

# MULTIMODAL IMAGE REGISTRATION USING HYBRID TRANSFORMATIONS

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**Abstract**— Feature selection is the fundamental step in image registration. Various tasks such as feature extraction, detection are based on feature based approach. In the current paper we are going to discuss about our technique that is hybrid of Local affine and thin plate spline. An automatic edge detection method to achieve the correct edge map is put forward to dealing with image registration with affine transformation for the better image registration. Registration algorithms compute transformations to set correspondence between the two images. The purpose of this paper is to provide a comprehensive comparison of the existing literature available on Image registration methods with proposed technique.

**Key words**— Image registration, Feature matching, Local Affine transformations, Correlation, RANSAC, Thin-plate spline method.

## I. INTRODUCTION

Image registration is the initial step in almost all image processing applications. Image registration is the process of matching two or more images of the same target by different time, or from different sensors or by different perspectives. It is the establishment of various geometrical transformations that will align points in one view of the source image with corresponding points in another view of that image or the reference image [2]. Image registration can be defined as the determination of a one-to-one mapping between the coordinates in one space and the ones in other, such that points in the two spaces that correspond to the same anatomical point are mapped to each other.

- Image Registration is a process of finding an optimal transformation between two images.
- Sometimes also known as “Spatial Normalization” (SPM).

The present difference between the images is due to different imaging conditions. The main objective of image registration is to combine data from different sources accurately and without any redundancy, because the data contained by sources depends upon the method of acquisition. Basically we can define method of acquisition in following ways:

### A. Multiview analysis (Different viewpoints):

Images of the same scene may be acquired from the different viewpoints. In this, images may differ in translation, rotation, and scaling, more complex transformations mainly due to camera positions [5]. Examples include: computer vision shape recovery.

### B. Multitemporal analysis (Different times):

Images of the same scene may be acquired at different times or under different lightning conditions may be [5]. Our aim is to identify and evaluate changes in the scene which

appeared between the consecutive images acquisitions. Examples includes: Medical image monitoring, remote sensing.

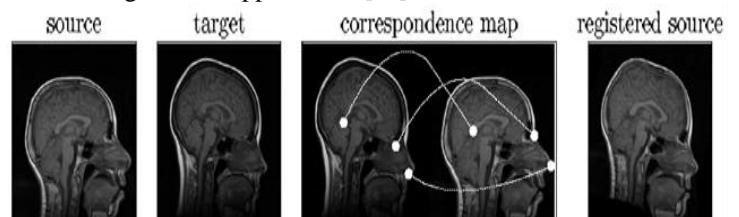
### C. Multimodal analysis (Different sensors):

Images are acquired by different types of sensors [5]. Here, the aim is to integrate the information from two different sources and then to obtain more representation detail.

### D. Scene to model registration:

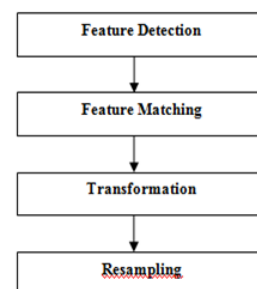
Images of a scene and model of a scene are registered [5]. The aim is to localize the acquired image in the model and to compare them. Examples include: Medical imaging.

- Image registration can be of rigid or of non-rigid registration. In rigid registration, only rotation and translation are applied for the spatial transformation. It is usually necessary to align the images from the same subject free of any deformation between the acquisitions of the image or as a pre-alignment for methods of the registration with higher degrees of freedom [11].
- 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. It is also necessary if the datasets from different patients must be registered, like in atlas registration applications [14].



**Fig 1. Registered source, obtained by matching source and target image by correspondence map**

Most of the Registration methods consist of the following four steps:



**Fig2. Block diagram of image registration.**

- **Feature detection:** Edges, contours, line Intersection; corners etc. are manually or automatically detected.
- **Feature matching:** In this step, the common features that are detected in the sensed image and those detected in the reference image are matched.
- **Transform model estimation:** The type and parameters of the so-called mapping function should be chosen according to the prior knowledge, aligning the sensed image with the respective reference image, are then estimated.
- **Image re-sampling and transformation:** The registered image needs to be resampling, after determining the transformation parameters.

Image registration can also be classified on the basis of the dimensionality, nature of the registration basis, nature of transformation, domain of transformation [4], interaction, and optimization procedure, modalities involved in the registration, subject and object.

We can also explain Image registration with the help of figure3:

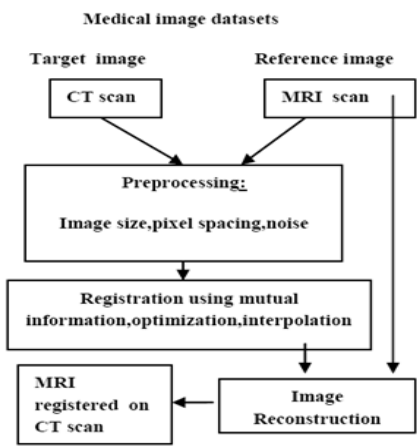


Fig 3. Image registration

Here, firstly we have two sets of medical images that we need to register. Then, preprocessing of both sates take place which includes, determining the image size, pixel spacing, noise present, etc. Then, registration process is started with the help of techniques based on mutual information or interpolation etc. then registered image is reconstructed and we have the final registered image.

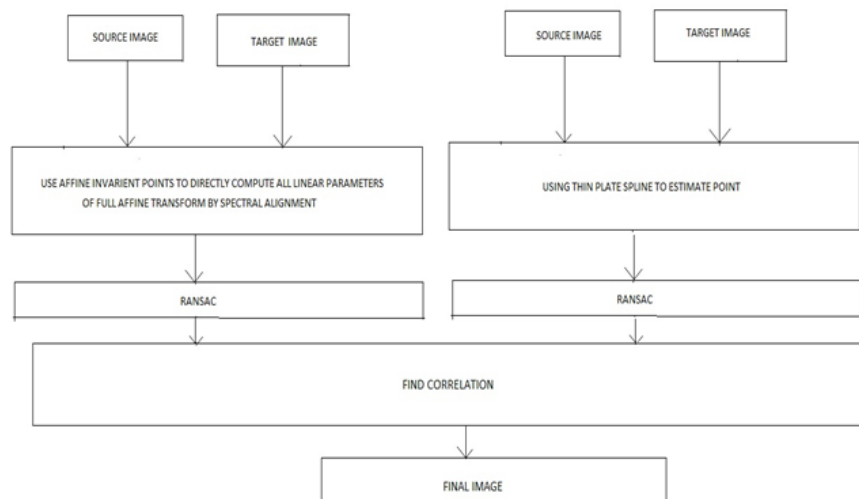


Fig.5. Overview of Hybrid Technology Consists of Local Affine transformation and Thin Plate Spline (TPS)

## II.LOCAL AFFINE

Local affine transformation is used for within- subject registration when there is global gross over distortion [1]. The affine transformation preserves the straightness of lines, and hence, the planarity of the surfaces and it also preserves parallelism between the lines, but it angles between lines may change.

- All rigid transformations can be treated as affine transformations, but all affine transformations are not rigid transformations.
- An affine transformation involves rotation, shearing, translation, scaling as shown in figure 4.

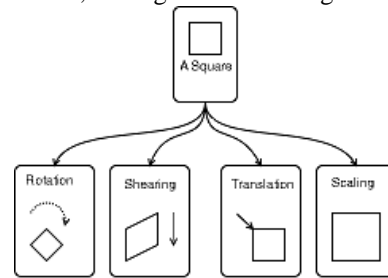


Fig 4. Affine Transformations [9]

- Affine transformations are represented in homogeneous coordinates because the transformation of point A by any affine transformations can be expressed by the multiplication of a 3\*3 matrix and a 3\*1 point vector [9].

## III.PROPOSED WORK:

We have proposed a hybrid method of Local Affine and Thin Plate Spline for effective Image Registration with comparatively less computation time and with more accuracy. The methodology of work will start with the overview of image registration algorithms. The results of various algorithms will then be interpreted on the ground of various quality metrics. Thus, our methodology for implementing the objectives can be summarized as follows:-

1. To focus on the feature detection so that we decide which algorithm to be applied.
2. Based on the Detection we will apply the hybrid Local Affine transformation and Thin Plate Spline (TPS) for Image Registration.
3. This will increase the efficiency of the registration method and quality in the Image.

#### IV. QUALITY METRICS

Various quality measures are there to compare different registration algorithms. Some of these are discussed below:

##### A. PSNR

The term peak signal-to-noise ratio (PSNR) is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale.

Image improving the visual quality of a digital image can be subjective. Saying that one method provides a better quality image could vary from person to person. For this reason, it is necessary to establish quantitative/empirical measures to compare the effects of image

Enhancement algorithms on image quality.

Using the same set of tests images, different image enhancement algorithms can be compared systematically to identify whether a particular algorithm produces better results. The metric under investigation is the peak-signal-to-noise ratio. If we can show that an algorithm or set of algorithms [13] can enhance a degraded known image to more closely resemble the original, then we can more accurately conclude that it is a better algorithm.

To compute the PSNR, We must calculate the mean-squared error with the help of equation:

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N} \quad [13]$$

In the above equation, M and N are the number of rows and columns in the images, respectively. Then the block will compute the PSNR using the equation:

$$PSNR = 10 \log_{10} \left( \frac{R^2}{MSE} \right) \quad [13]$$

In the previous equation, R is the maximum fluctuation in our input image data type. We can say, if our input image is having a double-precision floating-point data type, then value of R is 1. And if it having an 8-bit unsigned integer data type that is, R is 255, etc.

##### B. Entropy

Entropy is one of the quantitative measures in digital image processing E = entropy(I) returns E, a scalar value representing the entropy of grayscale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as

$$-\sum (p_i \cdot \log_2(p_i)) \quad [2]$$

Where p contains the histogram counts returned from imhist. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays.

It can be a multidimensional image. If I have more than two dimensions, the entropy function treats it as a multidimensional grayscale image and not as an RGB image.

##### C. Phase correlation

Fourier-based Correlation is another method for performing rigid alignment of images. The feature space it uses consists of all the pixels in the image, and its search space covers all global translations and rotations. (It can also be used to find local translations and rotations [31].) As the name implies, the search strategy are the closed form Fourier-based methods, and the similarity metric is correlation, and its variants, e.g., phase only correlation [12]. As with Principal Axes, it is an automatic procedure by which two images may be rigidly aligned. Furthermore, it is an efficient algorithm.

Phase Correlation is a method of image registration, and uses a fast frequency-domain approach to estimate the relative transliterate offset between two similar images.[4] Unlike many spatial-domain algorithms, the phase correlation method is resilient to noise, occlusions, and other defects typical of medical or satellite images.

##### D. Spectral Alignment:

The method can be extended to determine rotation and scaling differences between two images by first converting the images to log-polar coordinates. Due to properties of the Fourier, the rotation and scaling parameters[7] can be determined in a manner invariant to translation.

$$F_i(\theta, \lambda) = f_i(\theta, \log r)$$

$$F_j(\theta, \lambda) = s^{-2} f_i(\theta - \theta_0, \log r - \log s). \quad [11]$$

Spectral alignment: The affine transform in (1) can be described as the alignment of a pair of 2-D vectors to another pair. Assuming the presence of double energy clusters in the Fourier spectra of the respective patch, as shown in Fig. 3, identifying two representative centroids (affine invariant coordinates) of each cluster can disclose an affine transformation relating the two patches by simply solving a matrix equation.

$$\sigma^2(\theta_1, \theta_2) = \frac{1}{E_{\text{half}}} \sum_{x \in \Lambda(\theta_1, \theta_2)} |x \cdot \|x - \mu\|^2$$

Ehalf is the sum of the energy (magnitude) of the half plane. The angular segments and the corresponding centroids are equivariant under the invertible transformation of (4), which makes the variance analysis legitimate.

#### V. CORRELATION

Correlation is the degree to which two or more quantities are linearly associates. In a two-dimensional plot, the degree of correlation between the values on the two axes is quantified by the so-called correlation coefficient [113]. When two sets of data are strongly linked together we say they have a high correlation.

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}} \quad [6]$$

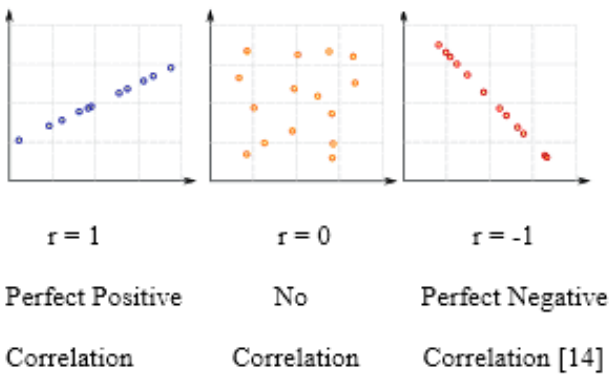
Where:

- $\Sigma$  is Sigma, the symbol for "sum up"

- $(x_i - \bar{x})$  Represents each x-value minus the mean of x.
- $(y_i - \bar{y})$  Is each y-value minus the mean of y[14].

Correlation coefficient r can be used in image processing, security applications or in pattern recognition.

- If  $r = 1$ , it means that the two images are absolutely identical.
- If  $r = 0$ , it means that two images are completely uncorrelated.
- If  $r = -1$ , it means the two images are completely anti-correlated[115].



#### VI.RANSAC

RANdom SAMple Consensus algorithm proposed by Fischler and Bolles in 1981. It is a resampling technique and used for parametric matching. Cross correlation method doesn't guarantee that all the correspondences are correct, introducing outliers. RANSAC algorithm handles this problem by introducing a classification of the data into inliers (valid points) and outliers while estimating the optimal transformation for the inliers. A threshold  $t$  is used; it insures that none of the inliers deviates from the model [11]. The basic algorithm is summarized as follows:

**Step 1:** Select randomly the minimum number of points required to determine the model parameters.

**Step 2:** Solve for the parameters of the model.

**Step 3:** Determine how many points from the set of all points fit with a predefined tolerance

**Step 4:** If the fraction of the number of inliers over the total number points in the set exceeds a predefined threshold  $t$ , re-estimate the model parameters using all the identified inliers and terminate.

**Step 5:** Otherwise, repeat steps 1 through 4 (maximum of N times).

The number of iterations, N, 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 does not include any outlier. Let  $u$  represent the probability that any selected data point is an inlier [11].

#### VII.THIN PLATE SPLINE NON-RIGID REGISTRATION

For registration of the images with large distortion at some special places, the non-rigid thin plate spline registration is very much accurate and necessary if compared with the rigid Registration [1]. It is a generalized approach for the correction of distortion and will make a better registration effect for the large image distortion that was experimentally proved [15].

Thin plate spline have many advantages for using it like smooth deformation with physical analogy, closed-form solution, few free parameters(no turning is required) but it takes time for solving the equations.

TPS is an interpolation and smoothing technique, the generalizations of splines so that these may be used with two or more dimensions [1]. These provide a smooth interpolation between a set of control points.

- These belong to set of radial basis function.
- It interpolates a surface that passes through each control point. A set of three points will thus generate a flat plane. It is easy to think of control points as position constraints on any bending surface. An ideal surface is one that bends the least.
- TPS has been widely used as the non – rigid transformations model in image alignment and shape matching.
- Here, the model has no free parameters that need manual tuning, the interpolation is smooth with derivative of any order, and there is a physical explanation for its energy function.
- But, as the control points has the global influence, thus it limits the ability to model complex and localizes deformations and as the no of control point increases, the computational cost associated with moving a single point rises steeply.

#### VIII.APPLICATIONS OF IMAGE REGISTRATION

Image registration can be used for clinical diagnosis (cancer detection), radiation therapy, treatment planning, surgical planning and evaluation, fusion of multimodal images, inter-patients comparison etc.

#### IX.RESULTS

To illustrate the effectiveness of the algorithms, results are presented for the approximation of composite images as well as natural images. Four different quality parameters: phase correlation (PC); spectral alignment (SA); Entropy; and PSNR (Peak to Signal Noise Ratio), were tested and the results are better than the existing algorithms.

IMAGE SET	Entropy		PSNR		S.A		P.C	
	Earlier Technique	Proposed Technique	Earlier Technique	Proposed Technique	Earlier Technique	Proposed Technique	Earlier Technique	Proposed Technique
Sk11, Sk12	4.61	0.197	20.57	50.33	74.68	74.4	0.315	2.17
MRI1,MRI2	1.29	0.05	32.57	50.31	26.58	10.54	2.67	1.93
CT1,CT2	2.11	0.17	44.82	50.48	61.1	74.00	1.75	5.52

**TABLE I COMPARATIVE RESULTS OF TRANSFORMATION: PC (PHASE CORRELATION), SA (SPECTRAL ALIGNMENT), PSNR (PEAK TO SIGNAL NOISE RATION), AND ENTROPY. THE EXPERIMENT IS PERFORMED TO ESTIMATE EACH TYPE OF DEFORMATION AND COMBINED DEFORMATIONS**

### X.CONCLUSION AND FUTURE PERSPECTIVES

In this paper, we propose a Hybrid technique which consists of the Local Affine Transformations and Thin Plate Spline method for effective image registration which will remove all the deficiencies remain while using other methods of image registration. Various Quality Metrics have been used for computing results to compare quantitatively these Techniques. Experimental results show that proposed method achieves well than the prior methods (Local Structure affine) in terms of quality of images by maintaining the data represented by the images. Image registration process can be improved by a combination of Harris corner detection and thin plate spline algorithm. Correlation can be used for the linear relationship between the intensities of two images and RANSAC is used to remove unnecessary landmarks.

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