IMAGE REGISTRATION AND TEMPLATE MATCHING USING WAVELET FUNCTIONS

P.NOELIEN SELVARANI

Abstract: Radiometric degradation is a general problem in the image recognition considering many applications. The aim of image recognition is to produce complete description of the original image from the degraded image. The degradation factors include blurring of the image due to various reasons like climatic change and temperature, loss of information due to testing and different source of noise like salt and pepper noise, defocus of camera and atmospheric turbulence. There are many efforts taken to deblur such images. To overcome these problems a special kind of descriptor called blur invariants were introduced. These blur invariants were introduced in the wavelet domain which are centrally symmetric to blur. In this paper, image recognition is done using these wavelet based blur invariants. Inspite of severe degradation the images are accurately registered using Coiflet and Haar wavelet functions and registration is done also using spatial domain blur invariants. The proposed method is to compare the spatial domain blur invariants and wavelet domain blur invariants to see that which blur invariant descriptor performs best in registering the image. The blur invariants have been used in various fields of application such as deblurred photography, remote sensing, medical images and forensic science images.

Key Words: centrally symmetric blur, blur invariants, image recognition, spatial domain wavelet domain and wavelet functions

Introduction: The imaging conditions are not always perfect, particularly in the cases where we have no control on the subject. The photos in surveillance and the medical images are real-world subjects that are not ideally controllable when the images are acquired. Environmental situations such as weather conditions and long distances between camera and subject might also have a negative effect on the quality of images. Deteriorations in images are generally classified into two types, i.e., geometric distortions and radiometric degradations. There are many different approaches that are proposed for dealing with these kinds of problems. Hu therefore proposed descriptors that are invariant to some of basic linear geometric distortions. Unlike geometric distortions, there are fewer research works carried out on radiometric degradations. These blur invariants are introduced to images due to the movement of the subject, unfocused camera, and non-ideal image-capturing environment. The commonly used general model for the observed signal is $Y[n] = Bx[n] + Z[n]$

In this model, Y is the observed image; x and n are the actual image and noise, respectively; and B is the degradation operator. Blur moment invariants has showed its practicality in vast research areas like image registration, remote sensing, forgery detection, recognition, stereo matching and control point extraction. In this paper, wavelet-domain descriptors are proposed, which are invariant to centrally symmetric blur systems. The advantages of these invariants are the different alternatives that exist for wavelet functions and the benefit of analyzing signals at different scales in the wavelet domain. The idea has been developed for 2-D signals, and the effect of different types of blur is studied. A simple representation of these invariants has been proposed for 1-D signals by Makaremi and Ahmadi. Furthermore, it is proven that these invariants do not have any null space for centrally symmetric signals, which is the problem of spatial-domain invariants.

The degradation perform is given as a linear shift-invariant system, the relation between ideal image f(x, y) and an observed image g(x, y) is given by, $g(x,y)=f(x,y)*h(x,y)+n(x,y)$ where h(x, y) is the point spread function of the system, n(x,y) is noise and * denotes 2D convolution the point spread function h(x, y) denotes blur during other degradation are captured by the noise term n(x, y).

In this paper, wavelet domain blur invariants are proposed for image registration. The two dimensional image registration captured from the same scene at different times, viewpoints or sensors is a fundamental image processing. The image registrations are registered using feature based method i.e. wavelet based method. This wavelet domain blur invariants are demonstrated are discussed.

The Aim of the Paper: The major aim of this paper is to perform template matching using the proposed blur invariants. Template Matching shows the capability of the invariants to recognize objects in a blurred scene. It is showed how the wavelet domain blur invariants perform better image registration than the spatial domain blur invariants. Coiflet of order 2 and haar wavelet function is used for the wavelet domain blur invariants.

Blur invariants: Functional, invariant to convolution with arbitrary centro symmetric PSF in image analysis literature they are often called "blur invariants" because common PSF's have a character of a low-pass filter. Blur invariants were firstly introduced by Flusser and Suk. They have been successful in various applications like face recognition, on out-of focused photographs, template-to-scene matching of satellite images, in blurred digit and character recognition, in registration of images and in focus/defocus quantitative measurement.

Definitions: Some of the basic definitions are reviewed, and complimentary ones are proposed.

Definition 1: Image is a real discrete function

$$x \in L^1(Z^2)$$

Definition 2: The ordinary geometric moment of order (p+q) of in the spatial domain is defined by

$$m_{p,q}{}^{x} = \sum_{n1 \in N1} \sum_{n2 \in N2} n_1{}^{p}\, n_2{}^{q} x[n1, n2]$$

Definition 3: The centroid of signal is

$$c_1{}^{x} = \frac{m_{1.0}{}^{x}}{m_{0,0}{}^{x}}, c_2{}^{x} = \frac{m_{0,1}{}^{x}}{m_{0,0}{}^{x}}$$

Definition 4: Let functional C: $L_1(R^2) \times N_0 \times N_0 \rightarrow$ R be defined as follows:

- If $(p+q)$ is even then

$$C(p,q)^{(f)} = 0$$

- If $(p+q)$ is odd then

		Spatial Domain	Wavelet Domain using Daubechies
Lena	Original	-1.6106	-2.5165
	Blur at 5	-1.6080	-2.5124
	Blur at 10	-1.5932	-2.4892
	Blur at 15	-1.5609	-2.4389
Barbara	Original	-1.9830	-3.0984
	Blur at 5	-1.9826	-3.0978
	Blur at 10	-1.9812	-3.0956
	Blur at 15	-1.9788	-3.0919
Baboon	Original	-6.6614	-9.0407
	Blur at 5	-6.4086	-9.9997
	Blur at 10	-5.8073	-9.0591
	Blur at 15	-5.3073	-8.2777

$$C(p,q)^{(f)} = \mu_{pq}{}^{(f)} - \frac{1}{\mu_{00}{}^{(f)}} \sum_{n=0}^{p} \sum_{\substack{m=0 \\ 0<n+m<p+q}}^{q} \binom{p}{n}\binom{q}{m} C(p-n, q-m)^{(f)} \mu_{nm}{}^{(f)}$$

Then

$$C(p,q)^{(f*h)} = C(p,q)^{(f)}$$

Definition 5: The central moment of order (p+q) of in the spatial domain is defined by

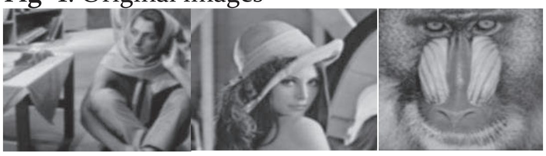
$$\mu_{p,q}{}^{x} = \sum_{n1 \in N1} \sum_{n2 \in N2} (n_1 - c_1)^{p}\, (n_2 - c_2)^{q} x[n1, n2]$$

Experiments: In this paper, the performance of the proposed invariants is evaluated on three different problems. The first experiment is designed to study the effect of blur on the proposed invariants. In the second experiment, real-world degraded images are acquired, and the invariants are used for registration. The SDBIs are used here as well for a comparison. Haar wavelet function is used is used for registration. In the third experiment, a degraded template image is acquired, and the invariants are used for registration. The SDBIs are used for comparison.

Experiment I: In the first experiment, three well-known images are used: Lena, Barbara and Baboon. These photos are degraded using disk filter of radii 5, 10 and 15.

Barbara Lena Baboon

Fig- 1: Original images



Images blur at 5

Images blur at 10

Images blur at 15

Fig- 2: Original and degraded images

The original and the degraded images are shown in Fig 1 and Fig 2. The blur invariants of these images are calculated using Daubechies of order 1. From the Table: 1 we can see that different subjects of the images are distinguishable from each other using the blur invariants and the effect of the blur does not affect the blur invariants. The small changes observed in the blur invariants are because the signals are finite extended.

Table -1: Blur Moment Invariants

Experiment II: In this experiment, the invariants are used for image registration. One sharp and two degraded photos are taken from an outdoor scene, and a part of the sharp image is taken as the template for registration in other degraded images. Fig 3 shows the source image, where the template is illustrated in a window. The out-of-focus images are presented in

Fig 4. The size of the images is 256×256, and the template image is 99×99. For this experiment, the wavelet function haar is used. For the sake of comparison, spatial-domain blur moment invariants are also used. For registration, the similarity measure of the template to every section of the image is calculated is using

$$S_{ij} = exp\left(-\sum_{n=1}^{N}\left|\frac{B^{y}(n) - B^{x}(n)}{B^{x}(n)}\right|\right)$$

B is the array of calculated invariants, x is the template, and y is a section of the target photo. Fig. 3 shows where the template is registered using the WDBIs and SDBIs. The registration done by wavelet domain blur invariants is accurate compared to the spatial domain blur invariants.From Fig 4 we can see that one of the images is not correctly registered using the spatial domain blur invariants, whereas wavelet domain blur invariants did not cause any problem.

Fig – 3 Source image in registration

Wavelet Domain Spatial Domain

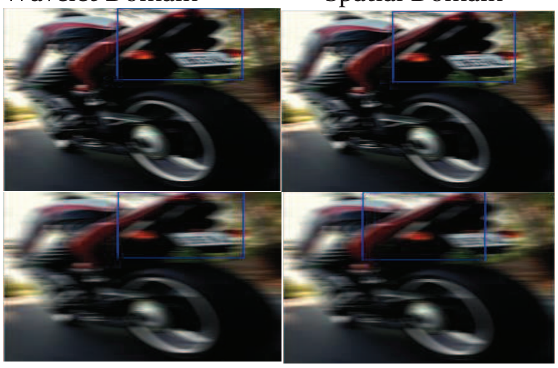


Fig – 4 Registration results with SDBIs and WDBIs.

Experiment III: In the third experiment template matching is done using the blur invariants. A template image is taken and degraded using motion filter and Gaussian noise. Then the degraded template image is then registered on the source image.

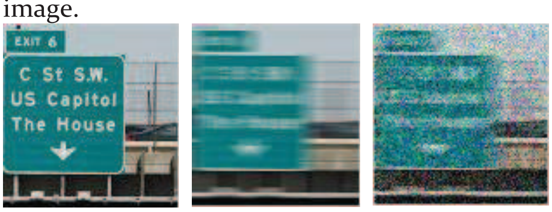


Fig – 5 Original and Degraded template image using motion blur and Gaussian

Fig 5 shows the original template image and the degraded template images. For this experiment, the wavelet function Coiflet of order of 2 is used and moments of orders up to 7 are calculated.

Wavelet Domain Spatial Domain

Fig – 6 Template matching using WDBI and SDBI

Conclusions: A new set of blur invariant descriptors has been proposed in this paper. These descriptors have been developed in the wavelet domain. The wavelet-domain grants the advantage of different alternatives of bases, and analysis at different scales. The SDBIs are also proved to be a special case of these invariants. To evaluate the performance of the invariants three different experiments have been carried out. In the first experiment, three images have been degraded with disk filter. The invariants successfully could put a discrepancy between different subjects while showing very negligible difference due to the degradations introduced by blur.

In the second experiment, there were photos taken such that the scenes have been deteriorated by defocus blur. Then, a part of the scene, which has been selected from a sharp photo, has been used as templates for image registration. Despite the presence of severe blurs, registration has been perfectly performed. The experiment has been carried out with the SDBIs, which failed in one of the registration tasks.

The third experiment has been designed for template matching. The template image is degraded with blur and noise. Then the template image is registered on the source image using the blur invariants. The wavelet domain blur invariant performs much better than the spatial domain blur invariants.

There are numerous papers on wavelet bases, each of which yields its specific advantages. Finding what type of wavelet functions could be the most beneficial in blur-invariant extraction in the wavelet domain is a major direction for further research on the proposed invariants

References:

1. Iman Makaremi and Majid Ahmadi, "Wavelet Domain Blur Invariants for Image Analysis" IEEE Trans. In image processing ,Vol. 21, No. 3, March 2012.
2. J. Flusser, J. Kautsky, and F. Roubek, "Implicit moment invariants," Int. J. Comput. Vis., vol. 86, no. 1, pp. 72–86, Jan. 2010.
3. J. Flusser, T. Suk, and B. Zitov, Moments and Moment Invariants in Pattern Recognition. Hoboken, NJ: Wiley, 2009.
4. Anwar Bhasha Pattan, Makkena Madhavi Latha , FPGA Implementation Of A 64 Point Radix-2 Single Path Delay Feedback FFT Architecture.; Engineering Sciences international Research Journal : ISSN 2320-4338 Volume 3 Issue 2 (2015), Pg 57-60
5. M. I. Sezan and A. M. Tekalp, "Survey of recent developments in digital image restoration," Opt. Eng., vol. 29, no. 5, pp. 393–404, May 1990. IEEE Trans. Image Process., vol. 12, no. 5, pp. 597–606, May 2003.
6. J. Flusser, T. Suk, and S. Saic, "Image features invariant with respect to blur," Pattern Recognit., vol. 28, no. 11, pp. 1723–1732, Nov. 1995.
7. J. Flusser, T. Suk, and S. Saic, "Recognition of blurred images by themethod of moments," IEEE Trans. Image Process., vol. 5, no. 3, pp.533–538, Mar. 1996.
8. J. Flusser and T. Suk, "Degraded image analysis: An invariant approach," IEEE Trans. Pattern Anal. Mach. Intell., vol. 20, no. 6, pp. 590–603, Jun. 1998.
9. Dr. Dhananjaya Reddy, Role Of Mathematics Teacher In Using Technology.; Engineering Sciences international Research Journal : ISSN 2320-4338 Volume 3 Issue 2 (2015), Pg 61-64
10. T. Suk and J. Flusser, "Features invariant simultaneously to convolution and affine transformation," in Proc. CAIP, W. Skarbek, Ed., 2001, vol. 2124, Lecture Notes in Computer Science, pp. 183–190.
11. J. Liu and T. Zhang, "Recognition of the blurred image by complexmoment invariants," Pattern Recognit. Lett., vol. 26, no. 8, pp. 1128–1138, Jun. 2005.
12. H. Zhang, H. Shu, G. Han, G. Coatrieux, L. Luo, and J. Coatrieux, "Blurred image recognition by legendre moment invariants," IEEE Trans. Image Process., vol. 19, no. 3, pp. 596–611, Mar. 2010.
13. H. Ji and H. Zhu, "Degraded image analysis using zernike moment invariants," in Proc. IEEE ICASSP, Apr. 2009, pp. 1941–1944.
14. Dr.Ca Jyothirmayee, Chemical And Microbial Analysis Of Potable Water In Public – Water Supplywithin Five Mandals In The Upland Area Of West Godavari District, Andhra Pradesh, India.; Engineering Sciences international Research Journal : ISSN 2320-4338 Volume 3 Issue 2 (2015), Pg 65-72
15. V. Ojansivu and J. Heikkilä, "Object recognition using frequency domain blur invariant features," in Proc. SCIA, B. K. Ersbll and K. S. Pedersen, Eds., 2007, vol. 4522, Lecture Notes in Computer Science, pp. 243–252.
16. Y. Bentoutou, N. Taleb, K. Kpalma, and J. Ronsin, "An automatic image registration for applications in remote sensing," IEEE Trans. Geosci. Remote Sens., vol. 43, no. 9, pp. 2127–2137, Sep. 2005.
17. X. Dai, H. Zhang, H. Shu, and L. Luo, "Image recognition by combined invariants of legendre moment," in Proc. IEEE ICIA, 2010, pp. 1793–1798.
18. I. Makaremi and M. Ahmadi, "Blur invariants: A novel representation in the wavelet domain," Pattern Recognit., vol. 43, no. 12, pp. 3950–3957, 2010.
19. Chetna, Dr. Hardeep Singh, Representation Of Numbers Divisible By A Sufficiently Large Square.; Engineering Sciences international Research Journal : ISSN 2320-4338 Volume 3 Issue 2 (2015), Pg 73-76
20. M. J. Shensa, "The discrete wavelet transform:Wedding the a trous and mallat [17] I. Daubechies, Ten Lectures on Wavelets. Philadelphia, PA: SIAM, 1992

***

P.Noelien Selvarani/ PG scholar/ Control and Instrumentation/
St.Joseph's College of Engineering/ TamilNadu/ India/