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An Advanced Technique of Image Matching Using SIFT and SURF

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Abstract: Image matching is a method of identifying an image from the already stored images in the database. Feature detection and feature matching are two important stages of the image matching process. This paper explains the improved method of image matching to enhance the performance of two well known images matching methods SIFT and SURF by considering the color information present in the images and provides an algorithm for reducing the matching time. The behaviour of feature detection algorithms is compared by taking one image of different conditions like illumination, scale, rotate, etc. The performance is evaluated and compare the results of SURF with SIFT by using a dataset of five images. SURF algorithm is better than the SIFT algorithm in terms of speed and will give better matching.

Keywords: SIFT, SURF, Feature detection, Image Matching.

I. INTRODUCTION

Image matching basically consist of following steps features detection, feature description and then matching the features. Feature detection means key points are extracted from distinctive locations from the images such as edges, blobs, corner, etc. or is a process to find out some special points which are also known as key points and these key points are our features which vary from problem to problem. The definition of feature depends on the application where it is used. Nowadays images are much used on the internet for various purposes and it becomes a source of information passing over the network. Various algorithms are used for the matching purpose and it all depends on the quality of feature detector. The feature detector should have repeatability property for detecting the same features of different types of images. Feature detection is very expensive in respect of time when there is a limit of time constraints, for searching particular parts of an image to detect feature to we can use other higher level algorithms.

Feature description means neighbouring regions are picked around key points and distinctive feature descriptors are computed from each region. For image matching, extracted features from feature detection step can provide reliable matching of two different images. The descriptor found by above step has to be robust, distinctive and, free from various types of errors. Lastly, the feature descriptors of different images are matched. On Euclidean distance, matching of feature descriptor is based on that. In order to analyze the performance and efficiency of algorithms used in matching of images can be easily found by obtaining how many images are best matched from the images that are stored in the database.

In 2004 Lowe [1] gave a method of extracting distinctive invariant features from images and can be used in various applications. The extracted features are invariant to image rotation and scale. Then in 2006,

Bay and Tuytelaars [2] found speeded up robust features and used integral images for image convolutions and Fast-Hessian detector, and found that it is somewhat faster and performed well. Nagar, Atulya, Ankur Saxena [3] had worked on color information of images by SIFT and includes different color information for finding results. Some researchers gave a comparison of these algorithms [4] to find the matching time of images to evaluate the performance and also increase the stability and reliability of the detectors [5]. There are many applications like image registration, object recognition, tracking, image stitching, 3-D reconstruction, camera calibration, object classification, recognition, computer vision, augmented reality etc. where image matching is considered.

II. PROPOSED METHODOLOGY

An image consists of various information's like colors, textures, features, etc. If we work on gray channel only, an image is having a large amount of color variation as compare to gray variation and after that if we compare images then it limits the performance of matching. So what we had done, we take various channels Red, Green, Blue with addition of gray or Luma channel. But by doing this we had some problem that the features found by this procedure was four times and also increases the matching time. So we provide an algorithm whose work is to minimize the number of cabinets and to increase the matching speed. Figure 1 shows the block diagram for the proposed system. First, we alter the image into different color bands from the reference folder, then we determine the features by applying SIFT (scale invariant feature transform) and SURF (speed up robust features) on

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each image. For reducing the number of key points and to extract best key points, we apply pooling algorithm. Now found key points are saved in database then these key points are used for matching with query images.

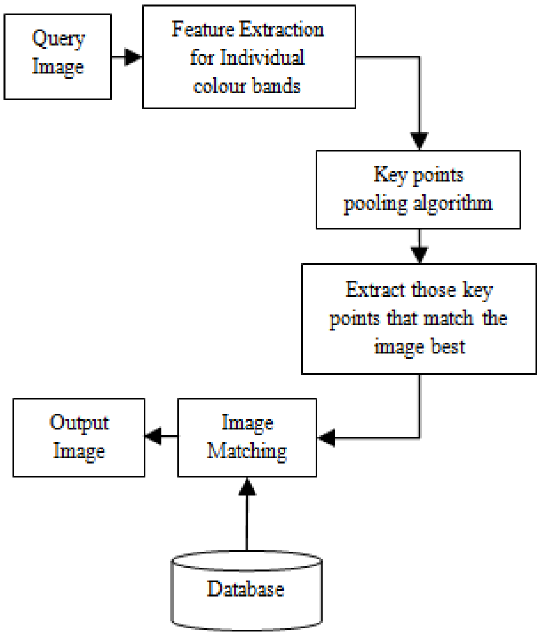

Figure 1: Block diagram for proposed system.

Proposed SIFT and SURF algorithms are explained as follows:

SIFT
D. Lowe in 2004 [1] gave the concept of Scale Invariant Feature Transform (SIFT). Basically, it is used for various purposes like face, object, fingerprint detection, logo matching [6] and specially for the image matching.
SIFT consist of various steps of finding key points and descriptors.

- Scale Space Extrema Detection
- Key point Localization
- Assigning an orientation to the found key points
- Generate SIFT descriptor

First, we generate the scale space of images using the Gaussian blur operator. Then determine the Difference of Gaussian for detecting the stable key points. The main thing is finding here is the location and the scale of the image by using the scale space and DoG which is LoG approximation which is the difference of two consecutive images of scale separated by k constant.

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y),$$
$$D(x, y, \sigma) = (G(x, y, k\sigma) - G(x, y, \sigma) \times I(x, y)$$

Where, G is the Gaussian function and I is the image.
After finding the DoG of scaled image, find the max and minima from DoG. For that compare the Neigh- boring pixels of 3 scale image and found number of key points here.

In the next step of key point localization, to increase the efficiency of algorithm some key points are not used for the forward processes so disposing all the points which are not useful for the matching. From the above step we have scale invariance, but in this orientation assignment step we also get the property of rotation invariance, so here assigns the orientation to each key points and histograms are generated for that.

In descriptor generation stage here basically we create the fingerprints of key points which is very important for matching. The creation of windows of 16 4x4, we calculate the gradient orientation and magnitude for each point in histogram of 8 bins. Finally, find a 128 values key point descriptor. Interest points obtained by SIFT are robust to scale, rotation etc.

Algorithm-SIFT
1. Separate image I to color bands (Ired, Igreen, Iblue, Igray).
2. Find Feature and key points.
   [DES{1}, KEY{1}] = sift(Igr);
   [DES{2}, KEY{2}] = sift(Ir);
   [DES{3}, KEY{3}] = sift(Ig);
   [DES{4}, KEY{4}] = sift(Ib);
3. Starting of pool

a. Add all gray features.
Ftr= DES{1};
Pts= KEY{1};
b. Finding key points of red (not present in the pool) and adding them to the pool
Fred = DES{2};
Kred = KEY{2};
(i) Match Ftr and Fred to find the index
(ii) If index> Fred
Then index size = Fred size
(iii) for i = 1:size(index,1)
If sum(index(:,2)==i) is less than 1 for i

(Boost feature size and point size by 1 and add that feature and points of i).

c. Finding key points of green (not present in the pool) and adding them to the pool
Fgreen = DES{3};
Kgreen = KEY{3};
(i) Match Ftr and Fgreen to find the index
(ii) If index > Fgreen
Then index size = Fgreen size
(iii) for i = 1:size(index,1)

If sum(index(:,2)==i) is less than 1 for i
(Boost feature size and point size by 1 and add that feature and points of i).

d. Finding key points of blue (not present in the pool) and adding them to the pool
Fblue = DES{4};
Kblue = KEY{4};
(i) Match Ftr and Fblue to find the index
(ii) If index > Fblue

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(iii) Then index size = Fblue size for i = 1:size(index,1)
If sum(index(:,2)==i) is less than 1 for i
(Boost feature size and points size by 1 and add that feature and points of i).

4. Now, total (Ftr) features and (Pts) points found in the pool will be used for matching.

SURF

Herbert Bay SURF [2] gave a concept of Speed Up Robust Feature. It can also be used for various purposes like face, object, fingerprint detection, logo matching [6] and specially for the image matching.
SURF consists of various steps of finding key points and descriptors.

- Key point Detection.
- Key point Description.

In key point detection, integral image is used for speeding up the process of key point detection, which uses a box filter for computation. Because of using the integral image size of the filters doesn't matter, any size can be applied to the same speed. For the detection of key point's Hessian matrix are used. And for the rotation invariance it calculates the haar wavelet responses in the direction of x and y.

In image I, x = (x, y) is the given point, the Hessian matrix H(x, σ) in x at scale σ, it can be characterized as:

$$H(x,\sigma) = \begin{bmatrix} L_{xx}(x,\sigma) & L_{xy}(x,\sigma) \\ L_{yx}(x,\sigma) & L_{yy}(x,\sigma) \end{bmatrix} \qquad (2)$$

Where Lxx (x, σ) is the convolution result of the second order derivative of Gaussian filter $\frac{\partial^2}{\partial x^2} g(\sigma)$ with the image I in point x, and similarly for Lxy (x,σ) and Lyy (x,σ).

Algorithm-SURF

1) Separate image I to color bands (Ired, Igreen, Iblue, Igray).
2) Extract key points and features of each band with function detectSURF and extract features.
3) Starting of pool

a. Add all the gray features into the pool
Pts = Kgray;
Ftr = Fgray;
a. Finding key points of red (not present in pool) and adding them to pool.
(i) Match Ftr and Fred to find the index
(ii) If index > Fred
Then index size = Fred size
(iii) for i = 1:size(index,1)

If sum(index(:,2)==i) is less than 1 for i
(Boost feature size and points size by 1 and add that feature and points of i).

b. Finding key points of green (not present in the pool) and adding them to the pool.
(i) Match Ftr and Fgreen to find the index
(ii) If index > Fgreen
Then index size = Fgreen size
(iii) for i = 1:size(index,1)

If sum(index(:,2)==i) is less than 1 for i
(Boost feature size and points size by 1 and add that feature and points of i).

c. Finding key points of blue (not present in the pool) and adding them to the pool.
(i) Match Ftr and Fblue to find the index
(ii) If index >Fblue
Then index size = Fblue size
(iii) for i = 1:size(index,1)

If sum(index(:,2)==i) is less than 1 for i
(Boost feature size and points size by 1 and add that feature and points of i).

2. Now, total (Ftr) features and (Pts) points found in the pool will be used for matching.

Where,
I=color Image, **Ired**=Red component
Igreen=Green component, **Iblue**=Blue component, **Igray**=Grey component, **Kred**=Key points from Red Component, **Fred**=Features from Red Component, **Kgreen**=Key points from Green Component, **Fgreen** =Features from Green Component, **Kblue**=Key points from Blue Component, **Fblue**=Features from Blue Component, **Kgray**=Key points from Grey Comp- onent, **Fgray**=Features from Grey Component, **Pts**= Final Key points used after pooling, **Ftr**= Final Features used after pooling.

III. EXPERIMENTAL RESULTS

BEHAVIOUR:
To show the behaviour of two algorithms Sift and Surf for image matching including color information we used one image which includes various deformations like scale changes, rotation changes, blur changes, illumination changes. From the results we found that key points are greatly reduced by applying pooling algorithm so that matching time can be minimized.

Scale Changes

a b Reference image

Fig 2. Scale Change comparison. The last image is the reference image (1500x842) pixel and the other two are query images.

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Scale	a(1000x561pixel)		b(2000x1122 pixel)	
Algorithm	SIFT	SURF	SIFT	SURF
Key points before algo	3089	2051	18178	4443
Key points after algo	1376	779	7370	1650
Matched points (after algo applied)	421	152	582	167
Matching time	0.57	0.02	3.03	0.04

Table 1. Scale Change comparison.

From the table, we find that when scale change get larger SIFT matches number of key points as compared to SURF but takes more time for matching images.

Image rotation

a b Reference image

Fig 3. Rotation comparison. The last image is the reference image and the other two images are rotated by 15 and 45 degrees.

Degree	15 degree		45 degree		90 degree		120degree	
Algorithm	SIFT	SURF	SIFT	SURF	SIFT	SURF	SIFT	SURF
Key points before algo	6884	2007	5359	2118	6340	1915	6724	1903
Key points after algo	3190	874	2567	913	3002	824	3276	835
Matched points (after algo applied)	1791	400	1993	779	1797	292	1888	290
Matching time	1.33	0.02	1.11	0.034	1.44	0.019	1.56	0.01

Table 2. Rotation comparison.

This experiment shows the impact of rotation over images. We had taken same image of having a different rotation and then find the results by matching those rotated images with the reference images. We conclude that as we increase the degree of rotation there will be a wavy output for the matching key points. Matching points increases for 45% as compared to 15% and then decrease to 90% and the again increase to 120%. It means a change in angle makes variations in results of matching.

Illumination changes

a b Reference image

Fig 4. Illumination (I) changes comparison. The last image is the reference image and the other two images are query images where image b (I2) is less illuminated as compare to a (I1).

Illumination	I1 (a)		I2 (b)	
Algorithm	SIFT	SURF	SIFT	SURF
Key points before algo	4966	2021	3556	1053
Key points after algo	2376	856	1589	423
Matched point (after algo applied)	1993	734	804	254
Matching time	1.07	0.02	0.66	0.01

Table 3. Illumination change comparison.

This experiment shows the illumination effect. When the illumination gets lower and lower key points found were also getting less. For this condition sift again shows a good performance over surf, but taking more time to match image as compared to sift.

Image blur

a b Reference image

Fig 5. Blur (B) comparison. The last image is the reference image and the other two images are query images where image b (B2) is more blurred as compared to a (B1).

Blur	B1 (a)		B2 (b)	
Algorithm	SIFT	SURF	SIFT	SURF
Key points before algo	1591	641	649	227
Key points after algo	722	261	235	87
Matched points (after algo applied)	447	154	162	43
Matching time	0.43	0.01	0.13	0.006

Table 4. Blur comparison.

As the blur of the image gets larger the images are not much visible and when we match the image having blur, then sift founds more number of key points than surf and less effective for image having more blur because methods found less key points of matching points.

PERFORMANCE:

To show the potency of the algorithm based on color information in the image, check the performance of image matching on 5 images clicked by Microsoft lumia 535. To evaluate the performance the time, FRR and accuracy are measured in this study. In order to check the proposed method increases the overall accuracy, we calculate the accuracy of both the algorithms, including color information for matching the image with a given dataset of images. We found that the accuracy of SURF is increased from 80% to 100%, but SIFT shows almost the same

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response with the given dataset. Results depend on the images taken.

$$\text{Accuracy} = \frac{\text{Number of correct image matches}}{\text{Total number of images}} \text{ X } 100$$

Algos.	Images	Recognized Image	Unrecognized image	Accuracy	Time	FRR
SIFT	5	4	1	80	2.64	0.2
SURF	5	5	0	100	0.15	0

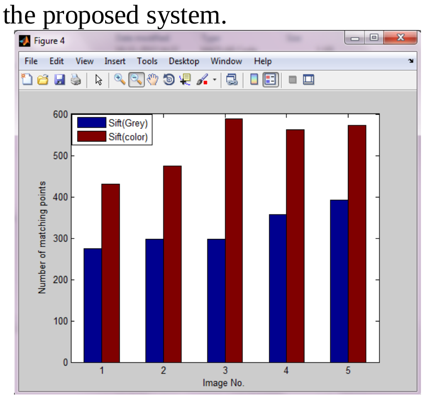
Table 5. Performance analysis of proposed system.

FRR (False Rejection Rate) is also a way of investigating the best method for doing the image matching including color information in any applications. FRR is basically used to find the capability of algorithm failing to identify the correct image. FRR of SURF is good enough as compared to SIFT.

$$\text{FRR} = \frac{\text{Number of unrecognised images}}{\text{Total no of images}}$$

While matching the images, if we are having more numb of matching interest points than it would be easy for us to get a better results as compared to less number of matching points in the image. So with our technique of matching images we also increases the number of matching interest points.

Fig 6. Shows how many interest points are increased by using the proposed method as compared to the existing matching method for both SIFT and SURF algorithms when using different input images. Table 5 shows the output of the proposed system.



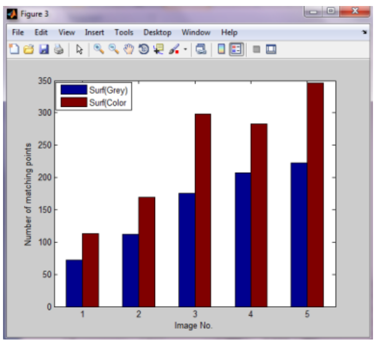


Fig 6. Comparisons of Number of Matching Interest Points using SIFT and SURF algorithms

IV. CONCLUSION AND FUTURE WORK

This paper presents two efficient feature detection methods for image matching. Here we handle the color information very adequately to extract the important features hold from the image. In this paper, we analyze two thing's behaviour and performance of the proposed system as compared to the existing system. Based on the experimental results, it is found that the extracted interest points (from R, G, B, gray channel) are greatly reduced with the help of the proposed algorithm and solve the problem of computation time. SIFT has detected a number of features compared to SURF but it is suffering with speed. To compare the results of implementing algorithms, performance of both the Algorithms are evaluated and find that SURF is fast and has good performance as the same as SIFT with better accuracy as compared to the existing system. Choosing the method mainly depends on the application. Our future scope is to use different channels from other color spaces, such as CMY, CMYK, and LUV etc. We can use some other algorithm which ensures high accuracy to reduce the computation time which increases because of taking different color bands of color spaces.

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