Rotation Estimation Between Two Images Using Feature Analysis

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Summary
Image matching, Analysis, and registration required two images of the same aligned scene. Scaling, rotation, and translation are the most artifacts which a companied with them, so the image transformation estimation is the most effective step in image matching. A proposed algorithm has been done to estimate the rotation between images of the same scene. Features or segments play an important part in evaluating the appropriate degree of rotation and do not need for control points or image regression for finding transformation. These features have different aspect in different images and influence on the image matching. A computer simulation was applied on images for angles of (1o-90o). Different types of images may affects the goodness of rotation estimation. Satellite images of planet differs from others in their contrast and resolutions. Two different images have been tested for the rotation process.

Key words:
reference point, feature, center feature.

1. Introduction

Image matching and image registration play a significant role in computer vision and image sensing. Transformation estimation is an important step in image matching [1].Image matching can be split in two types; global feature based algorithms and local features based algorithms. Global features based on the color or texture analysis in image as a whole, may affected by: occlusion, background clutter, and other content changes. These artifacts may introduce by arbitrary imaging condition [2]. Local features based algorithms are more stable than global features algorithms [3]. Local features represent local image structure formed by pixel content high intensity variation. These pixels called interested points, and these points carry more information due to signal change that represent the content of image [2].

There are many proposed and explored features, including line segment, grouping of edges, and regions through many other proposals. A subset of the features must be found in two image in order to adapt transformation between them [4, 5].

Principle component of many views for a single object have been utilized by Murase and Nayar (1995) to visualize multidimensional caused by rotation and illumination condition [6]. Schmid and Mohr (1997) are used Harris detector to extract points which is invariant to image rotation [7].

Another type of researcher used image contours or region boundaries for extracting features start by Nelson and Selinger (1998) followed by Pop and Lowe (2000) which used feature based on hierarchical grouping of image contour [8].

The research article is organized as follows; in section 2: the methodology and steps of proposed method which represent the main area of this work. Section 3: the test results and discussions are given, section 4: the comparisons with previous studies, and section 5: the conclusion of the work is given.

2. Methodology

A simple region with homogenous properties (like texture, color, and intensity) is associated with a segment process. The meaning of detection is to assign each pixel to its segment and this process make it easy to distinguish between different part of an image. These process match an array of pixels of homogenous groups and give a label to each pixel. The label also named as classes, which each class have its pixel according to segment process [9-11].

Segmentation based on edge detection which depend on grey histogram and gradient based method. Threshold method is related by defining a selective value. Region based segmentation method is applied to partition image to regions which have similar properties (ex. color, intensity, or object)[12, 13].

Matching between two images of the same scene has been established. The goal of our research is estimate the degree of rotation without need for finding sift-points or image registration. A modified algorithm is utilizing which is more stable against some degree of distortion. Image of planet is applying with image of cameraman for test the algorithm. A preprocessing steps was done on both images for visualize the contrast and best segment features. A filter on the selected features has also been used for remove unstable ones. The method was tested for the range of angles (1o-90o).

First, a reference point is determined in both images. To accomplish this, a preprocessing steps must be done to

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select this point. At first, the range of grey value have been elongate through applying (standardization transform or Z-score) equation. The equation of (Z-score) is given by [14]:

$$\bar{x} = \frac{x-\mu}{\sigma} \quad (1)$$

Where μ represent the mean and σ is standard deviation.

A segmentation is based on histogram was used to find the segment features. These features are bounded to be with the range minmum and maximum in order to avoid the extrem dynamic range of brightness which is most probably caused by brightness distortion. This is done by determining a suitable threshold values of $[Min', Max']$ are assessed using the following criteria [15]:

$$\frac{1}{MN}\sum_{I=\max'}^{\max} Hist(I) \geq c \quad (2)$$

$$\frac{1}{MN}\sum_{I=\min'}^{\min} Hist(I) \geq c \quad (3)$$

Where Max' is the minmum brightest possible value, given in equation (2) and Min' is the maximum dimmest possible value, given in equation (3). *c* is a threshold value, *MN* is the size of image.

The value of *c* is a threshold value adopted to define the ratio of brightness levels should included. The levels values that are lays between ($Max - Max'$) are accepted to define a segment features and this also for the ($Min - Min'$).

Median filter is utilzed to remove the small region (island and gaps) which caused unwanted features.

The largest feature should be selected so as to pick its center (the reference point). The rest features will be eleminate. Seed filling algorthim has been used to distinguish different features. A four neighbour of each pixel is depend for the seed filling as in figure (1) [16].

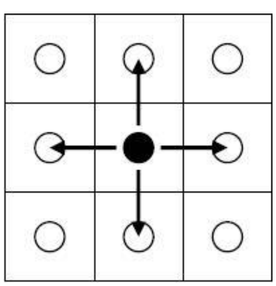


Fig. 1 Seed Filling tech [16].

Features near the edge of image has been filtered and in the same way for others near center. Edge features is subject to distoration. Other features such as lined features also be rejected. Lined features may represent a slots, river path, and some times crack in land which is subject to various conditions through time of the years. On the other hand, circle or semi-circle features are more consistent so that need to be established. A morphological operation is applied in this stage. To detect objects that have circle shape or semi-circle, a threshold is used to check their shapes depends on the area of that features by definning as:

$$R_{\min} < length < R_{\max} \quad (4)$$

$$R_{\min} < width < R_{\max} \quad (5)$$

Where $R_{\min}$, and $R_{\max}$ are:

$$R_{\min} = R * \frac{2}{3} \quad (6)$$

$$R_{\max} = R * \frac{3}{2} \quad (7)$$

Where *R* is the radius of each feature.

The largest feature was selected to accomplish the procedure. Some of the enhancement is done on the selected feature by checking their boundary according to the following equation:

$$V_{\min} = \mu - \alpha * std \quad (8)$$

$$V_{\max} = \mu - \alpha * std \quad (9)$$

Where μ is the mean of gray level values, *std* is the standard deviation, and α is a constant (a value of 0.9 was used in this work).

Finally, the reference point is choosing according to the center of selected feature. This point is founded by applying the following equation [15]:

For the (*x-axis*) is:

$$x_i = \frac{1}{N}\sum_{k=1}^{N} x_k \quad (10)$$

For the (*y-axis*) is:

$$y_i = \frac{1}{N}\sum_{k=1}^{N} y_k \quad (11)$$

Where *N* is the size of column in the (*x-axis*) and the size of row in the (*y-axis*).

The degree of estimate rotation has been computed by determine their raw and column of the selected points as in equation [17]:

$$\theta = \tan^{-1}(\frac{y}{x}) \quad (12)$$

The error percentage was evaluated for estimation of rotation using the following equation [18]:

$$Percentage\ Error = \frac{OV - EV}{OV} * 100\% \quad (13)$$

Where *OV* is original value, and *EV* evaluated value.

3. Result and Discussion

The results of apply estimate rotation was done on two of images. First image of cameraman was used in figure (2). A computer simulation was executed on that image for range of angles (1o-90o). The result of the estimate rotation is shown in figure (3) with percentage error in figure (4).

Fig. 2 image of cameraman.

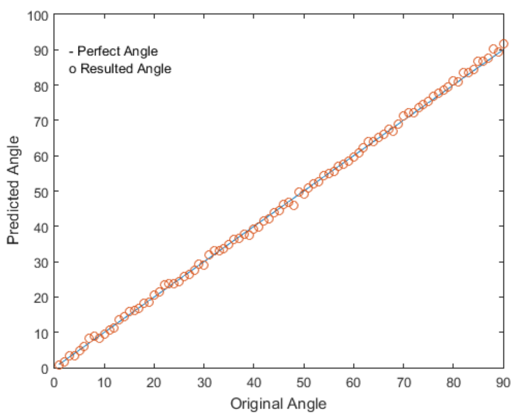


Fig. 3 The estimation of angle as compare to the original value.

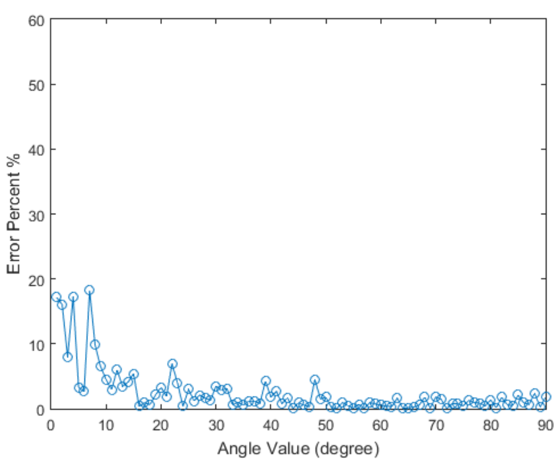


Fig. 4 The percentage error.

The second one was image of Mars near its equator showed in figure (5). The image was taken on 22 November 2016 and is one of the first acquired by the Colour and Stereo Surface Imaging System (CaSSIS) onboard the ExoMars Trace Gas Orbiter. A smaller, 1.4 km-diameter crater is seen in the rim along the left hand side of the image. The image scale is 7.2 m/pixel. The estimation of angle is show in figure (6) with its percentage error in figure (7).

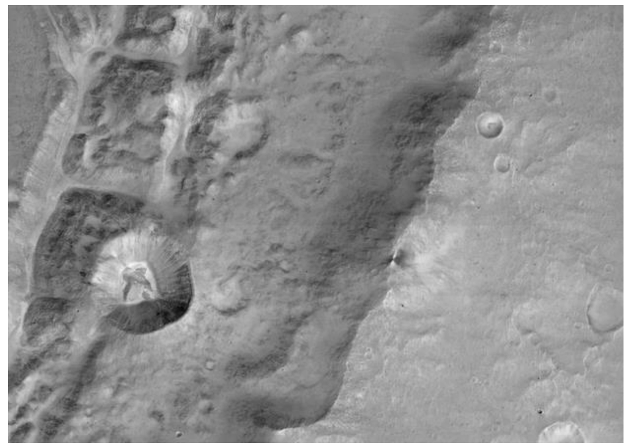


Fig. 5 Mars image taken by ExoMars Trace Gas Orbiter.

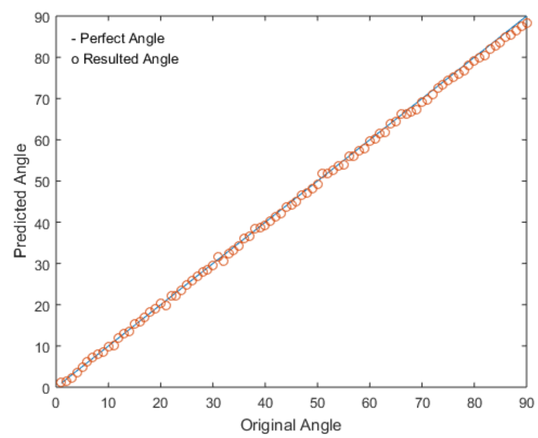


Fig. 6 The estimation of angle as compare to the original value.

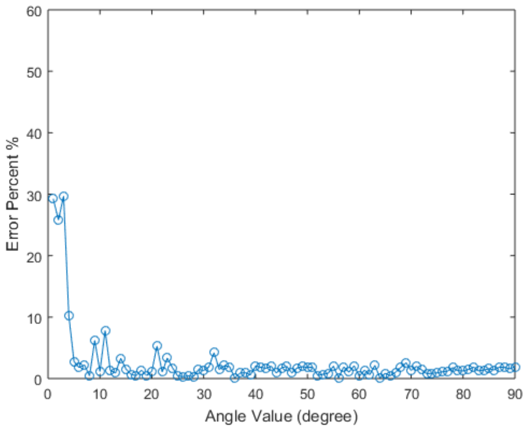
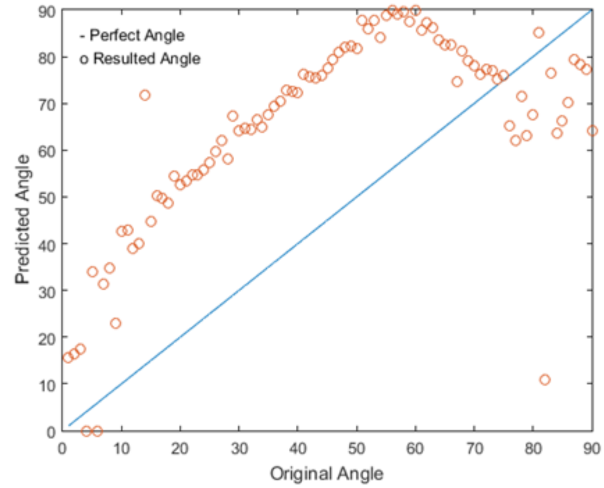


Fig. 7 The error percentage.

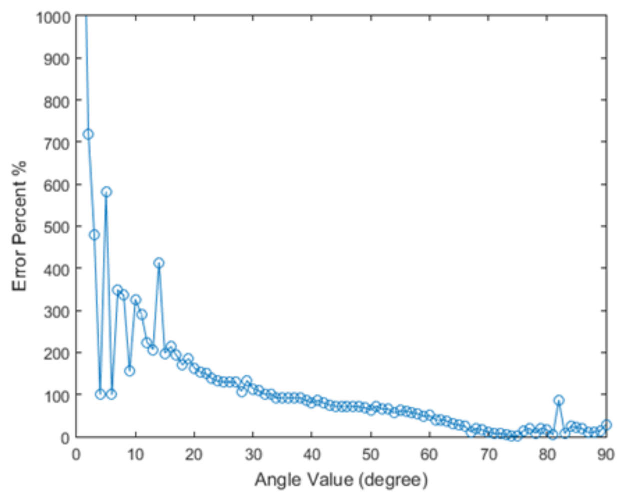
The work was done using Matlab language. The result of applied the estimate rotation were shows small variation in the evaluation as showed in figure (3) and figure (6). The small variation in the results refer to the little variation in the position of reference point in each evaluation that affect on results this is due to nature of two images. Also the enhanced feature after selectin may affected because of the boundary intensity variation with the rotation. The enhanced feature was done with the use of equation (7) and equation (8). The result of cameraman image shown a better result than the Mars image because of their texture aspect and it resolution. Figure (4) and figure (7) shows percentage error of two images. The percentage error represents the relation between the original data and the computed one. The difference in estimation of angle of two images are more pronounce in percentage error. This algorithm is check their strength in both images when there is some degree of distortion. First, when there is a Gaussian blur distortion which convolve with the original image for sigma in the range (0.5-5). Second, a Gaussian additive noise (0) mean and (0.001) variance associated with blur.

4. Comparisons with Previews Studies

Many methods have been developed for the estimate rotation. These methods were used a spatial domain and others depend on the frequency domain. The proposed method for this paper is state on the spatial domain. As compared with other methods are shown below.
First, a symmetry measure is checked for both images for the same range of angles used before. Figure (8) and figure (9) shows estimation results for images of cameraman and Mars near its equator respectively [19].

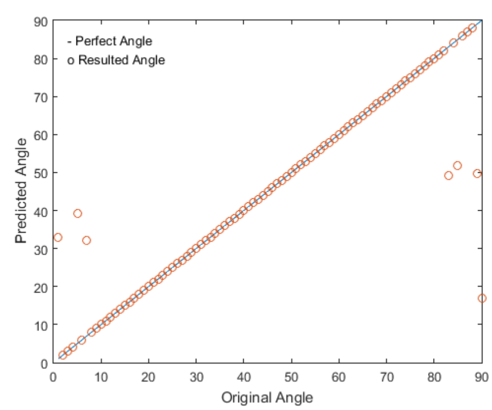


(a)

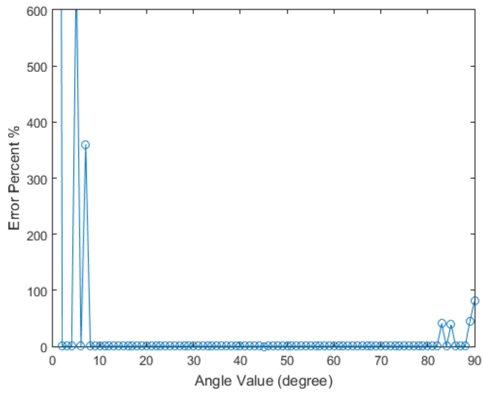


(b)

Fig. 8 Image of cameraman results using symmetry measure where: (a) estimate rotation plot (b) error percentage.



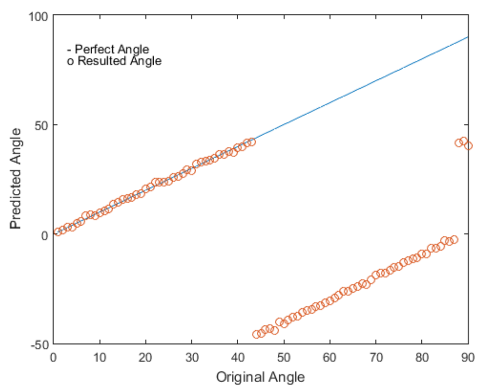
(a)



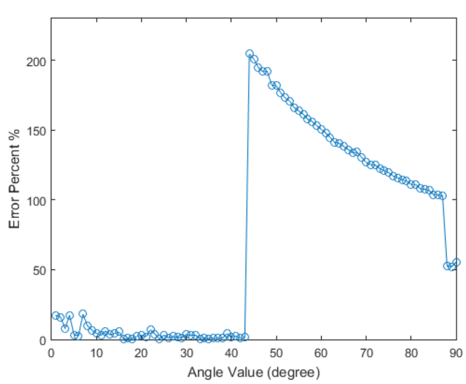
(b)

Fig. 9 Image of Mars planet image results using symmetry measure where: (a) estimate rotation plot (b) error percentage.

Second, a Principal Component Analysis (PCA) is checked for both images for the same range of angles used before. Figure (10) and figure (11) shows estimation results for images of cameraman and Mars near its equator respectively [20].

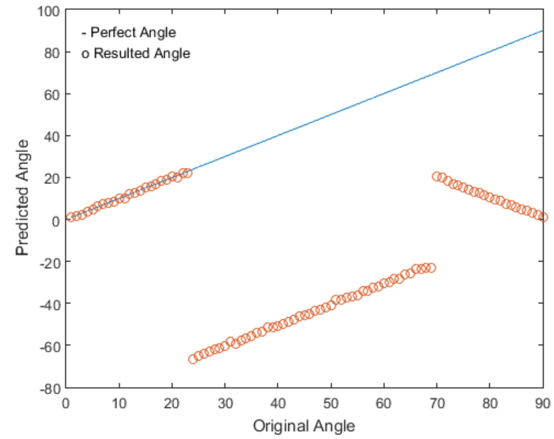


(a)

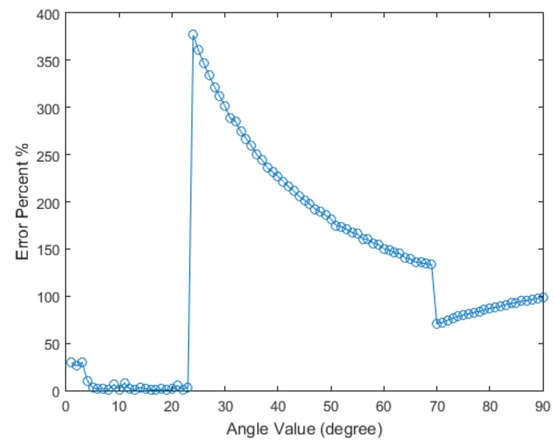


(b)

Fig. 10 Cameraman results using pca where: (a) estimate rotation plot (b) error percentage.



(a)



(b)

Fig. 11 Mars planet image results using pca where: (a) estimate rotation plot (b) error percentage.

5. Conclusion

The work on estimation of angle may help in alleviate the problem of rotation of two images of the same scene. Choose two images of different aspect may reveal the robustness of the proposed algorithm for estimate the degree of rotation. One of the most problem of image matching and analysis was the rotation between images. The proposed algorithm is more stable in estimate rotation as compared to other algorithms. The results of two images may clearly indicate the different affects depends on its resolution with the texture aspect.

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