AN EFFICIENT APPROACH WITH ZERNIKE AND ANT COLONY OPTIMIZATION FOR IMAGE REGISTRATION

Prabhjot Kaur¹, Associate Prof. Manish Mahajan²
Department of Information Security, CGC, Landran, India.

Abstract: - Image registration is one of the techniques that enable us to join two images to form a single image. Its applications lie for general photography, medical imaging etc. Nowadays, medical image registration plays a vital role for diagnosis. So, we have rigid and non-rigid images that need to be registered properly. None of single method can work as generalized for image registration. In the current paper we are going to combine two methods which is Zernike and ant colony optimization in order to make it applicable for different types of images especially complex images. The result of this technique shows that it proves to be better, accurate and improves quality for registration of images.

Keywords: - Zernike moments, Ant colony optimization, RANSAC.

I. INTRODUCTION

Image registration maps and align two images with its respective coordinate. These images may be taken from different sources at different time. It gives information from the data that how two images may be fused. Also change detection, and multichannel image restoration is achieved by combining various data sources is a crucial step in all image analysis tasks. Virtually all large image analysis systems which evaluate images use image registration techniques as the intermediate step[1].

A) General registration process

Feature detection: This is the former step, in this feature or objects are detected either manually or automatically.

Feature matching: This is the second step, in this similarity between the features detected in the sensed image and in the reference image is established. The matching algorithm used should be robust and efficient.

Transform model estimation: This is the third step in which, estimation is made about the mapping functions that are used to align the sensed image with the reference image.

Image re-sampling and transformation: Finally, the choice of the appropriate type of re sampling technique depends upon the trade-off between the demanded accuracy of the interpolation and the computational complexity.

B) Techniques

Many image registration techniques have been proposed in the literature. Basically, they are categorized into two classes [2]: intensity-based and feature-based methods.

Intensity based methods use directly the image pixels to estimate the parameters of the transformation between two images, as in [3], [4]. On the other hand, feature based techniques rely on locating features in both images and using these features to obtain the transformation parameters for registering the two images. Some of these techniques rely on image contours, such as [5], [6], or curves in the images, such as [7]. Other techniques rely on feature points of the image, such as [8], [9]. The performance of such techniques depends on several factors, such as the area of overlap between images and to what extent it is possible to model the image distortions with simple geometric transformations. Further, image quality, affected by degradations such as noise contamination and blurring, as well as, image characteristics such as smooth/textured areas or similarity of different areas, play also a role in the techniques’ performance.

C) Types of Transformation

Image registration can be of rigid or of non-rigid registration [10,12]. In rigid registration, only rotation and translation are applied for the spatial transformation. Non-rigid image registration is a natural extension to rigid
registration, allowing also deformations in an image, in order to achieve a good match. This is necessary in all instances of a patient’s motion within an image, such as either in respiratory or in heart motion.

II. ZERNIKE MOMENT

Zernike moments are the mappings of an image onto a set of complex Zernike polynomials. Since Zernike polynomials are orthogonal to each other, has no redundancy as well as there is no overlap of information between the moments. Also, are rotationally invariant, this property makes them suitable for many applications. Hence, we can utilize them to describe shape characteristics of the objects [13, 14].

STEP-1:- Feature Point Extraction

In image registration, feature points become locations which can be used to determine whether two images have matching points and also to estimate the transformation parameters required to register the two images. There are many approaches to find feature points. It is a two-step process as in [9,20]:

- Filtering an image with the Mexican-hat wavelet.
- Searching for local maxima of the response.

STEP-2:- Zernike Moment Calculation

After finding the feature points, the descriptor vectors are obtained by computing the Zernike moments of circular neighbour hoods centered on each feature point. The computation is done as in[9].

STEP-3:- Correspondence

Once the Zernike moments for each feature point are calculated the correspondence is obtained by comparing the descriptor vectors of each feature point.

STEP-4:- Transformation parameter estimation

Least square technique is used to transform the distorted image to its appropriate size, orientation and position. This is a similar method to the one used in robust statistics [19].

III. ANT COLONY OPTIMIZATION

The ant colony optimization Technique [16] is used for solving problems basically that are related to finding good paths through graphs. It has an advantage that it is fast and consist of less computations.

The Behavior of each ant in nature:

1) The first ant wanders randomly until it finds the food source (F), then it returns to the nest (N), laying a pheromone trail.

2) Other ants follow one of the paths at random, also laying pheromone trails. Since the ants on the shortest path lay pheromone trails faster, this path gets reinforced with more pheromone, making it more appealing to future ants.

3) The ants become increasingly likely to follow the shortest path since it is constantly reinforced with a larger amount of pheromones. The pheromone trails of the longer paths evaporate.

Paradigm for optimization problems that can be expressed as finding short paths in a graph. Its goal is to design technical system for optimization and not to design an accurate model of nature.

IV. PROPOSED WORK

We have proposed the hybrid of Zernike moment and ant colony optimization (ACO). Both have their own features and limitation. As ACO is very fast in finding the feature points but it finds difficulty in finding complex feature points. Whereas Zernike has the property that it is orthogonal and rotationally invariant [15]. But it has a problem that its resistance to noise is poor. So we have combined the features of ACO with the Zernike moment for registration of medical images because Zernike alone
will not be sufficient for registering such images because medical images contain noise. So, the combination of both methods will make the technique effective. The proposed algorithm is as follows:

Step-1: Source image is passed through Zernike moment, in which feature points are extracted and after finding the feature points, the descriptor vectors are obtained by computing the Zernike moments of circular neighborhoods centered on each feature points. [9,20]

Step-2: Then the same, original source image is passed onto ant colony optimization in which feature points are estimated [16, 17]:

The algorithm is as follows:

INITIALIZATION:

<table>
<thead>
<tr>
<th>In Nature</th>
<th>In Computer science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural habitat</td>
<td>Graphs(edges and nodes)</td>
</tr>
<tr>
<td>Nest and food</td>
<td>Nodes in the graph: start and destination</td>
</tr>
<tr>
<td>Ants</td>
<td>Agents, our artificial ants</td>
</tr>
<tr>
<td>visibility</td>
<td>The reciprocal of distance,$g$</td>
</tr>
<tr>
<td>Pheromones</td>
<td>Artificial pheromones,$\delta$</td>
</tr>
<tr>
<td>Foraging behavior</td>
<td>Random walk through graph (guided by pheromones)</td>
</tr>
</tbody>
</table>

Step-3: After extracting and estimating the feature points, the process of correlation is done.

In this step the correlation among the set of feature points find out by ACO and Zernike for source image is counted. Basically correlation means that to what extent two or more quantities linearly associates [26]:

It is computed as[26,27]:

Scheme:
- Construct ant solutions
- Define attractiveness $\delta$, based on experience from previous solutions
- Define specific visibility function, $\gamma$, for a given problem (e.g. distance)

Ant walk
- Initialize ants and nodes (states)
- Next edge is chosen probabilistically according to the attractiveness and visibility

$$\text{prob(choose available edge } e) = \frac{\delta(e)^{(c)}}{\sum_{\text{available edges } e} \delta(e)^{(c)}(e)}$$

- A prohibited list of infeasible transitions for that iteration is maintained by each ant.
- Attractiveness of an edge is updated according to the number of ants that pass through.

- Pheromone update
  If edge is not traversed, then:
  $$\delta(e) = \{(1 - \rho).\delta(e)\}$$

  If edge is traversed, then:
  $$\delta(e) = \{(1 - \rho).\delta(e) + \text{new pheromone}\}$$

  - Parameter $0 \leq \rho \leq 1$ is called evaporation rate
  - Pheromones = long-term memory of an ant colony
  - If $\rho$ is small→ evaporation is low→ slow adaptation
  - If $\rho$ is large→ evaporation is high→ fast adaptation
  - Note: rules are probabilistic, so mistakes can be made!
  - “new pheromone” or $\Delta \delta$ usually contains the base attractiveness constant $Q$ and a factor that you want to optimize(e.g.) $Q$/length of tour.

Figure 3: Registration process using ANT Zernike
$$r_{xy} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}}$$

Where

- $\sum$ symbol for sum – up, $r$ is cross correlation coefficient.
- $(x_i - \bar{x})$ Represents each x-value minus the mean of x.
- $(y_i - \bar{y})$ is each y-value minus the mean of y. 
- It application exist for image processing, pattern recognition etc.
- If the coefficient of correlation i.e. $r = 1$, it means that two images are absolutely identical.
- If $r = -1$, it means the two images are completely anti-correlated.
- If $r = 0$, it means that two images are completely uncorrelated.

Step-4: Next step, is that the same process from step-1 to step-3 is applied for target image

Step-5: After, this again the process of correlation is done. This time the correlation is find out between the source image and target image. Computation is same as done in step-3.

Step-6: RANSAC (Random Sample Consensus) is applied after the correlation is done between the source image and target image. RANSAC is basically used to find out the validity of points or as an approach which estimates the parameters in a way to deal or cope with a large proportion of outliers in the input data.

Algorithm of RANSAC is as follows [11]:

(i) Minimum number of points is selected that are required to determine the model parameters.

(ii) The parameters of the model are solved.

(iii) Then we find out that how many from the set of points fit predefined tolerance $\sigma$.

(iv) Re-estimate the model parameters if the fraction of number of inliers to the total number of points in the set exceeds the threshold using all the identified inliers and terminate.

(v) We repeat this process till all the points are estimated.

The number of iterations, $X$, is chosen high enough to ensure that the probability $p$ (usually set to 0.99) that at least one of the sets consists of random samples that does not include any outlier [11].

Step-7: Finally the transformation parameters are estimated using a weighted least square technique which has an objective function that depends upon the weighted difference between the location of two sets of features points extracted from reference and target image as computed in [19] and finally image is registered.

V. EXPERIMENTAL RESULTS

The performance of the proposed technique is calculated using three examples of images. The standard deviation specifies that over a region how good contrast is obtained after reconstruction. Two error matrices are used to compare image compression quality i.e. mean square error (MSE) and peak signal to noise ratio (PSNR). Greater value of PSNR means quality of image is improved. The lower the value of MSE, the lower the error.

Example 1: (i) image registered using ANT Zernike
(ii) image registered using Zernike

Source Image | Target Image

(i) | (ii)
Example 2: (i) registered image using ANTzernike (ii) registered image using Zernike

Example 3: (i) registered image using ANTzernike (ii) registered image using Zernike

Example 4: (i) registered image using ANTzernike (ii) registered image using Zernike

Example 5: (i) registered image using ANTzernike (ii) registered image using Zernike

TABLE 1: Results using proposed technique that is image registration using ANTzernike:

<table>
<thead>
<tr>
<th>IMAGE SET</th>
<th>SD</th>
<th>MSE</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>30</td>
<td>12940.21</td>
<td>50.319</td>
</tr>
<tr>
<td>Example 2</td>
<td>92.2241</td>
<td>12968.7</td>
<td>50.3365</td>
</tr>
<tr>
<td>Example 3</td>
<td>93.829</td>
<td>23457.73</td>
<td>55.09</td>
</tr>
<tr>
<td>Example 4</td>
<td>61.0</td>
<td>9866.7</td>
<td>48.2</td>
</tr>
<tr>
<td>Example 5</td>
<td>96.4</td>
<td>17506.8</td>
<td>52.7</td>
</tr>
</tbody>
</table>

TABLE 2: Results using earlier technique that is image registration using Zernike

<table>
<thead>
<tr>
<th>IMAGE SET</th>
<th>SD</th>
<th>MSE</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>26.5</td>
<td>153634</td>
<td>32.57</td>
</tr>
<tr>
<td>Example 2</td>
<td>74.6</td>
<td>508859</td>
<td>20.5</td>
</tr>
<tr>
<td>Example 3</td>
<td>71.6</td>
<td>602540</td>
<td>38.505</td>
</tr>
<tr>
<td>Example 4</td>
<td>40.63</td>
<td>98374</td>
<td>31.6</td>
</tr>
<tr>
<td>Example 5</td>
<td>76.5</td>
<td>450260</td>
<td>36.89</td>
</tr>
</tbody>
</table>
Results shows that SD for proposed technique is increased as compare to earlier method which signifies that contrast obtained is better after reconstruction. PSNR has increased indicating the improvement in quality and decrease in MSE shows the fall in error.

VI. CONCLUSION AND FUTURE WORK

An efficient approach with Zernike and ant colony optimization for image registration has been presented. The combination of the features or the properties of both Zernike and ANT makes this technique suitable for using it for almost all types of images especially for complex (medical) images.

The proposed technique has some following features:

- Improvement in contrast
- Improvement in quality
- Fall in error rate
- Resistant to noise

In future other methods can be combined with Zernike such as sift method or with surf and results can be verified.

REFERENCES

[18] Bernardo RodriguezPires and Jose e M. F. Moura “FEATURE MATCHING IN GROWING DATABASES”978-1-4673-2533-2/12/$26.00 ©2012 IEEE.


