Proceedings of the 11th International Conference

PRIP'2011

Pattern Recognition and Information Processing

18–20 May 2011, Minsk, Belarus

Belarus, Minsk

UDC 004.93'1
BBC 32.973.26–018.2
P32

Pattern Recognition and Information Processing (PRIP'2011) : proceedings of the 11th International Conference (18 – 20 may, Minsk, Republic of Belarus). – Minsk : BSUIR, 2011. – 472 p.

ISBN 978-985-488-722-7

The book collects the papers accepted for publication and presentation at the 11th International Conference on Pattern Recognition and Information Processing (PRIP'2011) that will be held at may 18 – 20 in Minsk, Belarus. The proceedings are prepared for publication by PRIP'2009 Program Committee and Belarusian Association for Image Analysis and Recognition .

Proceedings will be useful for students and researchers working in the following areas: pattern recognition and image analysis; knowledge processing and representation; knowledge based decision support system, fuzzy mathematics and systems, applications of pattern recognition and image analysis.

Papers are reviewed by at least two reviewers and approved by Program Committee. All papers have been photographically reproduced exactly as submitted by authors on their own responsibility.

UDC 004.93'1
BBC 32.973.26-018.2

Contributors PRIP'2011

Conference is organized by:

- Belarusian State University of Informatics and Radioelectronics

in cooperation with:

- United Institute of Informatics Problems of the National Academy of Sciences of Belarus
- Belarusian State University, Faculty of Applied Mathematics and Computer Sciences
- Belarusian Association for Image Analysis and Recognition
- Enterprise IT-Park
- Bluemedia Ltd.
- Effective Software Ltd.
- Enterprise ISsoft Solutions
- Enterprise TelesoftService
- Syncsis Ltd.

in colloboration with:

- Belarusian Republican Foundation for Fundamental Research
- International Associations for Pattern Recognition

Section list

Contents

Histological Image Stitching Algorithm Based on Normalized Statistical Moment

Dzmitry Hancharou [1], Alexandr Nedzved [2], Valery Starovoitov [2]
1) Belarusian State University, Nezavisimosti avenue 4, goncharovda@gmail.com
2) United Institute of Informatics Problems (UIIP NAS of Belarus), Surganova street 6, valerys@newman.bas-net.by

Abstract: *The problem considered in this paper is the automatic histological image stitching. In this paper, invariant local features based on normalized statistical moment are used to select matching points and calculate the translation. This algorithm consists of feature detection, feature registration and spatial transition. The experimental results with histological images in different categories demonstrate this algorithm is fast, effective and does not require human interaction.*

Keywords: Image Stitching, Harris Detector, Normalized Statistical Moment (NSM)

1. INTRODUCTION

Stitching techniques have been used to combine overlapped signals into a new one with as little distortion of each signal as possible. Building a stitched image from a sequence of partial views is a powerful means of obtaining a complete, non-redundant view of scene [1]. Image stitching has been applied in medicine, computer vision and photogrammetry.

In general, most image stitching techniques developed in recent years can be divided into two categories: template and feature based. Template based algorithms attempt to correlate the grey levels of image patches in the views, assuming that they present some similarity [2]. Feature based algorithms establish correspondences between points, lines or other geometrical entities and use properties of local intensity values to match them.

In our application, overlapping images are used to construct an image with a far larger field of view. It solves the problem that histological image covers a very small area. The approach proposed in this paper as shown in Fig.1 extracts interesting points by Harris corner detector and then matches them using a NSM technique followed by a statistical procedure. We choose Harris corner detector here due to its invariant to geometric transformations. NSM feature which belongs to invariant image feature is from physical conceptions. Experimental results show that the NSM feature of image has the ability of antitonal and geometric distortion (translation, rotation and scaling, TRS) and its extracting method is simple [3]. Thus, NSM feature offers a solution to correlate interesting points and recover the translation between images.

This work was supported by ISTC project B-1636.

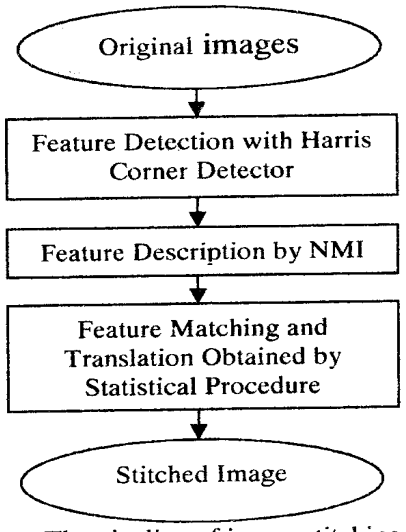

Fig. 1. The pipeline of image stitching

2. FEATURE DETECTION

The Harris measure M is the second moment matrix, describing the curvature of the autocorrelation function in the neighborhood of a point [4].

$$M = w_{u,v} * \begin{pmatrix} L_x^2 & L_x L_y \\ L_y L_x & L_y^2 \end{pmatrix}. \quad (1)$$

where * is convolution operator and $w_{u,v} = e^{\frac{-(u^2+v^2)}{2\sigma^2}}$ a Gaussian smoothing window. We can get image L_x from image I_x smoothed by a Gaussian $L_x^2 = I_x^2 * w_{u,v}$.

And the first gradients I_x and I_y in x, y direction respectively are approximated by

$$I_x = I * (-1,0,1) \approx \partial I / \partial x . \quad (2)$$

$$I_y = I * (-1,0,1)^T \approx \partial I / \partial y . \quad (3)$$

Let α, β be eigenvalues of M. α and β will be proportional to the principal curvatures of local autocorrelation function and form a rotationally invariant description of M [5, 6]. A corner point will have an M with two strong eigenvalues. An edge will present one strong and one weak eigenvalue and a flat region will have two weak eigenvalues.

Now, we can measure the corner response R with eigenvalues α and β, thus

$$R = Det(M) - kTr^2(M). \quad (4)$$

Where $Det(M) = \alpha * \beta$, $Tr(M) = \alpha + \beta$. R is positive in the corner region, negative in the edge region, and small in the flat region [5]. An interesting point is selected as a corner pixel by applying high threshold as shown in Fig.2.

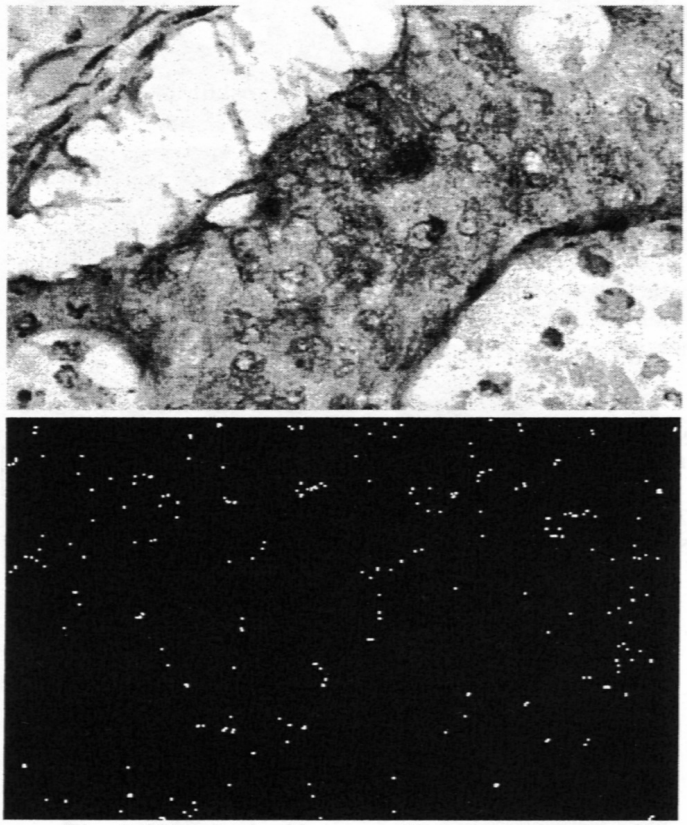

Fig. 2. Histological image with interesting points in blue with the threshold 5000

3. FEATURE DESCRIPTION

The definition of NSM is as follows:

$$NMI = \frac{\sqrt{J_{(cx,cy)}}}{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)}. \quad (5)$$

where (cx, cy) is the center of mass of the image and $J_{(cx,cy)}$ the statistical moment.

$$cx = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} x \times f(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)}. \quad (6)$$

$$cy = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} y \times f(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)} \quad (7)$$

$$J_{(cx,cy)} = \sum_{x=1}^{M}\sum_{y=1}^{N}((x-cx)^2 + (y-cy)^2) f(x,y). \quad (8)$$

NSM feature is invariant to translation, rotation and scaling. In our application, we use NSM to describe the interesting points in images. The approach calculates NSM for a disk around the points and the same points in different images will have similar properties.

4. FEATURE MATCHING

In our application we only consider translation between images though tiny rotation and scaling may exist from measure errors. Feature matching is performed with NSM and centers of gravity corresponding to interesting points between images. We define a measure of the strength of the match (SM for abbreviation), as

$$SM(NMI_{1i}, NMI_{2j}) = \frac{\left|NMI_{1i} - NMI_{2j}\right|}{0.5 * (NMI_{1i} - NMI_{2j})}. \quad (9)$$

NMI_{1i} is the NSM of $i-th$ interesting point in the first image and NMI_{2j} the $j-th$ in the second image. Let $G_{1i}(x,y)$ and $G_{2j}(x,y)$ are the centers of gravity.

If $SM(NMI_{1i}, NMI_{2j}) \le 0.1$ and $Dist(G_{1i}, G_{2j}) \le 0.1$, then the pair of interesting points is a potential match. $Dist(G_{1i}, G_{2j})$ is defined as follows.

$$Dist(G_{1i}, G_{2j}) = \sqrt{(x_{1i} - x_{2j})^2 + (y_{1i} - y_{2j})^2}. \quad (10)$$

Until now the match relationship is multi-to-multi and the purpose is to contain correct matches in potential matches. For every pair of math points, calculate translation in x and y directions each, then we can get a statistical char of quantities of matching points at different translation as shown if Fig.4. Correct matching points will result in same translation and others are stochastic, so maximum exists at proper translation between images in theory. In practice, we use following expression to estimate.

$$score = \frac{Num_x(best)}{Num_x(\text{sec}\,ond)} + \frac{Num_y(best)}{Num_y(\text{sec}\,ond)}. \quad (11)$$

$Num_x(best)$ and $Num_x(\text{sec}\,ond)$ mean the number of best and second best match in x direction in the statistical chart. If the condition $score > 1.2$ is met, these two images are treated as overlapped and the location of maximum in the chart is the translation between them.

5 EXPRERIMENTAL RESULTS

The proposed algorithm has been evaluated by histological images and pathological images and good stitching results have been obtained.

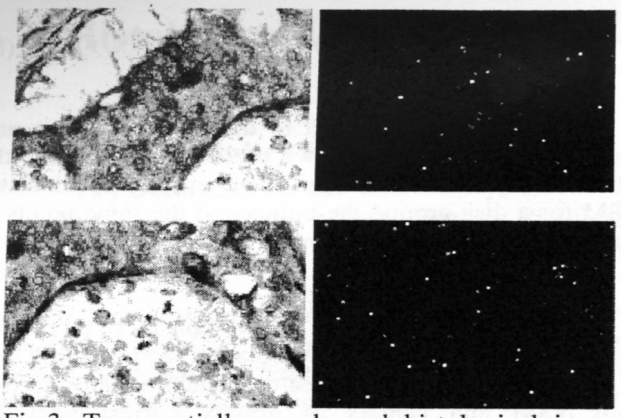

Fig.3. Two partially overlapped histological images (top) and the images with detected interesting points (bottom)

Fig.3 shows two original overlapped histological marrow images and interesting points which are detected by Harris corner detector with the threshold 5000. For such a color image, we only use intensity component to calculate interesting points and NSM.

After feature matching, the statistical cart of distance of matching points is shown in Fig.4. We can easily find maximums in each direction and this can demonstrate the robustness of our algorithm. The location of peak value on x and y axis is the translation between the two images to be stitched and in this case the peak is at (313, 50). The stitching result is shown in Fig.5.

This method can achieve fast image stitching and the time elapsed during the procedure of feature detection and feature matching is theoretical proportional to the number of interesting points. Table 1 compares the time consumed of NSM based method with Zernike moment [4], phase correlation [6] methods in image stitching and the results are average time of experiments on same size images. Fig.6 shows the mosaic results based on these two methods.

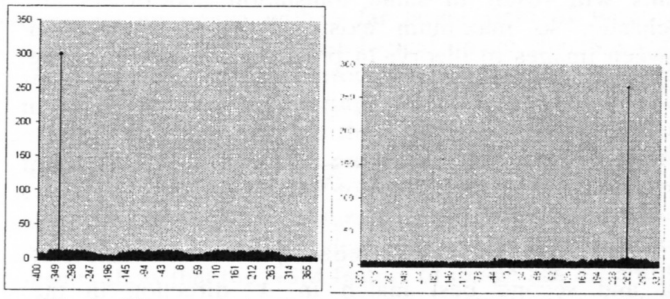

Fig.4. The statistical chart of quantities of matching points at different translation in x direction (left) and y direction (right)

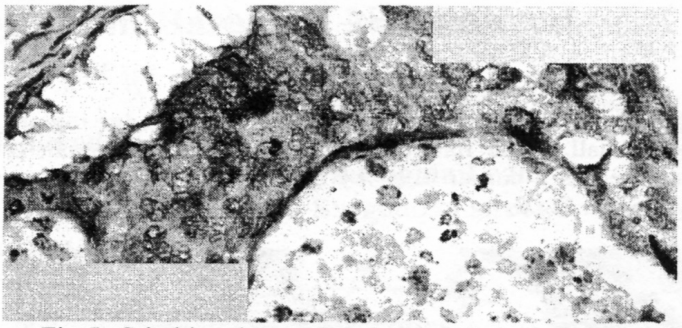

Fig.5. Stitching image by the translation obtained in Fig.4

NSM based mosaic result shown in Fig.5 is almost the same as Zernike moment and phase correlation based results shown in Fig.6, but their efficiency is distinct. Table 1 demonstrates that NSM based method is much faster in stitching images with translation. Its advantage becomes more prominent when the size of images increases. Fig.7 shows image stitching with NSM.

Table 1. A comparison of time-consuming of three different methods (unit: ms)

Image size	NSM	Zernike Moment	Phase Correlation
1798x1438	5601	47631	44692
2592x1944	9659	65798	174676

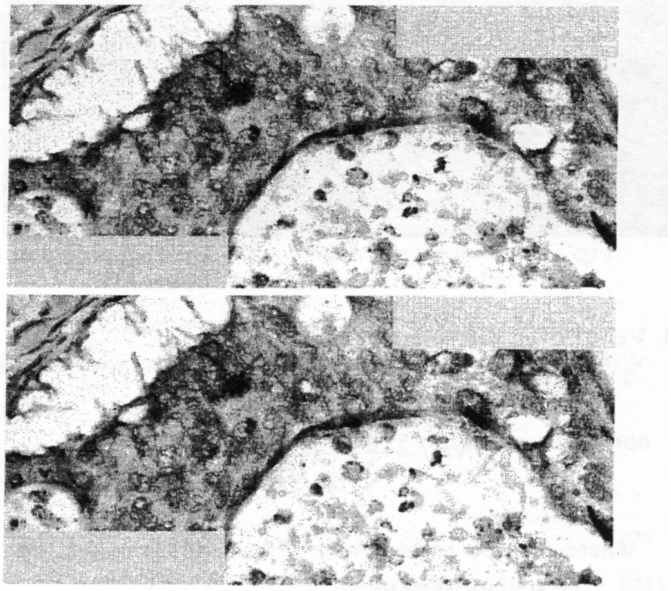

Fig.6. Mosaic based on Zernike moment (top) and phase correlation (bottom)

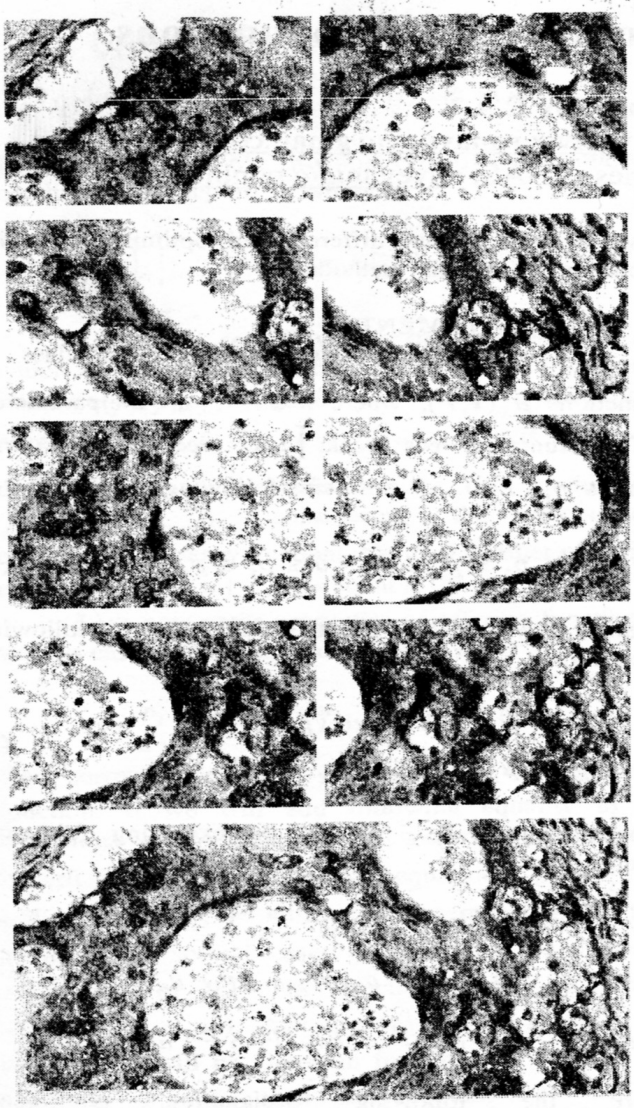

Fig.7. Original partially overlapped images to be stitched (top) and the stitching result with NSM (bottom)

6. CONCLUSION

In this paper, a novel approach based on normalized statistical moment to solve the histological image stitching problem has been proposed. The algorithm can calculate and recover the translation between the images quickly and efficiently to completely meet the demands of stitching histological medical images. Our experiments with histological images in different categories have demonstrated the proposed algorithm's robustness and speed, so it has been successfully integrated in our automatic histological image analysis system.

7. REFERENCES

[1] M. Irani, P. Anandan, S. Hsu: Mosaic Based Representations of Video Sequences and Their Applications. *Proc. IEEE Int. Conf. on Computer Vision (1995)*, p. 605-611

[2] Z.Y. Zhang, R. Deriche, O. Faugers, Q.T. Luong: A Robust Technique for Matching Two Uncalibrated Images Through The Recovery of The Unknown Epiipolar Geometry, *INRIA* (1994)

[3] Yang X.G., Fu G.Y., Miao D., Zhang W.J.: A New Approach to Target Recognition Based on Image NSM Feature, *Computer Engineering* (2002)

[4] Pizarro O., Singh H.: Toward Large-Area Mosaicing for Underwater Scientific Applications, *IEEE Journal of Oceanic Engineering*, 28 (2003)

[5] Harris C., Stephens M.: A Combined Corner and Edge Detector, *Proc. Alvey Conf.*, Manchester, U.K. (1988) 189-192

[6] S. Suen; E. Lam, and K. Wong (2007). "Photographic stitching with optimized object and color matching based on image derivatives". *Optics Express* **15**: 7689–7696.