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A Survey of Image Registration Techniques Using Neural Networks

Takshak Desai[1*], Udit Deshmukh[2] and Prof. Ruhina Karani[3]

[1*,2,3]*Dept. of Computer Engineering,*
D. J. Sanghvi College of Engineering, Mumbai

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***Abstract*—** The importance of using neural networks for image registration has increased since the enhancement in technology responsible for capturing images. Traditional methods rely on manual selection of control points and/or finding a suitable geometric transformation that maps two images. This approach is especially tedious and time consuming for registering multiple images. Further, traditional methods are not able to register images effectively if non-linear transformations are used to convert one image into another. To provide a robust and efficient way of registering images, neural networks provide a powerful alternative. They have proved to be highly reliable especially with medical and satellite imaging; making room for uncertainty and imprecision. This paper highlights the important image registration approaches that make use of neural networks and performs a comparative analysis of these approaches. It also suggests suitable areas in which research can be carried out to improve the efficacy and scalability of the techniques.

***Keywords*—**Image registration; neural networks; non-linear transformations

I. INTRODUCTION

Image registration refers to a technique in image processing that aligns the coordinate points of two or more pictures or views of the same scene or object. The idea is to find a suitable geometric transformation that integrates the corresponding pixels from these views; called the reference and sensed images so that they represent the same image. Pictures of an object or a scene are either taken at different time intervals or from different sensors or from different perspectives. Through image registration, it is possible to obtain an accurate match between these views. Image registration finds application in many areas such as medical imaging, cartography, astrophotography, change detection, military target recognition and panoramic image creation. As a large number of domains rely on image registration, it has become an important subject of study in computer vision and image processing.

The process of image registration typically begins with control point selection in which small windows are selected in the reference image and searched for in the sensed image. Then, features that describe the neighborhood of the selected points are calculated, out of which, the most informative features are selected. Using this information, an initial relation is identified between the corresponding points of the two images which is used to find a function or transformation that maps the sensed image to the reference image [11]. A flowchart depicting the process is given below:

A variety of intensity and feature based image registration techniques were recommended for automatic registration of images. Although the latter has provided good results; when combined with neural networks, the process became highly robust and provided good results even if the images were noisy. In addition to these advantages, the low computational complexity rendered them as perfect options for high performance image processing applications.

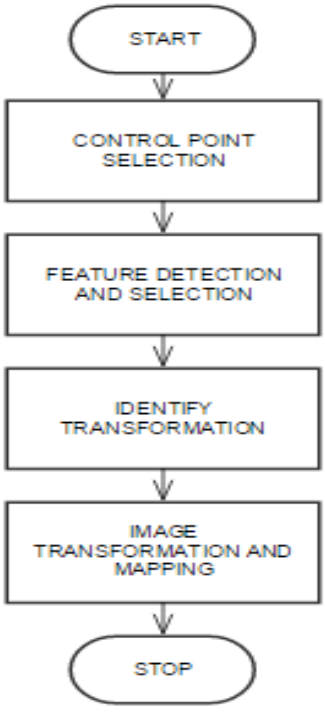

Figure 1: A flowchart showing steps in image registration

The paper first introduces the traditional algorithms that were devised to carry out image registration. It highlights the drawbacks and reasons for inadequacy of these methods. Then, it briefs upon the techniques that make use of neural networks for image registration; carrying out a comparative analysis of these methods. In conclusion, it suggests important areas in which research can be carried out to improve said methods.

II. TRADITIONAL ALGORITHMS

The idea was first successfully applied in the field of remote sensing in which an automatic method for image registration was developed by Anuta [14] in 1970 that made use of Fast Fourier transform techniques to align satellite images. This method worked successfully for the dataset which comprised of images having translational differences between them. Later, methods were suggested by Barnea and Silverman [4]; and by Pratt [18] to reduce the time taken to register the images and account for the intensity differences in the images. However, these methods suggested made use of affine transformations for image alignment and were not well-suited for aligning images having geometrical differences. Methods proposed by Barrow et al. [3] and by Borgefors [7] were able to explain away these issues. These methods are collectively called intensity based methods and are no longer prevalent.

The concept of using control point selection became popular with a marked improvement in resolution and quality of images taken. Several algorithms were developed [5][10] and successfully tested on real time data coming from different sources. The general idea was to correlate these feature points using translation and rotation: each correct alignment would generate the same rotational parameter. Another approach, albeit similar, is to rely on Fourier transforms for image registration [2] in which the spectral coefficients of the Discrete Cosine Transform (DCT) are used to estimate the information required for image registration.

A major problem that all these algorithms suffered from was that they were not robust and hence were not quite applicable to major image processing applications. Moreover, with the introduction of neural networks, the efficiency of image registration systems improved drastically making them more scalable.

III. TECHNIQUES USING NEURAL NETWORKS

The idea of using neural networks for image registration was proposed by Piraino et al [15]. The authors made use of backpropagation networks to carry out registration of three dimensional medical images. The network was able to successfully correlate images which had undergone basic affine transformations such as rotation, translation or scaling. However, correlation between were non-linear mapping spaces was not found to be exact. A remedy suggested was to increase the size of the training set which improved the accuracy of the algorithm.

Another approach suggested [12] was to make use of unsupervised learning algorithms to carry out image registration. Two neural networks were used namely Kohonen topology preserving map and Fukushima's neucognitron like model. An unsupervised learning algorithm was used to obtain the cluster centres. Later, the testing set was classified on the basis of the clusters obtained.

Qian and Li [17] wrote a research paper that suggested using neural networks for two dimensional image registration. In this paper, the process of image alignment was treated with the minimisation of the energy function of a Hopfield network. The locations of the control points of an image were used as input data for registration and a fast block based algorithm was proposed that will improve the efficiency of the system.

A hybrid approach that combines the DCT with neural networks was proposed by Elhanany et al. [6] in which the coefficients of the DCT were estimated by using a feedforward neural network. The neural network was tested using gradient descent learning algorithms: it was observed that the root mean square error values were very low and an improvement of 30% was reported when compared to the traditional method [2] from which it was derived. Sarnel et al [16] showed that if a radial basis function neural network was instead of a feed forward neural network, more accurate results are obtained. A similar idea was later adopted [1] in which the coefficients of Fourier transform were fed to a feedforward neural network that would output the required geometric transformation for carrying out image registration.

Similarly, Zernike moments could also be used as image features [19]. These are fed to a feedforward neural network that provides the necessary translation, rotation and scaling parameters. Experimental results proved that the technique offered a high degree of robustness to noise.

A novel approach for automatic selection of feature points of images was suggested by Wang et al [20]. Firstly, the image was smoothed using filtering, and then converted into a binary image. A feature point would be selected manually and then contour mapping is performed to obtain the remaining feature points using backpropagation network.

IV. COMPARISON OF TECHNIQUES USING NEURAL NETWORKS

V. CONCLUSION AND FUTURE RESEARCH

Comparison of techniques	Techniques Used							
	[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*
Authors	Piraino et al.	Le Beux et al.	Qian and Li	Elhanany et al.	Sarnel et al.	Abche et al.	Wu and Xie	Wang et al.
Neural Network used	Backpropagation network	Kohonen self-organizing map	Hopfield Network	Feedforward network	Radial basis function network	Feedforward network	Feedforward network	Backpropagation network
Transforms identified	Linear	Linear	Linear and non-linear	Linear	Linear	Linear	Linear	Linear and non-linear
Type of learning	Supervised	Unsupervised	Supervised	Supervised	Supervised	Supervised	Supervised	Supervised
Training set	Medical imaging	Medical imaging	Medical imaging	Satellite imagery	Medical imaging	Medical imaging	Medical imaging	Satellite imagery
Robustnes	Low	Low	Low	Low	High	Low	High	High
Susceptibility to noise	High	High	Low	High	Low	Low	Low	Low

Neural networks provide the ideal alternative to traditional methods used for image registration. The process can be automated easily using neural networks and provides an ideal means to expedite the process of feature point selection and image registration. Further research can be carried out in this field to incorporate other neural networks such as Spiking neural networks or Associative memory neural networks to improve the overall efficiency of the process. Of late, genetic algorithms have been widely used to estimate the transform parameters needed to carry out mapping of images. Genetic algorithms have been adopted by several industry because of their accuracy, robustness and ease of use. A suitable way to improve the process of image registration could be to opt for a neuro-genetic algorithm in which possible transform parameters could be encoded as chromosomes and based on the fitness function value, could be fed to a neural network that would output the necessary solution.

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