
| -2 | -1 | 1 | 2 |
| -5 | -2 | 2 | 5 |

Fig. 1. Image filter mask.

The convolution procedure is multiplied by filter mask and the pixel of input image and the result is added up. The filtering equation to the input image is shown as the below.

$$I_{i,j} = \sum_{p=0}^{3} \sum_{q=0}^{3} (P_{(p+i,q+j)} F_{p,q}) + T \quad (10)$$

Where $P_{i,j}$is input image value in$\{i, j\}$, $F_{p,q}$is a filter mask value of the point $\{p, q\}$. T is threshold value of filtering data. Sometimes filtering results has a negative value. Image data must have a positive value and the filtering results are transformed to positive on the threshold value. The threshold value is adjusted on the condition of input image, where using T=258.

*B. correlations*

Autocorrelation is the process which detects a feature pattern from the previous image, the pixels operation is processed by the reference window and reference frame. The reference window means an area to be specified by the previous image size. The displacement is set up by shifting per one pixel again. The reference frame is chosen by the center area of the reference window. If the position of the reference window is changed, the position of the reference frame must be reset to set the center area of the changed reference window. The reference window size is bigger 2 pixels to the length and wide than the reference frame. The autocorrelation processing is started by locating the reference frame on the center of reference window. The result of autocorrelation gets one correlated value. Next the reference frame shifts one pixel and continues correlation. The direction of the reference frame heads from the center to outside one by one pixel in the reference window to be clockwise. Finally nine correlation values are generated by autocorrelation processing. Autocorrelation value connotes a similarity of the pixel. Correlation is given by square of sum to the difference of the pixel plane. So the result of correlation function comes close to 1, which the similarity is increased, on the contrary the result is close to zero, which similarity is low. The correlation function $C_{i,j}^{k}$ is given by equation (11).

$$C_{i,j}^{k} = \sum_{m=1}^{M}\sum_{n=1}^{N}\left|r_{m,n} - c_{m-1,n-j}\right|^{k} \tag{11}$$

Where $r_{m,n}$ denotes value of pixel $\{m,n\}$ in reference window, $c_{m,n}$ is value of pixel $\{m,n\}$ in reference frame. $i,j \in Z$ is the frame movement. $k$ is the order of square term to the correlation difference. The range is set to $k \in N,\ k \in R > 1$. The reference frame 4x3 is used at autocorrelation process and the reference window is 6x5. The processing of the reference window and the reference frame in autocorrelation is shown in Fig.2. The gray area is showing reference window, and rectangle box is the reference frame. The processing is that the reference frame is place at the center of reference windows first, be headed for left and shifts clockwise direction to come toward outside gradually like convolution.

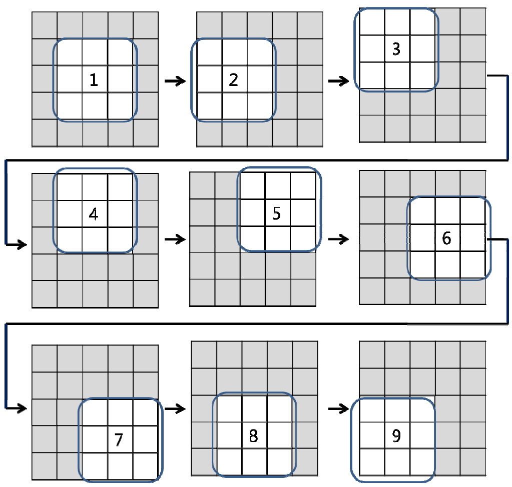



Fig. 2. Autocorrelation of the reference windows

Crosscorrelation is a process to detect a duplication area of the previous image (image1) after applies ACCF of autocorrelation to the current image (image2) and to make moving vector from the difference between two frames. First, current image left upper side puts the reference window. ACCF is located at the center of the reference window and compute correlation like the processing of autocorrelation. The correlation results are compared to correlation criteria. If the condition is not good then the reference window is shifted to right down. The shifted reference window is measured to get correlativity in placing ACCF in the center. The comparison process is continued from top of left to bottom of right in current image. Fig.3 shows crosscorrelation procedure between the reference mage and reference window. The correlation is processed by arranging the reference window from left upper and each pixel is headed for right down one by one successively.

## III. IMAGE STITCHING

Image stitching is the processing that compounds the interframe, the previous and current images into one image using moving vector.

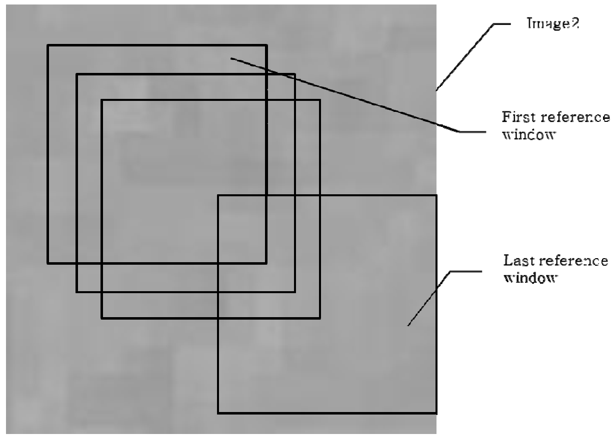



Fig. 3. Crosscorrelation process for the current image.

The previous and current images are aligned with the corner of the two images in the image buffer. The current image is shifted right down using the moving vector. Next, the current and previous images are laid overlapping each other as shown in Fig.4. The image buffer size is allocated enough to be easy to move two images.

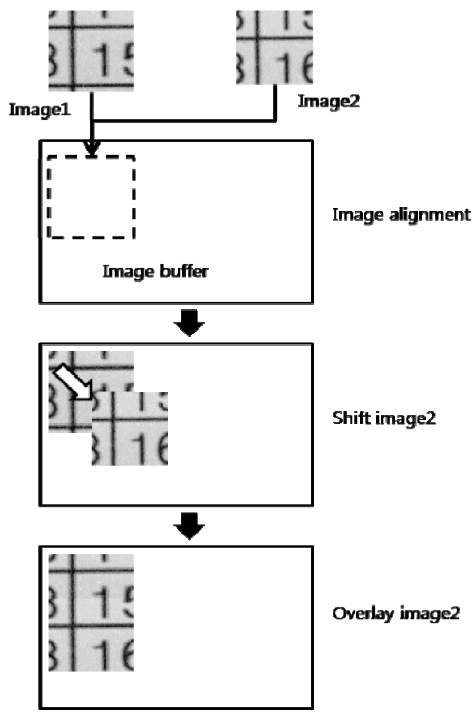



Fig. 4. Image stitching process.

## IV. EXPERIMENT AND RESULTS

The experimental conditions are that test patterns are captured by CMOS camera for input images. Capture camera is place on the test pattern plane. Camera is fixed while image is capturing. For next capture, camera is moved to vertical direction. Image labels are Img1~Img6 in sequence of capture. The camera is moved manually.

The proposed ACCF is realized in PC. Input image are transferred to DC removed image and enhanced to be prominent features by filter mask. Next, image1 is used to define ACCF by autocorrelation function and image2 is used to find a pixel point having a high similarity with previous defined ACCF. If searched position is satisfied with crosscorrelation condition then the point is used to stitch parameter. Fig.5 shows the flowchart of image stitching on ACCF.

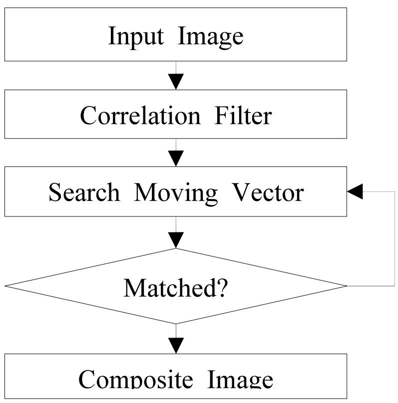
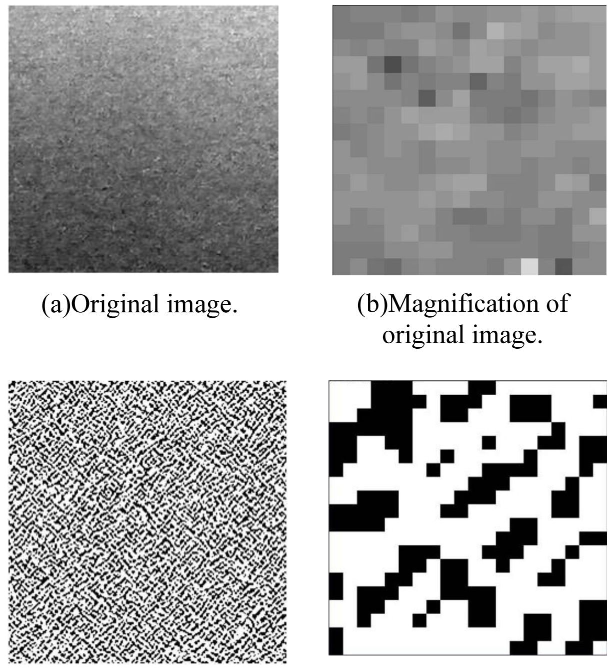



Fig. 5. Image stitching flowchart.

The captured input image and the result of lowpass filter to the input image are shown in Fig. 6. Fig. 6(a) shows The gray image with 256 levels and the magnified image of box area are shown in Fig. 6 (a) and (b) respectively. The brightness to the upper side and darkness to down side on the image is owing to illumination of around the sensor. The image capture is done by the white paper, but the result image is shown by various brightness and complicated background image patterns. This phenomenon results from sensor characteristics probably. The various illumination differences generate complicated patterns and more complex processing. This condition is applied to degraded images as well. The applied filter reduces the interference of a brightness and sensor condition, and simplifies the input image for the comparing computation. Fig.6(c) and (d) is a result of filtering and magnification to the block area of input image as shown in Fig.6. The Fig.6 (c) and (d) shows inputs, (a) filtered and expended images, and (d) pattern image with black and white levels.

The written text captured image and the background image which has also various illumination differences as well are shown in Fig. 7 (a). The lowpass filtering is given in threshold value 258, and the background is removed other than text in Fig.7 (b). If the threshold value is 275, then the image is reduced more to the feature of the text pattern as shown in Fig.7(c) than Fig.7 (b). Thus, to keep the characteristics of the original image, the threshold is required to find critical value. In this experiment, the critical threshold value is given in 258 in this experiment.



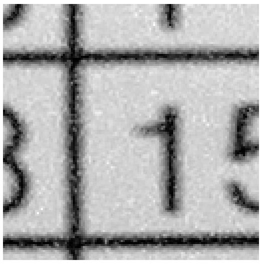
(a)Original image. (b)Magnification of original image.

(c)Filtered image. (d)Magnification of filtered image.

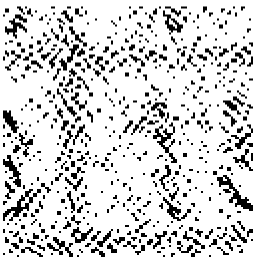
Fig. 6. The results of filtering.

The correlation rate using autocorrelation function on the image1 is shown in Fig. 8. Fig.8 (a) shows a case of the satisfied autocorrelation condition. The correlation rate of the image center is close to one. The value range of correlation rate is from zero to one, and correlation rate is higher, the rate is closer to one. The circular contour line means the same correlation. Lots of digits in each contour are showing the change of the correlation rate gradually. The diameter and digits of contour line are changed by an image pattern applied to autocorrelation function. The reference window enables to be compared with and detected by choosing correlation function from a unique feature like Fig. 8 (a).

The range of contour line is 0~1 which is equal to autocorrelation processing, which shows the same pattern as autocorrelation function processing as shown in Fig. 9 (a). The standard condition is satisfied with the crosscorrelation result between the reference and the comparing image, and autocorrelation result, the both images are placed on the same pixel position. An oblique contour line on the center represents that the both images are different according to the correlation rate is lower as shown in Fig. 9 (b), (c) and (d).



(a)Input image

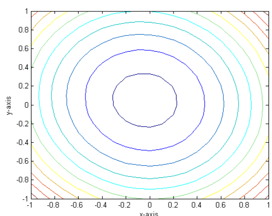


(b)Threshold 258

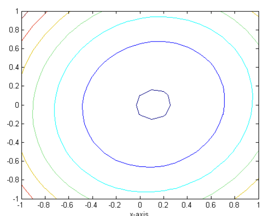
(c)Threshold 275

Fig. 7. Filtered text images.

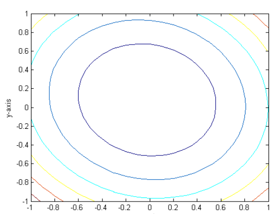
The moving vector detection rate in ACCF and window correlation method using the current image with 113 pixels movement is shown in Fig. 10. The moving vector detection rate of window correlation method is 80% and ACCF method is 91%, which the detection performance is enhanced as compared with the conventional method. The result of image stitching by two methods is shown in Fig. 11. In window correlation technique, the missed alignment of image is depicted in dot box as shown in Fig. 11(a). However ACCF technique reduced the error of image in Fig. 11(b).



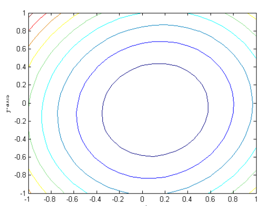
(a)



(b)

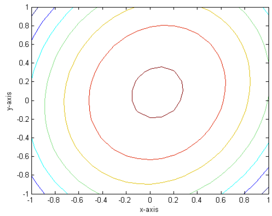


(c)

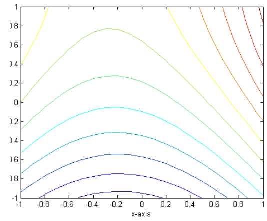


(d)

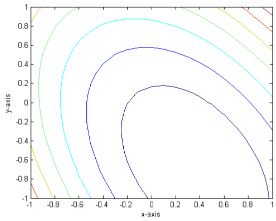
Fig. 8. The results of autocorrelation.



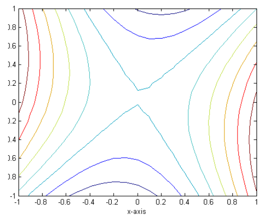
(a)



(b)



(c)



(d)

Fig. 9. The results of crosscorrelation.

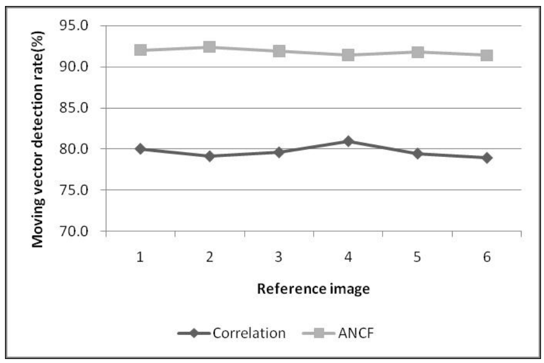
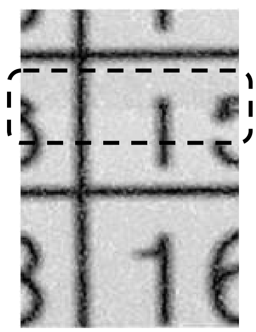
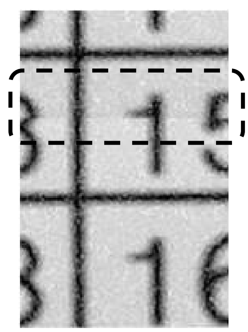



Fig. 10. Detecting performance comparison.



(a)



(b)

Fig. 11 Stitching image comparison.

## V. CONCLUSIONS

The proposed ACCF is created by autocorrelation and crosscorrelation functions to stitch images between the interframes. The previous image is applied to autocorrelation function, and extracted features on the images. The current image to be compounded is applied crosscorrelation function to detect the max similarity and duplicated area, search the crossing position and extract the moving vector in the interframes.

Input image captured from CMOS is used to be compared with the performance between the ACCF and the window correlation. The results of ACCF show that there is no seam and distortion at the joint parts in the stitched image, and the detection performance of the moving vector is improved to 12% in comparison with the window correlation technique. The proposed method enables to apply to a medical high resolution images with an electron microscope and character recognition system to stitch document images.

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