Volume 6, Issue 7, July 2016 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

New Methodology for Image Registration- An Application to Digital Image Processing

[1]Sindhu Madhuri G., [2]Dr. Indra Gandhi M. P.
[1] Research Scholar, [2] Associate Professor (S.G.)
[1, 2] Department of Computer Science, Mother Teresa Womens University, Kodaikanal, Tamilnadu, India

Abstract*: Image Registration is identified as the most important and essential preprocessing task in digital image processing field of computer science. Even though the basic four steps in the image registration process are key & common, their internal structure & procedure for each step dynamically varies during the critical aspects of its methodology design based on its purpose & application. Geometrical Transformation in one of the essential requirements for any image registration process to bring the reference and source images into a common coordinate system. Many transformation techniques are existing in the literature for this purpose, but each one has its own pros and cons. The requirement of accurate image registration process calls for the invention of new methodologies that ignites this research work. Therefore, a new methodology for image registration is developed using Radon Transform. The method is analyzed with three sets of image data, and evaluated for the accuracy of image registration process through measurement of entropy as a new similarity measure. It is observed from this research study with limited data, and found that this newly developed methodology for the Image Registration process is superior & unique in accuracy for the broad area applications in the image processing.

Key Words: IR - Image Registration Process; RT – Radon Transform; Ri , Si , and IIR - Reference, Source and Registered Images; R, T, S - Rotation, Translation and Scaling;

I. INTRODUCTION

Image Registration is used in vast and wide varieties of applications in digital image processing, therefore, it is impossible to develop a unique generalized method. This ignites for invention of new methods based on applications in image registration and became an open and challenging research area. Archaeology, Astrophysics, Cartography, Climatology, Computer Vision, Defence research, Geology, Hydrology, Image fusion, Medical Imaging, Pattern recognition, Radar Imaging, Remote Sensing, Space research, Unmanned Aerial Vehicle (UAV) imaging, etc., are few core and complex applications areas for Image Registration [1-8].

Basically, image registration is a process of transformation for geometrical alignment of various image data sets of same scene collected from various times or sensors or view-points or space into a common coordinate systems in order to investigate a relationship between reference & target images through alignment of its pixels for necessary comparison, and to acquire the required intelligence embedded in them [9-16].

The transformation based image registration methods are classified according to the transformation models used to relate reference & target images. Linear and non-linear are two broad categories of transformation models. In general, based on the application it can be divided into four main groups in accordance with the manner of image acquisition process. They are at different –

(i) Times (ii) Sensors (iii) Views (iv) Spaces.

A. Different Times:

The image data of same scene is required to be collected at different times regularly under different conditions by a single sensor, and is also called multi temporal system. The aim is to investigate and evaluate changes in the same scene among various acquisitions.

B. Different Sensors:

The image data of same scene is required to be collected at different times regularly under different conditions by different sensors or a multi sensor modal, and is also called multi modal system. The aim is to investigate and evaluate changes in the same scene among various acquisitions with multi sensor modal.

C. Different Views:

The image data of same scene is required to be collected at different views or view-points regularly under different conditions by a single or a multi sensor modal, and is also called as a multi view-point system. The aim is to investigate and evaluate changes in the same scene among various acquisitions with different-view-point modal.

D. Different Spaces:

The image data of same or different scene with similar content is required to be collected at different spaces or depths regularly under different conditions by a single or a multi sensor modal, and is also called as a multi depth system.

The aim is to investigate and evaluate changes in the scenes among various acquisitions with different spaces or depths to modal the scenes for instance maps in digital elevation models.

II. IMAGE REGISTRATION PROCESS

It is nevertheless to mention that the basic image registration process consists of four major steps. They are (i) Feature Detection (ii) Feature matching (iii) Transformation (iv) Optimization and Re-sampling [1-6].

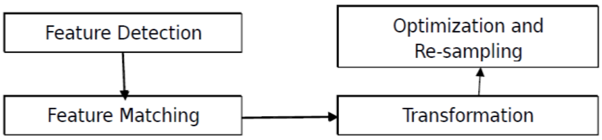


Fig - 1: Image Registration Process

The source images are generally –

(i) undergo various geometrical transformation, viz, R, S, T; (ii) corrupted by frequency, phase or some other noise - during its acquisition process due to various reasons, is a natural problem. Also, new features existing in the source image can be obtained as new or useful information, only after removal of noise and its alignment with its reference image during IR. And, all the basic four steps are essential to follow in the IR [1-6]. Finally, it is required to evaluate for the accuracy where there is a basic need for development of a new methodology for IR. The Radon transform and its properties are chosen and developed a new methodology for IR in this research work.

III. NEW METHODOLOGY FOR IR

A new methodology for image registration using Radon Transform and entropy as new similarity measure is developed and suggested in this research work.

The Radon transform has been introduced in 1917 by Johann Karl August Radon, an Austrian Mathematician, during his research on integral geometry. In mathematics, integral geometry is the theory of measures on geometrical space where transformations from the space functions on one geometrical space to the space of functions on another geometrical space, i.e transformations often take the form of integral transforms such as the Radon transform and its generalization. More specifically, it deals with integral transforms modeled on the Radon Transform [22-24].

Let a function 'f' is taken as an unknown density, its Radon transform represents the projection data obtained as output of a tomographic scan image. To reconstruct the original image from this projection data, the inverse of Radon transform can be used. The Radon transform of a Dirac delta function is a distribution of a sine wave on the graph, hence called as a 'sinogram'. Graphically, the Radon transform of a number of small objects appear as a number of blurred sine waves with different amplitudes and phases. Therefore, the Radon transform and its properties are used in the transformation, optimization and resampling steps in the image registration process to achieve better accuracy and robustness as a new methodology.

IV. COMPUTATION OF RANDON TRANSFORM

Mathematically, the Radon transform is represented as FR (ρ, θ) for any image as function f (x, y). The Radon transform applied to an image FR (ρ, θ) for a given set of rotation angles, θ. Then, the projection of the image along the angles is computed using line integral. The resulting projection is the sum of the intensities of pixels in each direction, i.e. Line integral. The result of new image after Radon transform application over the line ρ is represented as R (ρ, θ). It is mathematically represented as given in eq. (1) & (2) below:

$$\rho = x \cos\theta + y \sin\theta \text{ – eq. (1)}$$

$$F^R(\rho, \theta) \text{ or } R(\rho, \theta) = \int\int f(x, y)\, \delta(\rho - x\cos\theta - y\sin\theta)\, dx\, dy \text{ -- eq. (2)}$$

Where δ(·) is the Dirac delta function.

V. ENTROPY AS A NEW SIMILARITY MEASURE FOR IR

The requirement of new similarity measure for accurate image registration process is already identified as a open research area [17-21]. Therefore, the entropy as new similarity measure for the image registration is considered and studied for this research work.

The Entropy, also called as Shannon Entropy, generally refers to understand disorder or uncertainty of a system. It means that the Entropy measure gives unpredictability of any required information content, and the concept is extended to image registration [25-29]. The intensity values obtained from reference and source images during image registration process after radon transformation are useful to calculate Entropy as new similarity measure, which in turn used to evaluate the proposed image registration methodology for its accuracy.

VI. EVALUATION OF NEW IR MEDHODOLOGY

A. Data:

Three different set of images with different resolutions and pixel size are chosen to evaluate the new image registration methodology. Three images of Lena, Cameraman and a Satellite are three sets named as I1, I2 and I3 respectively as Ri . And I1 (R), I2 (T) and I3 (S) are Rotated, Translated and Scaled images of I1, I2 and I3 respectively as S***i***. The Radon transform is applied operated on Ri & S***i*** sets and obtained IIR sets.

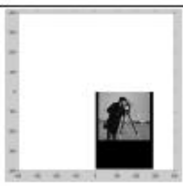
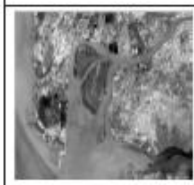
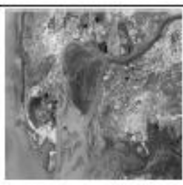
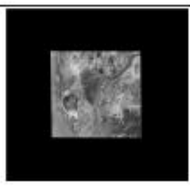
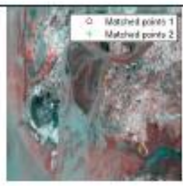
B. Analysis:

Analysis is carried out using MATLAB in windows environment.

C. Evaluation of new methodology:

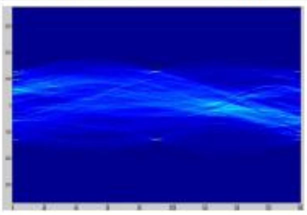
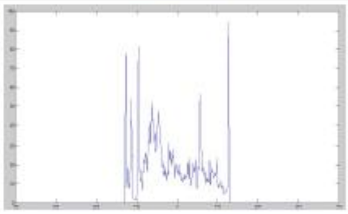
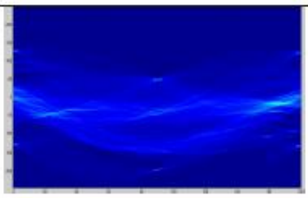
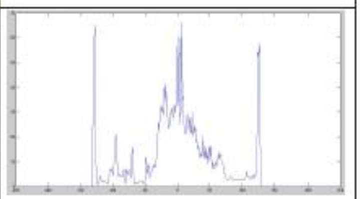
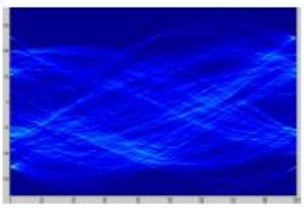
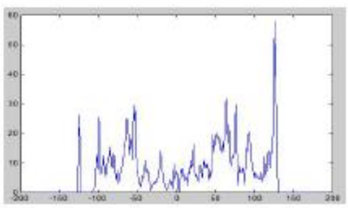
The performance of proposed new methodology for image registration on Radon domain is evaluated from three set of images (I1, I2, I3). These three set of images are subjected to rotation (I1(R)), translation (I2(T)) and scaling (I3(S)) as basic transformations in Radon domain. Radon Transformation is applied and carried out image registration and obtained better features on registered images for these three set of images. The sinograms and graphs are also obtained. Finally, the entropy as a new similarity is also obtained. The MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio) are calculated to estimate the accuracy measure of the new IR methodology [2, 3, 15, 16]. All these results are summarized and tabulated in the table I to III below:

Table I Three Set Of Images Used In New Methodology For Ir In Radon Domain

R_i I1, I2, I3	S_i I1(R), I2(T), I3(S)	I_{IR}	More features obtained in RT domain from IR
			
			
			

Note: Last row could not be printed as seen on the computer display due to print limitations.

Table-II Sinograms And Its Graph Plots For Three Set Of Registered Images

R_i	S_i	Sinograms of registered Image	Plot/Graph
I1	I1(R)		
I2	I2(T)		
I3	I3(S)		

Note: Last Two columns could not be printed as seen on the computer display due to print limitations.

Table Iii Entropy As Similarity Measure And Accuracy Measure Of Ir In Rt Domain

Images for IR	Similarity Measure			Accuracy Measure	
I	R_i	S_i	I_{IR}	MSE	PSNR
I1 & I1 (R)	7.5683	4.7711	2.7192	19.8323	35.1571
I2 & I2 (T)	7.0690	4.6648	2.6010	4.8792	41.2473
I3 & I3 (S)	7.2166	4.5616	2.5062	0.0001	54.7120

The above tabulated results indicate that the proposed new methodology for the image registration is superior and unique.

VII. CONCLUSIONS

A new methodology for image registration process is developed and suggested in this research study. It is observed from the analysis and results that the suggested approach for image registration is superior in terms of accuracy. The design and development of the new methodology is carried out using Radon Transformation. IR similarity measure is attempted with Entropy and its accuracy is computed with MSE & PSNR. High MSE values for image set I1 & I1(R) is an indication for improvement under rotation geometry on specific needs and applications. The results in above Table-I to III provides better insight about accuracy & similarity measures aspects of the IR process with the proposed new methodology with Radon Transform domain..

The performance of proposed methodology for the image registration is demonstrated with three set of images, and is also limited to one sample of R, S and T only. Even though the proposed methodology for IR is superior and unique with limited data, further studies are required for better understanding on the proposed new methodology for IR. The authors would like to continue the research work in these areas.

ACKNOWLEDGEMENT

The authors submit sincere thanks to the Hon'ble Vice Chancellor, Registrar, DEAN, and all the faculty members of all the departments of the Mother Teresa Womens University for their high level motivation and encouragement in all respects which gave this exponential progressive research work. Also, we thank all the - students, guest faculty and non-teaching staff of the entire University for their continuous support in all respects to us. Finally, thanks to M/s ATL, Hyderabad for their support on the resources.

REFERENCES

[1] A. A. Goshtasby, 2-D and 3-D Image registration for Medical Remote Sensing and Industrial Applications, Wiley Press, 2005.

[2] Barbara Zitova, Jan Flusser, Image Registration Methods: A Survey, Image and Vision Computing, vol 21, pp 977-1000, Elsevier, 2003.

[3] L. G. Brown, A Survey of Image Registration Techniques, ACM Computing Surveys, vol 24, issue 4, pp 325-376, Dec 1992.

[4] Fisher, B., Modersitzki, J., Ill posed medicine - An introduction to Image Registration, Inverse Problems, vol 24, No 5, 2008.

[5] Zhang, T., Cen, M., Robust DEM Co-registration Method for Terrain Changes Assessment using Least Trimmed Squares Estimator, Advances in Space Research, vol 41, pp 1827-1835, 2008.

[6] Liao, M., Lin, H., Zhang, Z., Automatic registration in SAR data based on Least Square matching and multi step strategy, Photogrammetric Engineering & Remote Sensing, vol 70, No 10, pp 1039-1044, 2004.

[7] Crum, W.R., Hartkens, R., Hill, D.L.G., Non rigid image registration: theory and practice, British Journal of Radiology, vol 77, pp 140-153, 2004.

[8] Rodrigues, M.A., Liu, L., On the representation of rigid body transformations for accurate registration of free form shapes, Journal of Robotics and Autonomous systems, vol 39, pp 37-52, 2002.

[9] Liying, W, Weidong, S., A Review of Range Image Registration Methods with Accuracy Evaluation, Joint Urban Remote Sensing Event, pp 1-8, 2009.

[10] Ranganath, R.N., Jayaraman, V., Roy, P.S., Remote Sensing Applications: An Overview, Current Science, vol 93, No 12, 2007.

[11] Sederberg, T.W., Parry, S.R., Free form deformation of solid geometric models, Computer Graphics, vol 20, no 4, pp 712-721, Aug'1999.

[12] Rogeli, P., Kovacic, S., Symmetric Image Registration - Medical Image Analysis, vol 10, No 3, pp 484-493, 2006.

[13] Fonseca, L.M.G., Manjunath, B.G., Registration Techniques for Multisensor Remotely Sensed Imagery, Photogrammetric Engineering & Remote Sensing, vol 62, No 9, pp 1049-1056, 1996.

[14] Sindhu Madhuri G., Classification of Image Registration Techniques and Algorithms in Digital Image Processing - A Research Survey, vol 25, No 2, ISSN: 2231-2803, Sep 2014.

[15] Sindhu Madhuri, G., Indra Gandhi, M.P., Image Registration Quality Assessment with Similarity Measures - A Research Study", IEEE eXplore, ISBN 978-1-4799-8080-2, Apr 2015.

[16] Sindhu Madhuri, G., Indra Gandhi, M.P., Image Registration with Similarity Measures using Correlation Techniques - A Research Study, IEEE eXplore, ISBN 978-1-4799-7848-9, Dec 2015.

[17] Penney, G.P., Weese, J., Little, J.A., Desmedt, P., Hill, D.L.G., Hawkes, D.J.: A comparison of similarity measures for use in 2D-3D medical image registration. IEEE Trans. Med. Imaging no. 17 pp. 586–595, 1998.

[18] Pluim, J., Maintz, J., Viergever, M.: Mutual information based registration of medical images: a survey. IEEE Transactions on Medical Imaging no. 22 pp. 986–1004, 2003.

[19] Pluim, J.P.W., Maintz, J.B.A., Viergever, M.A.: Image registration by maximization of combined mutual information and gradient information. IEEE Trans. Med. Imaging no. 19 pp. 809–814, 2000

[20] Rueckert, D., Clarkson, M.J., Hill, D.L.G., Hawkes, D.J.: Non-rigid registration using higher-order mutual information. Medical Imaging 2000: Image Processing Proc. SPIE 3979 pp. 438–447, 2000.

[21] Penney, G.P., Weese, J., Little, J.A., Desmedt, P., Hill, D.L.G., Hawkes, D.J.: A comparison of similarity measures for use in 2D-3D medical image registration. IEEE Trans. Med. Imaging no. 17 pp. 586–595, 1998.

[22] Deans, Stanley R. , The Radon Transform and Some of Its Applications, New York: John Wiley & Sons, 1983.

[23] Radon, Johann, Mathematisch-Physische Klasse [Reports on the proceedings of the Royal Saxonian Academy of Sciences at Leipzig, mathematical and physical section] (Leipzig: Teubner) (69): 262–277, 1917; Translation: Radon, J.; Parks, P.C. (translator) (1986), "On the determination of functions from their integral values along certain manifolds", IEEE Transactions on Medical Imaging 5 (4): 170–176, doi:10.1109/TMI.1986.4307775, PMID 18244009.

[24] Helgason, Sigurdur, Groups and Geometric Analysis: Integral Geometry, Invariant Differential Operators, and Spherical Functions, Academic Press, 1984, ISBN 0-12-338301-3.

[25] Shannon, C. E. A Mathematical theory of communication, The Bell Systems Technical Journal, No. 27 (3), pp. 379-423, 1948.

[26] Bell, A., Sejnowski, T., Information maximization approach to blind separation and blind deconvolution, Neural Computation, No. 7, pp. 1129-1159, 1995.

[27] Rodriguez-Carranza, C., Loew, M.: A weighted and deterministic entropy measure for image registration using mutual information. Medical Imaging 1998: Image Processing Proc. SPIE 3338 155–166, 1998.

[28] Ma, B., Hero, A.O., Gorman, J., Michel, O.: Image registration with minimal spanning tree algorithm. In: IEEE Int. Conf. on Image Processing, Vancouver, 2000.

[29] N. R. Pal, “On image information measures and object extraction,” Ph.D. thesis, the Indian Statistical Institute, Calcutta, Mar. 1990.

