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Review: Analysis of Image Registration Techniques

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Abstract: **This paper is based on image registration method to solve problem in medical field to compare image or data obtained from different angle & different time. It is useful in diagnosis of problem by coordinating systematically. This images or data sequence vice, image registration is helpful in diagnosis of cardiac, retina, pelvic, abdomen, liver, tissue disorder. It gives measurable figure in change between two elements. There are different methods which can be used in image registration like Harris corner, Hough Transform, genetic algorithm, RANSAC method & SIFT method.**

Keyword: **Image Registration, Harris corner, Hough Transform, Genetic Algorithm, Ransac method, Sift Method.**

I. INTRODUCTION

Image registration is one of the most active fields in image processing and computer vision of few decades. It is following step as in below.

- ***Feature detection*:** Salient and distinctive objects in both reference and sensed images are detected.
- ***Feature matching:*** The correspondence between the features in the reference and sensed image established.
- ***Transform model estimation:*** The type and parameters like mapping functions, aligning the sensed image with the reference image are estimated.
- ***Image resampling and transformation:*** The sensed image is transformed by means of the mapping functions.

❖ *Classification*

Below illustrate the classification.

- ***Dimensionality:*** 2D/2D, 2D/3D, 3D/3D Image registrations are possible. Sometimes time could be the fourth dimension[9].
- ***Domain of transformation:*** It could be global or local depending on whether the whole image or its part is to be registered.
- ***Type of transformation:*** The transformation could be rigid, affine, projective or nonlinear.
- ***Tightness of feature coupling*:** The transformation can be interpolating or approximating.
- ***Measure of registration Quality*:** Various measures are applied depending on the data features or data itself.
- ***Method of parameter determination:*** The parameters of the transformation can be found out using direct or search oriented methods.
- ***Subject of registration*:** If the two images contain the same subject it is intra subject registration. If the subject in the two images differs it is inter subject registration.
- ***Type of data*:** It can be raw data; features extracted from data or introduced markers in data.
- ***Source of features*:** Features explicitly present in the data are called intrinsic features where as those introduced from outside are called as extrinsic features.
- ***Atomization level:*** This can be automatic depending on user intervention. More details are explained in [1].

II. METHODS OF IMAGE REGISTRATION

2.1 Harris algorithm

Harris algorithm detects corners through differential operators and the autocorrelation matrix. The window *w* move infinitesimal displacement to any wanted direction. Then,computing each variation of gray. The maximum of these variations is the response function value.

The variation of gray can be defined as:

$$V_{xy}=\sum_{u,v} Wu,v[xf_x+yf_y+o(x^2,y^2)]^2 \approx A_x^2+2C_{xy}+B_y^2=(x,y)M(x,y)^T \quad (1)$$

Where f_x and f_y are one-order gray-level gradient which shows the changes of gray scale at each pixel,$W_{u,v}$ is the Gaussian window used in Gaussian smoothing filter of the image to enhance anti-interference ability.

$$f_x=\frac{\partial I}{\partial x}=I \otimes (-1,0,1)$$

$$f_y=\frac{\partial I}{\partial y}=I \otimes (-1,0,1) \quad (2)$$

$$W_{u,v}=\exp[\frac{-1}{2}(u^2+v^2)/\delta^2]$$

The M is:

$$M=\begin{bmatrix} f_x^2 & f_x \cdot f_y \\ f_x \cdot f_y & f_y^2 \end{bmatrix} \otimes w=\begin{bmatrix} A & C \\ C & B \end{bmatrix} \quad (3)$$

$$\text{Where } A=f_x^2 \otimes w, B=f_y^2 \otimes w, C=(f_x.f_y) \otimes w \quad (4)$$

Let λ_1 and λ_2 represent the eigen values of autocorrelation matrix *M*. The value of the λ_1 and λ_2 can determine the flat area, the corner point, and the edge:

1) Flat area: λ_1 and λ_2 are both small;
2) Edge: one eigen values is large, and the other is small;
3) Corner point: λ_1 and λ_2 are both large.

The corner response function is defined as follows:

$$R(x,y)=\det[M(x,y)]-k.\text{trace}2[M(x,y)] \quad (5)$$

Where det [M(x,y)]= λ1.λ2 is the determinant value of matrix M ;trace [M(x,y)]= λ1.+λ2 is the trace of matrix M;the value of k =0.04 give the best results.

2.2 Improved Harris algorithm

The traditional algorithm, image compression and block processing are adopted to improve accuracy and real-time of the algorithm, and then ensure the corners distribution uniformly, and reduce the clustering occurrence [2].

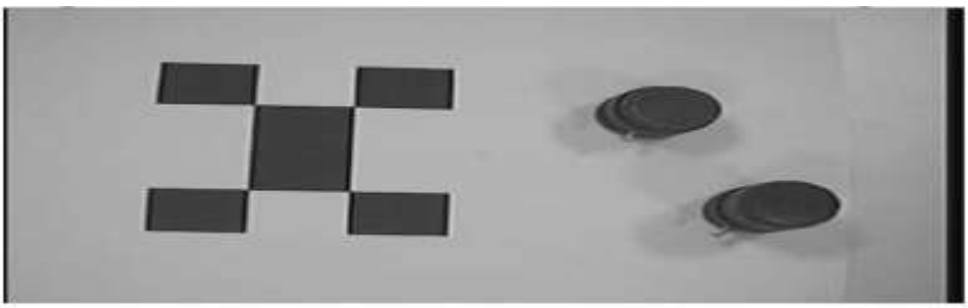


Figure1. The Original Image

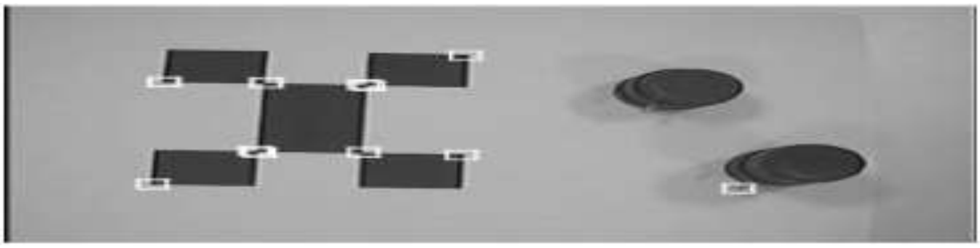


Figure 2.Original Harris Algorithm

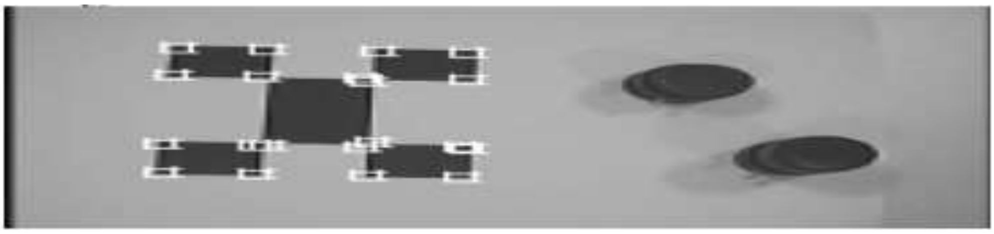


Figure 3.Improved Harris Algorithm

Above three Figures shows the experimented results of the harris algorithm and improved harris algorithm.

2.3 Hough Transform Algorithm

The concept of image registration shows in figure 4 and figure 5. Figure 4shows two input images taken at different camera position which causes the translation between two images. There must be the overlapped area between two input images. Then, by applying Hough transform and phase correlation technique to combine two input images and make a new one that contains details of two input images[3][4].

(a) (b)

Figure 4.Two images (a) and (b) that have overlapped area

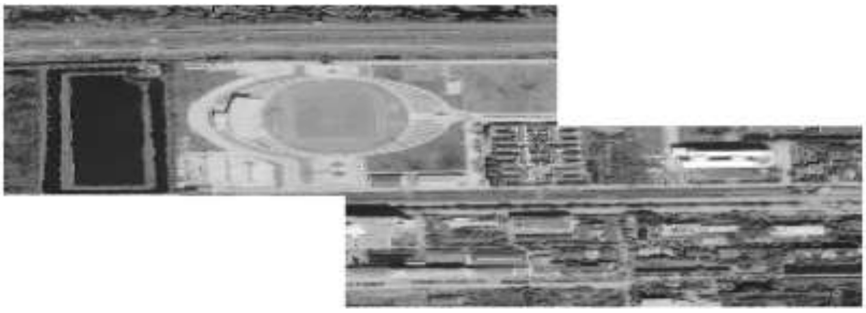


Figure5. A new Image contains details of images

Hough transform is combined with phase correlation to detect rotation and translation between two images. Hough Transform is a feature extraction technique used in digital image processing. The proposed algorithm, the Hough function is implemented using the Standard Hough Transform (SHT). In the standard Hough transform, each line in the images is represented by two parameters, commonly called ρ (rho) and θ (theta), which represent the length and angle of the line respectively.

The Hough transform is designed to detect lines, using the parametric representation of a line as presented in equation (1).

$$\rho = x\cos\theta + y\sin\theta \qquad (1)$$

Where ρ is the distance from the origin to the line along a vector perpendicular to the line and θis the angle between the x-axis and this vector

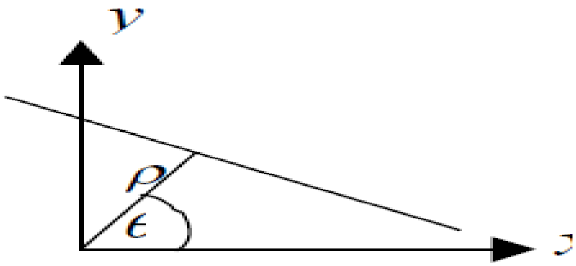


Figure6. Hough Space Representation of line

2.4 Genetic Algorithm

Genetic algorithms are search algorithms based on the mechanics of natural selection and natural genetics

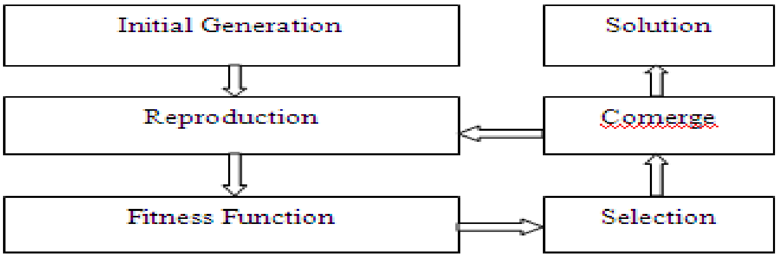


Figure 7.flow diagram of genetic algorithm

Above flow diagram gives the basic idea of the genetic algorithm steps [5].The genetic algorithms will have better convergence behaviour if the fitness function is generally continuous over the defined chromosome space and the chromosome with the optimal fitness value corresponds with the target solution.

The parameters as shown in below table give detail about Genes and chromosome.

Table: 1

Translation Genes	
T_x	Translation of x axis
T_y	Translation of y axis
T_z	Translation of z axis

Table: 2

Rotation Genes	
A	Rotation about x-axis
B	Rotation about y-axis
θ	Rotation about z-axis

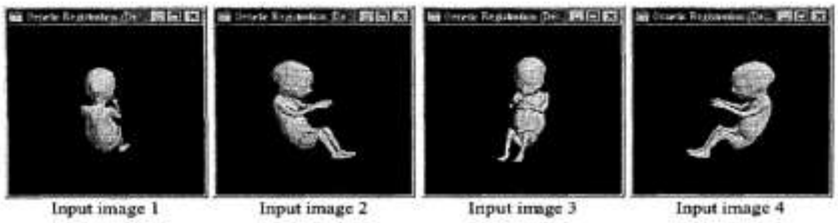
Tx, Ty,and Tz are the translation genes and α, β and θ are the rotation genes. The data points in two images are related by the mapping T:

$$T=Rx, Ry, Rz,S$$

Where

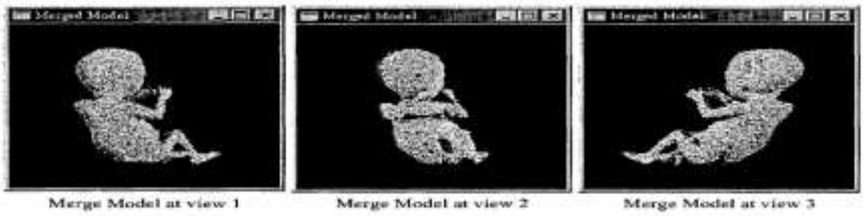
$$R_x=\begin{pmatrix}1 & 0 & 0 & 0\\ 0 & \cos\alpha & \sin\alpha & 0\\ 0 & -\sin\alpha & \cos\alpha & 0\\ 0 & 0 & 0 & 1\end{pmatrix} \quad R_y=\begin{pmatrix}\cos\beta & 0 & -\sin\beta & 0\\ 0 & 1 & 0 & 0\\ \sin\beta & 0 & \cos\beta & 0\\ 0 & 0 & 0 & 1\end{pmatrix}$$

$$R_z=\begin{pmatrix}\cos\theta & \sin\theta & 0 & 0\\ -\sin\theta & \cos\theta & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{pmatrix} \quad S=\begin{pmatrix}1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0\\ T_x & T_y & T_z & 1\end{pmatrix}$$



Input images

s=0.255



s=1.25

Figure 8. Expriment results of merging noisy image of human fetus computer model

2.5 Ransac Algorithm

RANSAC [6] has become the most popular tool to solve geometric estimation problem in datasets containing outliers. It operates in a hypothesis- and-verify frame work. A set of tentative correspondence, ransac randomly samples a minimal subset of size m from this set in order to hypothesis a geometric model. This model is then verified against the remaining correspondences and the number of inliers. This process is iterated until a certain termination criterion is met.

Steps of RANSAC algorithm

1. Use this formula to get the minimum sample size M

    1-(1-(1-ε)m)M = P

2. The computing parameters of model use initials to inspect the quality of parameter and obtain the number of Inliers of each model.
3. Selecting optimum parameters according to the number of inliers and the variances of in accuracy, then estimate the final parameter.

The application of RANSAC algorithm is image stability [7].

2.6 SIFT Algorithm

The features of SIFT are widely used in image matching because of its invariation to images scale and rotation, but 128-dimensional description of the feature point reduce the efficiency of the algorithm [8].

The algorithm includes five steps:

(1) Establishment of scale space

(2) feature point location

(3) Key point direction allocation

(4) Feature point description sub-generation

(5) Matching.

2.7 Improved SIFT Algorithm

In the step 3 in SIFT algorithm, one primary direction is assigned to key point to ensure the rotation invariance of descriptor. If the descriptor already has good anti-rotation performance, the step 3 could be ignored. As ring performs good rotation invariance, the characteristic point area does not changed while the image is rotating. We build characteristic descriptor by ring.

Experiment shows that step 4 costs 60% to 80% time using SIFT matching algorithm. We combine step 3 and 4, and substitute 24 dimensions for 128 dimensions while using traversal search the nearest and next nearest neighbourhood sample characteristic point [8].

The steps of the modified method are as below.

1) Scale space establishment

2) Characteristic point location

3) Characteristic descriptor generation

4) Matching

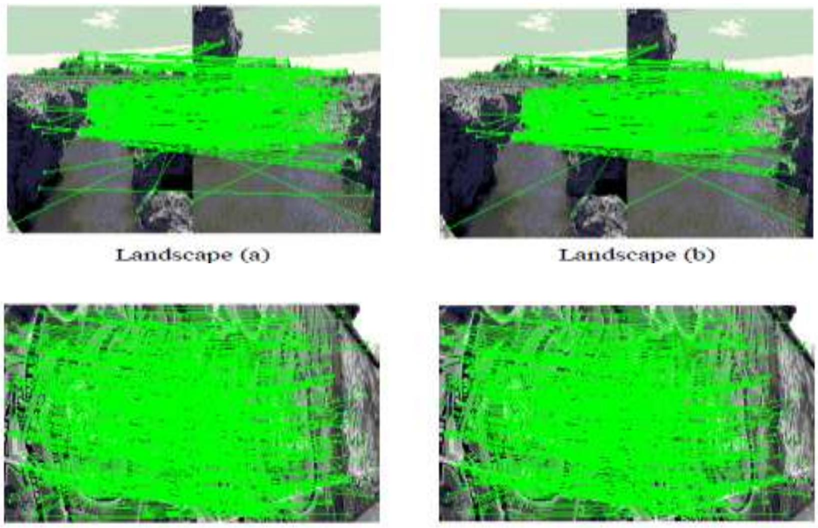


Figure9. Characteristic point matching image

Fig. 9(a) illustrates the effect of conventional SIFT matching method, while fig. 9(b) shows the result using improved SIFT.

CONCLUSIONS

The experimental result proves that image registration will bring transformation in solving critical problems in medical industry, satellite researches. RANSAC & SIFT method will be more successful in solving these problems in future.

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