1.1 A New Approach On Image Registration Technique

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Abstract - Image registration is the process of overlaying images (two or more) of the same scene taken at different times, from different viewpoints, and/or by different sensors. This paper aims to present a review of recent techniques being applied for image registration and also introduces a new registration technique including standard transformation based on a single matching point between two similar images. For each set of data, mainly, two satellite images are considered. Both feature-based methods are required to find control points to perform various transformations (like rotation, translation, scaling and shear) to map images in same scale. Next, linear least square best fit correlation algorithm is used for choosing appropriate control points and an affine transformation is applied and finally, images are superimposed. Results show the efficacy of the proposed scheme.

Keywords: Image registration, affine transformation, pseudo coloring, linear correlation

I. INTRODUCTION

In computer vision, image registration is the process of transforming different sets of data into one coordinate system. Registration is necessary in order to be able to compare or integrate the data obtained from different measurements. The presence of differences between images is introduced due to different imaging conditions. Image registration is a crucial step in various image analysis tasks in which the final information is gained from the combinations of multiple data sources like in image fusion, change detection, and multi-channel image restoration. Typically, registration is required in remote sensing, medicine (MRI’s, PET scans, etc), cartography, and in computer, etc.

Image registration or image alignment algorithms can be classified into two categories, namely, intensity-based and feature-based. It involves spatially transforming the target image to align with the reference image. Intensity-based methods compare intensity patterns in images via correlation metrics, while feature-based methods find correspondence between image features such as points, lines, and contours. Intensity-based methods register entire images or subimages. Feature-based method established correspondence between a number of points in images. Finally, a transformation is determined to map the target image into the reference images, thereby establishing point to point correspondence between images.

Alternatively, these algorithms can also be classified according to the transformation models (linear and non-linear) they use to relate the target image space to the reference image space. Moreover, linear transformation methods can be classified as spatial methods and frequency domain methods. Spatial methods operate in the image domain through matching intensity patterns or features of images. Frequency-domain methods find the transformation parameters for registration while working in the transform domain. Non-linear transformations allow ‘elastic’ or ‘nonrigid’ transformations.

In this paper, we have used feature based on transformation models, which include translation, rotation, scaling, and other affine transforms like shearing and linear correlation among the control points to superimpose the images. Results are satisfactory.

Rest of the report is organized as follows. Earlier works of image registration are described in Section 2. Section 3 outlines the brief overview of the present work through various subsections. Results of experiments are presented in Section 4. Evaluation of accuracy is outlined in Section 5. Description of future plan of our work along with conclusion is presented in Section 6.

II. PREVIOUS WORK IN IMAGE REGISTRATION

In general, the common theme applied for image registration is to apply some type of feature detection, compare the features using feature matching, map the features between the two
images, and apply the transformation to properly register the images.

The authors of [5] have discussed variations in images and appropriate image registration techniques that can be applied as a framework to address image registration problems. The affine transform can tolerate more complicated distortions by mapping straight lines from two separate images and can handle differences in images including different angles, different positions, and shearing.

Cross-correlation (see literature [7]) is the basic approach to image registration and is often used for template matching in pattern recognition. This approach is used in this work. A pattern or a template is compared between images and their location and orientation are determined before applying the registration. Point mapping can be used for spatial transformation and the general approach is to determine similar points of interest called Control Points and aligning those points using rigid and affine transformations. These control points play an important role because the accuracy of these point comparisons between images will indicate the success of the result.

Another paper of interest is “Image Registration Methods” by Barbara Zitova and Jan Flusser [6]. This paper discusses in great detail the techniques of feature detection, feature matching, and image transformations to register the images. Feature detection is the ability to distinguish objects in a single image by their regions, edges, or corners to determine control points that can be compared against another similar image.

The solution discussed in this paper is to scale each axis independently and apply rigid body transformations to adjust for the shearing. The rigid transformation handles retaining the relative shape and size of objects in images that usually vary by translation and/or reflection. This is typically done by recognizing the same object in two images and recognizing their coordinates.

III. PROPOSED WORK

To fuse satellite images a correspondence is established between them. Establishing correspondence means matching of identical shapes or points in the related image pair. One of the images is considered as the reference or source and the other one is referred as the target or sensed image. As registration involves spatially transforming the target image to align with the reference image, this requires geometric transformation of one image onto other. We have used affine transformation for this purpose. Details of this transformation are described in this part of discussion.

Registration Methodology: The registration methods consist of the following four steps:

- **Feature detection:** Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc.) are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points \( C_p \).

- **Feature mapping:** In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Standard feature descriptors and similarity measures along with spatial relationships among the features are used for that purpose.

- **Transform model estimation:** The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping functions are computed by means of the established feature correspondence.

- **Linear Correlation:** The linear least square best fit correlation is used to select appropriate control points from both the reference and the sensed images.

- **Image re-sampling and transformation:** The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates are computed by the appropriate interpolation technique.

Implementation of each registration step has its own constraints. First, we have to decide what kind of features will be appropriate for the given task. The features should be distinctive objects, which are frequently spread over the images and are easily detectable. Usually, the physical interpretability of the features is demanded. The detected feature sets in the reference and sensed
images must have enough common elements, even in situations when the images do not cover exactly the same scene or when there are object occlusions or other unexpected changes. The detection methods should have good localization accuracy and should not be sensitive to the assumed image degradation. In an ideal case, the algorithm should be able to detect the same features in all projections of the scene regardless of any deformation.

Cp detection using feature based special methods: We have used point detection scheme (see literature [8]). Edge detection techniques (CANNY detector), corner detection techniques (HARRIS detectors) and different morphological operators (e.g., dilation, opening, erosion and closing) are used for feature generation. Some of the feature matching algorithms are outgrowths of traditional techniques for performing manual image registration, in which we chooses corresponding control points (Cps) in images manually. For example, in fig 1 it is not possible to select appropriate Cp using any feature based point detection technique. So, in such cases manual selection of Cps are preferred.

**Linear Correlation among different C_p:s:** As the number of control points exceeds the minimum limit to define the appropriate transformation model, we use an iterative algorithm to robustly estimate the parameters of a particular transformation type. The algorithm is based on the linear least square best fitting algorithm among the C_p:s. It is done by calculating the variables which are required for estimation of affine transformation. Equation (3) suggests that it contains 6 variables. These variables are calculated using equation (1) and equation (2), respectively.

\[
S(a, b, tx) = \sum_{i=1}^{k} [x_i' - (ax_i + by_i + tx_i)]^2
\]

\[
S(c, d, ty) = \sum_{i=1}^{k} [y_i' - (cx_i + dy_i + ty_i)]^2
\]

Where \(S(a, b, tx)\) and \(S(c, d, ty)\) calculates the linear least square best fit values for parameters \(a, b, c, d, tx\) and \(ty\). The number of C_p:s is denoted by \(k\). \(x'\) and \(y'\) are the C_p:s for reference image and \(x\) and \(y\) are C_p:s for sensed image.

**Affine Transformation:** In case of affine transformation, the matrix for each co-ordinate is represented as mentioned in equation (3).

\[
\begin{bmatrix}
  x' \\
  y' \\
  1
\end{bmatrix} =
\begin{bmatrix}
  a & b & tx \\
  c & d & ty \\
  0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
  x \\
  y \\
  1
\end{bmatrix}
\] …… (3)

Affine transformation has 6 degrees of freedom and is equivalent to the combined effects of translation, rotation, isotropic scaling and shearing. Properties like parallelism, ratio of lengths of collinear or parallel segments (e.g. Mid points), ratio of areas, linear combination of vectors are invariant under affine transformation. Here \(a, b, c\) and \(d\) represent the measure of rotation scaling and shear whereas \(tx\) and \(ty\) represent measure of translation.

### IV. RESULTS

Performance of the proposed scheme is discussed in this part of the report. A large number of satellite images are collected from web. The dataset contains 100 images of size 481 X 321. The result contains 3 columns where first two are the two satellite images with on registration forms the 3rd one (see fig 2).

The results are quite satisfactory and it shows the efficiency of our methodology.
V. EVALUATION OF THE IMAGEREGISTRATION ACCURACY

Regardless of type of images, the registration method, and the application area, it is highly desirable to provide the user with an estimate of accuracy. The accuracy evaluation is a non-trivial problem, partially because the errors can be dragged into the registration process in each of its stages. It is hard to distinguish between registration inaccuracies and actual physical differences in the image contents. In this Section, we review basic error classes and methods for measuring the registration accuracy.

- Localization error: Displacement of the $C_p$ coordinates due to their inaccurate detection is called localization error.
- Matching error: Matching error is measured by the number of false matches when establishing the correspondence between $C_p$ candidates.
- Alignment error: By the term alignment error, the difference between the mapping model used for the registration and the actual between-image geometric distortion is denoted. Alignment error is always present in practice because of two different reasons. The type of the chosen mapping model may not correspond to the actual distortion and/or the parameters of the model were not calculated precisely. The former case is caused by lack of a priori information about the geometric distortion while the latter originates from the insufficient number of $C_p$s and/or their localization errors.

VI. CONCLUSION AND FUTURE WORK

Image registration is one of the most important tasks when integrating and analyzing information from various sources. It is a key stage in image fusion, change detection, super-resolution imaging, and in building image information systems, among others. This paper gives a study of transformed image model. Although a lot of work has been done, high accuracy in image registration still remains an open problem. Registration of images with complex non-linear and local distortions, multimodal registration, and registration of $N$-D images (where $N>2$) is regarded as a challenging task.

REFERENCES