Implementation of Efficient Real Time Image Matching Algorithm for Computer Vision

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***Abstract*— Image matching is of great importance in many real world applications. Although many traditional methods exist for image matching but those have several problems such as high computational cost problem and problem of scale invariance. For correct image matching and extracting appropriate point pairs have great significance to establish the relationship for among the images to be compared, which is proposed in this work. It determines the common areas of two images and divides them into blocks uniformly. The corresponding blocks of the two images are marked with the same sequence number to establish the one-to-one regional matching relation. Then, for each block, k-means based nearest neighbor approach is adopted to detect more relevant point pairs. Finally the regional matching strategy is performed to match the acquired points. The proposed method can extract control point pairs with high precision, and these point pairs conduct to improve the precision of image matching. The problems are analyzed in case of remotely sensed real time image matching. The rigorous experimentation is performed in MATLAB with 2D images, satellite images and several noise affected images. The experimental result shows that the proposed algorithm can effectively match the two images affected with noises.**

***Index Terms*— Block matching, Cross Correlation, Image Match, Noise Robust, Regional Similarity, Real Time Applications.**

I. Introduction

The goal of image matching is to decide whether a given image has been registered in the database or not. The query image may be affected with the noise, logo, scale changes etc. This work will mainly focus on how to extract exact point pairs tending to be unaffected. There are various methods for matching and retrievals. All these methods have tried to achieve greater matching rate but facing computational complexity and other problems related to invariance of scale.

Background

Previously many powerful techniques have been proposed for effective image matching using nearest neighbors patch-match based approach [1, 2] and real time content based image matching [3] etc. But the main point here is to extract the correct point pairs using precise method. Hence the main focus of the paper is combination of two approaches. The first approach is about the regional matching and second one is of finding the appropriate point pairs using nearest neighbor scheme. The point pairs are the resultant outputs which are going to provide the closest matching between the input image and the reference image. The results are definite and are able to reduce misjudgment rate. The paper describes about the existing methodologies and their drawbacks. This approach is advantageous because it is capable to provide more accurate matching results irrespective of scale changes and also proven to be more robust to all types of noises and computationally effective since it is using the hybridization of two approaches.

II. Literature Survey

The theories for image matching process are studied by many scholars and researchers previously. Many of the most powerful of these methods are patch-based. Connelly Barnes et.al presented a randomized algorithm for quickly finding approximate nearest neighbor matches between image patches [1]. This algorithm offered substantial performance improvements over the previous state of the art algorithms. The key insight driving this algorithm is that, the elements of search domain patches of image pixels are correlated and thus the search strategy takes advantage of these statistics. However, because these algorithms must search and manipulate millions of patches, performance in many cases had previously been far from interactive. It accelerates many patch-based methods by at least an order of magnitude. Patch-based sampling methods have become a popular tool for image and video synthesis and analysis. This method is not robust to JPEG artifacts, but uses our more general matching algorithm, so it could potentially be generalized to find different types of forgeries. On the other hand similar technical perspective for a perfect match has been presented by William Freeman [2]. There are problems the vision and image processing community has been struggling with for many years. Many different analytic approaches have been tried, but seldom capture the richness and subtle details needed to produce realistic images. Looking for a matching patch at random positions in the database region eventually finds good matches. This "patch match" algorithm combines these approaches with

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deterministic update of a previous solution while allowing improvements from random guesses to give a fast, approximate nearest neighbor algorithm for image patches that avoids getting stuck in bad solutions. However Yong Luo, et. al. proposed a fast image matching method. ORB is introduced in this method. ORB is among the recently developed fast image descriptor which is shown to have very low computational cost with satisfactory accuracy [3]. Proposed a strategy for matching decision, recommending auto-tune for projection, and investigate the influence of environmental factors. ORB is proven here to be more appropriate than Scale Invariant Feature Transform (SIFT) and SURF (Speed up robust Feature) for fast image matching in the case of the query image is contaminated. Here it is stated that histogram intersection is more appropriate than cosine similarity for fast image matching and the method of matching proven to be effective but does not achieves satisfactory robustness.

Shiliang Zhang et.al., presented another method for visual matching [4, 5]. Because matching duplicate visual contents among images serves as the basis of many vision tasks. Different local descriptors for image matching, e.g., floating point descriptors like SIFT, SURF, and binary descriptors like Oriented fast and rotated brief (ORB) and BRIEF. These descriptors either suffer from relatively expensive computation or limited robustness due to the compact binary representation [6]. This method allows more flexible matching and is more robust to quantization error. Comparison of matching Precision, Recall and Efficiency are discussed in Table 1. It discusses stepwise and oriented Multi-order visual phrase as well as bag-of-words model among which the most famous descriptor is Scale-invariant feature transform.

Methods	**SIFT**	**BOWS**	**SMVP**	**ORB**	**OMVP**
Precision	0.793	0.761	0.892	0.786	0.906
Recall	100	0649	0.614	100	0.847
Time (ms)	1121	413	436	75	113

Table 1. COMPARISON OF MATCHING PRECISION, RECALL AND EFFICIENCY FOR DIFFERENT DESCRIPTORS

III. PROPOSED METHODOLOGY

This work gives an efficient and improved approach for image matching using regional matching scheme. One of the key of this method is that it will extract appropriate point pairs having great significance to establish the relationship of two images. SIFT algorithm is difficult to confirm relevant parameters; it can extract only a few feature points which are distributed unevenly. So here the nearest neighbor match approach is used. Thus it can extract a large number of point pairs necessary for the matching process. Proposed approach tries to hybrid them to find a solution to extract control point pairs among the images with improved matching rate. Figure 1 explains flowchart of proposed methodology.

Procedure of proposed workflow

In order to extract reasonable distribution and high precision point pairs between the reference and input images, the extracting procedure of control point pairs is shown in Figure 1, and the processing steps are as follows:

A) Common region Checking

The scale space of two images may be different, and generally no point pairs exist if two images have no common regional scope. If two images have common regions, then the second step goes on. The two images are checked for whether the common areas exist between the reference and input image. If there are common areas existing, then divide them into blocks.

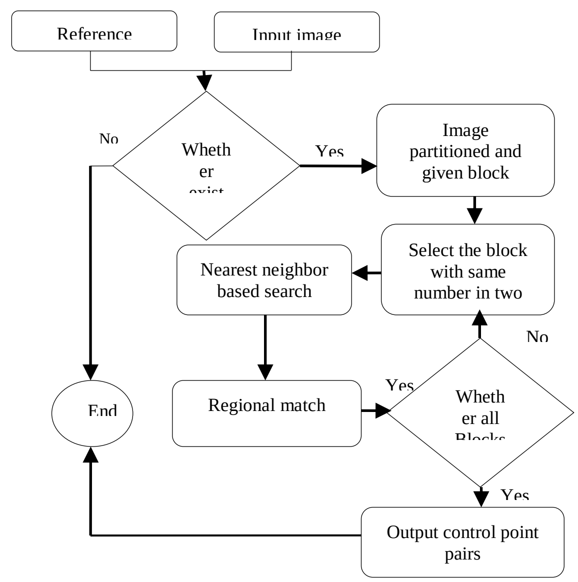

Fig. 1: Workflow of proposed method

B) Block partition

Common region between two images are divided into blocks uniformly, and the corresponding blocks which have the same scale range are given the same sequence number. Assuming that the number of block is p*q, the image with the size P*Q will get （P/p）*（Q/q） blocks. For each block, a unique sequence number is assigned and make sure that the blocks which have similar scale range get the same number. So that, i-th block in the reference and input image are referred to as Ai and Bi respectively. Block division is beneficial to the following regional matching and can reduce the computation cost to some extent.

C) Feature detecting and description

In order to extract much more features with scale and rotation invariability, two blocks which have the same sequence number are selected to building their multi-scale space, and then features are detected in each block by using method of kd-tree. The nearest neighbor match is performed. To improve this, it is common to use some well defined tree structures. The multiple randomized kd-trees [3] are effective to find nearest neighbors in regions and it certainly enhance independent search and truly will outperform in the presented method.

The standard k-means trees are built by recursively checking the regions for data points. And the data points split into k distinct regions at each level using k-means clustering or grouping scheme.

D) Matching strategy

Features of corresponding block in two images are matched according to the regional matching strategy. For each block, the ratio of the nearest neighbor and second-closest neighbor is computed based on k-means tree points. If the ratio is less than a threshold, the corresponding point pair will be selected as the reasonable point pair predictable to get matched. The proposed matching decision strategy is appropriate and effective as per the final decision is considered.

Compared with the latest fast image matching algorithms based on geometry features, AD-FIMA reaches faster approximately 1.75 times as compared to other algorithms. It can be understood very well from the following figure 2, how robustness is achieved against noise as compared to other algorithms, such as EC Arc matching, Graphical block matching algorithm.

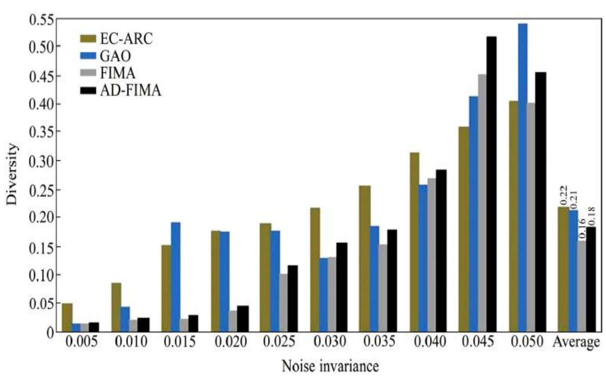

Fig.2 Noise invariance

IV. DESIGN AND IMPLEMENTATION

SIFT (scale invariant feature transform):

Feature points are represented from the left image i.e. base image as a set of M points
$B = \{b1, b2, b3, \ldots, bM\}$.
Match these features from the left image with the features of the right image. Let the number of features detected in the right image be N, introduced as categories:
$C = \{c1, c2, c3, \ldots, cN\}$.
match bi with cj .
Suppose p neighbors of bi are selected and represented by set Bip, where
$Bip \in B$
$Bip = \{bi1, bi2, bi3, \ldots, bip\}$.
Let a category set $Cn \in C$ be the interest points selected from the right image for finding a match for bi
$Cn = \{c1, c2, c3, \ldots, cn\}$.
The Euclidian distance between the descriptors of bi and cj is computed:
$\varepsilon i(c) = \{\varepsilon i(c1), \varepsilon i(c2), \varepsilon i(c3), \ldots, \varepsilon i(cn)\}$.
The respective point pairs will be processed further with next method.

K-means nearest neighbor approach

The standard k-means trees are built by recursively checking the data points. And the data points split into k distinct regions at each level using k-means clustering or grouping scheme. This stage will provide nearest neighbor point pairs which are ready to be processed further.

SMR (Stepwise Multiple Regression)

Multiple regression analysis is the most powerful tool that is widely used in statistical techniques.

Match Support Measure Parameter

This can be called as final matching model. After feature computation for the key-point, the next step is to match these key-points. The method can be understood very well with the following flowchart Figure 3.

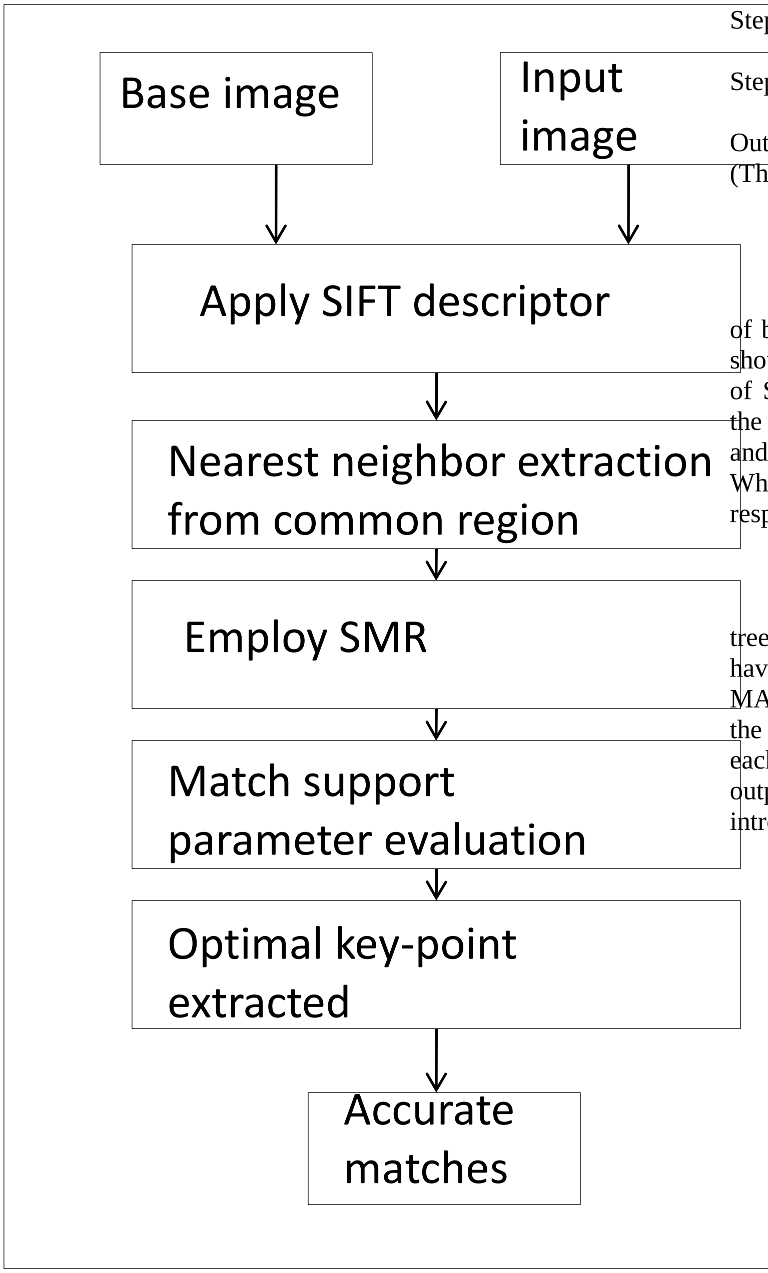

Fig. 3 Flowchart of proposed method

The algorithm can be stated in the form of above flowchart diagram. The method is applied on the two images to be matched, as explained above in detail.

Algorithm: Real-time image matching

Input : 1. Base image I_B.

2. Input image I_N (blur or noise affected)

Step I : For each image (I_B and I_N) find out matching points using SIFT descriptor and also use k-d tree approach to find the closest neighbor points.

Step II : [Pruning Step] Check the above matching point pairs with Stepwise Multiple Regression.

Step III : Calculate match support measure for candidate matches.

Output : Final optimum number of matching points. (Threshold value= 10)

V. IMPLEMENTATIONS

For implementation a GUI is developed. The GUI consists of base image, input image, three approaches where first plot shows initial matching points which shows the combined result of SIFT descriptor with nearest neighbor, second plot shows the SMR matching points, which shows the result of iteration and lastly optimum matching points shown on the last plot. When a button named perform matching is clicked the respective output is generated.

VI. RESULT ANALYSIS

Among all the techniques the methods namely SIFT, k-d tree approach, SMR and match support measurement scheme have been used. For implementation of these techniques MATLAB is used as a simulator which has ability to generate the proper results in critical condition. The performance of each technique depends on amount of time required to generate output, how does it deals with the various noise and distortions introduced. Images are considered as follows:

1. No noise : This will take the input image as it is without any kind of distortions and compare it with the base image.
2. Gaussian noise : (0-10 variance factor):Adds Gaussian white noise with constant mean and variance to the input image. When unspecified, Mean and Variance are at default values 0 and 0.01 respectively. In this implementation the value of variance in range of 0 to10 is considered.
3. Histogram : Enhances the contrast of images by transforming the values in an intensity image, or the values in the color-map of an indexed image, so that the histogram of the output image approximately matches a specified histogram.
4. Rotation : ($0\text{-}360^0$):Rotates input image by angle in degrees in a counterclockwise direction around its center point. To rotate the image clockwise, specify a negative value for angle. In MATLAB this feature uses nearest neighbor interpolation, setting the values of pixels in base image that are outside the rotated image to zero.
5. Poisson's noise : Generates Poisson noise from the data instead of adding artificial noise to the data. If image is double precision, then input pixel values are interpreted as means of Poisson distributions scaled up by 1e12 in MATLAB. For example, if an input pixel has the value 5.5e-12, then the corresponding output pixel will be generated from a Poisson

distribution with mean of 5.5 and then scaled back down by 1e12. If Image is single precision, the scale factor used is 1e6. If Image is unit 8 or unit 16, then input pixel values are used directly without scaling. For example, if a pixel in a unit 8 input has the value 10, then the corresponding output pixel will be generated from a Poisson distribution with mean 10.

6. Salt & Pepper : Adds "salt and pepper" noise to the input image, where noise density is also considered. This affects approximately Density*number of (Input image) pixels. The default for Density factor is 0.05.
7. Speckle: Adds multiplicative noise to the input image using uniformly distributed random noise with mean 0 and variance V. The default value for V is 0.04.

The two images are taken and converted to gray scale because gray scale images produce good results in terms of time and computations. The base image matching points are marked in red color while that of input image are marked with green color. The threshold value is considered as 10, it means if the final number of matching points are equal to or above 10, the images can said to be matched or similar in some context. The various example images are processed and results are as follows.

Figure 4 depicts the results of original base image and effect of salt & pepper introduced within the input image. The result proves that the two images are similar. Thus proposed method is robust to noise factor like salt & pepper.

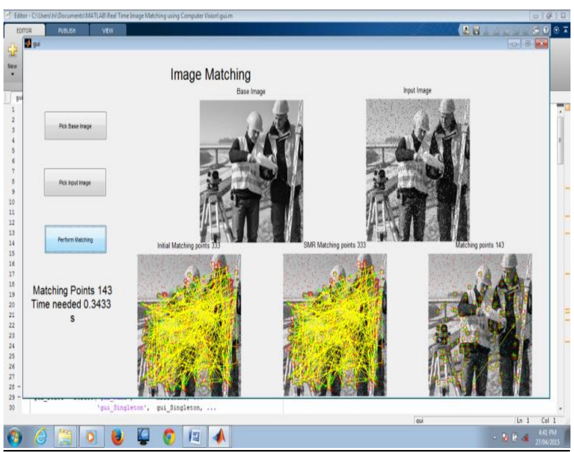

Fig. 4 Result with salt & pepper noise

VII. CONCLUSION

The regional match strategy is used not only to reduce the computation of feature point matching, but also makes the control point pair distribution reasonable and more exact. Much improved matching results can be obtained with this approach resulting into the increased matching rate. This method is also beneficial to improve the accuracy of remote sensing image registration. However, method can be extended to different search domains such as 3D geometry, videos and for other new applications. From the results of example images recorded above, it is observed that, time required for generating output is minimum. It is most effective technique to compare the two images which are under the influence of noise, rotation and other geometric distortion. The matching results are good with various images like remote image, face image and some other 2D images. The time required for processing and generating output is affordable and this is the key requirement achieved with the proposed methodology.

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