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EFFECTIVENESS OF IMAGE MATCHING ALGORITHMS IN DIGITAL IMAGE PROCESSING

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ABSTRACT

In digital image processing, image matching is one of the major parts used in various health care applications. The usage of correct matching algorithm will modularize the effectiveness in image matching process. The quality of image matching algorithms is based on various measures such as accuracy, processing speed, flexibility to use for various data sets, invariance to rotation, scale and illumination, etc.Mapping these parameters of various algorithms with sample image set is used to find out the effectiveness of image matching algorithm. So, in this article the three cross domain algorithms called as SURF (Speeded Up Robust Feature), SIFT(Scale Invariant Feature Transform) and ORB (Oriented fast and Rotated BRIEF) are taken to suggest the best image matching algorithm based on match time, match rate and other qualities of algorithm.

***Keywords*:** SIFT (Scale Variant Feature Transform), SURF (Speeded Up Robust Feature), ORB (Orientated fast and Rotated BRIEF), Fast Feature Detection, RANSAC (Random Sample Consensus)

INTRODUCTION

Over the last two decades, the compact algorithm for image comparison have been based on its accuracy, speed, scale invariant, rotation invariant, gestures limit and complexity. Many similarity learning algorithms assume that the available training data contains real-valued pair wise similarities or distances. In order to create fast and best algorithms with locally invariant representations, some selection strategy and normalization procedures are required. Image comparison method is broadly categorized into two steps, image matching and feature matching[1].

A unique algorithm has its own way of identifying and governing the data that is to be meaningful. Every algorithm is different from the other one and efficiency criteria differ in each case, even though the aim of the algorithm is the same. The field of computer vision has seen an abundant rise with the development of a wide variety of algorithms and techniques to accomplish many complicated tasks. These tasks include motion analysis, scene reconstruction, image restoration and image matching. Each and every image has identified by its features [2].

This paper, focused on various image matching techniques and algorithms. In account of the comparison, the research suggested the best technique out of all the considered techniques. It may happen that some of these algorithms work better with certain datasets, while others aren't as effective in analyzing the same data sets[3].

The following paragraphsdiscuses about SIFT, SURF and ORB algorithms.

i) SIFT (Scale Variant Feature Transform)

SIFT convertsthe image into a group of local feature vectors. This algorithm is used to find the point's extreme value and cluster their various functional attributes of the scale space. **SIFT** algorithm involves four stages to accomplish image comparison task. Assesses the scale space is the initial stage. The key point restrain achieved by removing the low contrast points is the second stage. The inclination allotment for key point based on image gradient is the third and finally the generation of descriptor based on magnitude of gradient. The images feature point is find and then explained in such a manner that delivers the characteristics of image comparison. The finding of description is very difficult and it takes the calculation time is more are the basic drawbacks of Scale Variant Feature Transform [4].

ii) SURF (Speeded Up Robust Feature)

SURFis actuate by the SIFT. SURF is speeder than SIFT because of it utilizes the integral images in a proper manner. SURF algorithm involves different pairs of images such as objects, Gestures and figures. The SURF algorithm is the best image matching algorithm in terms of higher accuracy. The two stages of SURF algorithm are fast second box filter and first order gradient features.

The computation of operators is very much fast because of using box filters. SURF algorithm extracts the feature of image and the significance of area. The reflection of image information is obtained by preserving key point's efficiently [5].

iii). ORB (Orientated fast and Rotated BRIEF)

ORB is a fusion of the FAST key point detector and BRIEF descriptor with some modifications. Initially to determine the key points, it uses FAST. Then a Harris corner measure is applied to find top N points. FAST does not compute the orientation and is rotation variant. It computes the intensity weighted centroid of the patch with located corner at center. The direction of the vector from this corner point to centroid gives the orientation. Moments are computed to improve the rotation invariance. The descriptor BRIEF poorly per forms if there is an in-plane rotation. In ORB, a rotation matrix is computed using the orientation of patch and then the BRIEF descriptors are steered according to the orientation [6].

This paper discusses about the comparison of these three algorithms.

LITERATURE REVIEW

Gal Chechik et. al. (2010) proposed Machine learning problems in associated with pairs of objects similarities. The core idea behind this paper is similarity is not only in visually but also in semantically in terms of objects. But the problem here is this approach is not opting for large datasets, because typically their CPU and storage requirements grow quadratically with the sample size, and because many methods impose complex positivity constraints on the space of learned similarity functions. This paper presents OASIS, an *Online Algorithm for Scalable Image Similarity* learning that learns a bilinear similarity measure over sparse representations. OASIS is an online dual approach using the passive-aggressive family of learning algorithms with a large margin criterion and an efficient hinge loss cost. This paper show that OASIS is both fast and accurate at a wide range of scales: for a data set with thousands of images, it achieves better results than existing state-of-the-art methods, while being an order of magnitude faster. For large, web scale, data sets, OASIS can be trained on more than two million images from 150K text queries within 3 days on a single CPU[7].

Feng Qi, Xu Weihong & Li Qiang(2014) discussed an algorithm related to SURF-DAISY algorithm of image matching methods. Image matching methods uses perfect SURF based algorithm applied to feature point extraction. Reference image is used by the Feature point extraction followed by stay registration and then to DAISY description vector. The speed is relatively improved from the experiments of the given description operator, the DAISY description operator generated time is more of standard SURF algorithm. DAISY operator dimension is high that causes long matching time problem. So to overcome this issue it uses RANSAC algorithm to ignore false matching point. At last the parameters between two images related to space geometric transformation is calculated in terms of matching based on the surplus matching point. When it keeps the matching success rate under the premise of the method in the whole process, it can reduce time consumption [8].

Edouard Oyallon & Julien Rabin (2015) presented the developing measure of SURF multi-scale representation based on box filters, Comparison with linear scale space analysis, Interest point detection, Invariant descriptor construction and comparison, Experimental validation and comparison with other approaches for fine tuning the better optimization techniques results [9].

N.Jeyanthi & S.Indu (2017) considered three image matching techniques such as Blob detection technique, Template matching and SURF feature extraction for performance comparison. Blob detection technique involved discovering regions that contrast in different properties. Template matching concentrates the image parts that exactly match with predefined layout. In SURF, matching is performed by comparing by different types of descriptors received from different types of images [10].

Erik Cuevas et. al. (2018) discussed that Computational intelligence (CI) is a group of robust information processing approaches for Knowledge engineering and decision making. CI methods are treated as functional tools for the development of advanced systems which maintain intelligent capabilities such as learning, Image Processing, Image comparison, Image Segmentation, adaptation, and evolution for solving complex problems. Examples of popular CI schemes include artificial neural networks, Digital Image processing, fuzzy systems, evolutionary algorithms, decision trees, multi agent systems, knowledge-based systems, rough set theory, and hybridization of these models [11].

Bei Xie et. al. (2018) proposed the combination of global and local features in related to image retrieval algorithm. Initially all images in the image database is extracted based on GIST features, then identify K nearest neighbors that is to be returned in the image database in accordance with Euclidean distance. The next step is to extract the feature of SIFT k nearest neighbors same as the above step and execute points matching in accordance with BBF algorithm. Based on the descending order of the matching point's number the query will be generated. The results showed that the new retrieval algorithm not only improved the retrieval precision, but also had good performance in real-time [12].

Manyi Wu (2018) suggested that the feature point matching based on BRISK and ORB algorithm and the algorithm improvement and feature point extraction experiment based on the combination of the two advantages are carried out.The main challenges in this domain are to keep most features from images and then to build a local description of these features which is invariant to various perturbations such as noisy measurements, photometric changes and geometric transformation. The ideal feature descriptor should be in the image of different size, direction, brightness, darkness and has a descriptor that is similar enough to be extracted [13].

Himanshu Bansal & Dr.Naveen Malik (2018) presented the concept about HMRF and its expectation-maximization algorithm. The core idea of HMRF is to merge data faithfulness and model smoothness, which have the same properties such as graph cuts, GVF, active contours, and random walks. The paper also merged HMRF-EM framework with Gaussian mixture models in related to color image segmentation. The HMRF segmentation is smoother more than direct k-means clustering. Clustering-based segmentation concentrates only pixel intensities but in the case of Markov random field strongly considers spatial constraints on the segmented regions. This paper also described burning and missing of pixel model effects in terms of linear degradation to determine the segmentation problem [14].

Rong Guo et. al. (2019) discussed the execution of the SIFT method is divided into two parts: first, the feature points are identified for the image, and then the feature points are described. The algorithm detects a stable feature point in an image with different degrees of blur, and then constructs a multi-dimensional descriptor by using some information retained in the detection process to express the feature point. In this paper, different strategies are adopted in different stages of the matching algorithm, and it shortens the running time. The algorithm makes full use of the gray information and corner position of the image. Experiments show that the proposed algorithm can achieve accurate and fast matching for images with large chromatic deformation, and its accuracy and speed are better than traditional matching algorithms, and increases the robustness of the algorithm [15].

Defu He & Si Xiong (2021) described the hardware implementation scheme of the image processing algorithm. By comparing the PC implementation of the image processing system and the dedicated digital signal processor (DSP) implementation, the structure of the cloud computing-based on-chip programmable system is constructed, and the various parts of image acquisition, storage, and real-time display of each part of image processing are carried out, and the overall structure design is improved. The structure design has been improved [16].

METHODOLOGY

The following paragraphs explain the implementation of SIFT, SURF and ORB algorithms.

i). Implementation of SIFT [10]

SIFT algorithm is to emphasize digital images feature and detection. This is a computer vision algorithm and these key points are first extracted from a set of reference images and stored in a database. The steps involved in the implementation of SIFT algorithm are:

1. Scale invariant feature transform
2. Constructing scale space
3. Laplacian of Gaussian approximation
4. Finding key points
5. Eliminate edges and low contrast regions
6. Assign an orientation to the key points
7. Generate SIFT features
8. Implementing SIFT in open CV

The efficiency of the SIFT matching algorithms is estimated accurately based on various image activities like Scaling and rotation. The proper and improper rates for more of paired images are neatly demonstrated and calculated. The SIFT evaluation based on false positive rate and matching rate threshold. Rotation involved positive rate against matching rate threshold. The distribution of the key point orientation difference for correct and incorrect matches is calculated.

ii). Implementation of SURF [5]

Beta version of SIFT is SURF. SURF (Speeded Up Robust Features) is a robust local feature detector, that can be utilized as a part of computer vision tasks like object recognition or 3D reconstruction. It is propelled by the SIFT (Scale Invariant Feature Transform) descriptor. The standard version of SURF is a few times speedier than SIFT and more vigorous against various image Transformations than SIFT. SURF is based on sums of 2D Haar wavelet responses and efficiently utilizes the integral images. It uses an integer approximation to the determinant of Hessian blob detector, which can be computed extremely quickly with an integral image (3 integer operations).

The steps of SURF algorithm contain the following sections:

1. Interest point detecting and
2. Interest point matching

Feature extraction plays a vital role in image matching algorithms. Extract the key points is entirely different in SURF algorithm. Key points are divided into two parts that is significant region and significant area in this algorithm for judge the importance of structure information. Both Visual saliency information and outside visible information are extracted in an efficient and neat manner.

iii). Implementation of ORB [13].

ORB algorithm uses a multi scale image pyramid. Once ORB has created a pyramid it uses the fast algorithm to detect key points in the image. By detecting key points at each level ORB is effectively locating key points at a difference scale.

The steps involved in the implementation of ORB algorithm are:

1. Download sample input image to different scale levels
2. Extract FAST feature on all levels
3. Apply grid filtering
4. Extract feature orientation
5. Extract descriptors

It detects the characteristics various feature points with fast detection, strong robustness, affine performance, high timeliness and high accuracy. RANSAC (Random Sample Consensus) is focused to mismatching pairs in a feature point detection and to find a best homographic matrix. This algorithm optimizes the combination of optimal parameters for feature point extraction. The algorithm optimizes the optimal parameter combination of the optimal feature point extraction and matching of SIFT, SURF and ORB algorithms and proposes the optimal parameter combination according to different data source scale relationships. On the other hand, combined with SIFT and SURF, the ORB is optimized and improved, so that the feature point matching algorithm has the scale invariance of integrated SIFT, SURF and the robustness and fast computing power of the ORB algorithm

The following steps were followed to optimize the ORB algorithm in image matching task.

- Read-in the image to be detected and perform feature point detection
- Create an image pyramid
- Calculate the centroid direction of the feature points
- Calculate the feature point descriptor
- Feature point matching using K-nearest neighbor algorithm
- Filter the feature point matching pairs and output the detected image

In this paper the research articles 10, 13 and 15 are analyzed and the efficiency of all these three algorithms are tabulated with various performance parameters.

RESULTS AND DISCUSSION

The following table shows the comparison table for the algorithms SURF, SIFT, and ORB for the extracting feature points while the match time, detected match point pair and correct match point pairs.

Table 1. Comparison table for extracting feature points

Algorithm	Detected match point pair	Correct match point pairs	Match rate	Match time
SIFT	216	156	72.22%	9.56s
SURF	432	340	78.70%	6.3s
ORB	580	460	79.31%	4.2s

The following Figure 1 is a chart that is generated using the match rate of each algorithm. This chart exhibits the comparison of matching rate in percentage for extracting feature points while comparing the detected match point pair and corrected match point pair using the algorithms SURF, SIFT, and ORB. This proves that the matching rate of ORB algorithm is more effective, compare with the remaining algorithms.

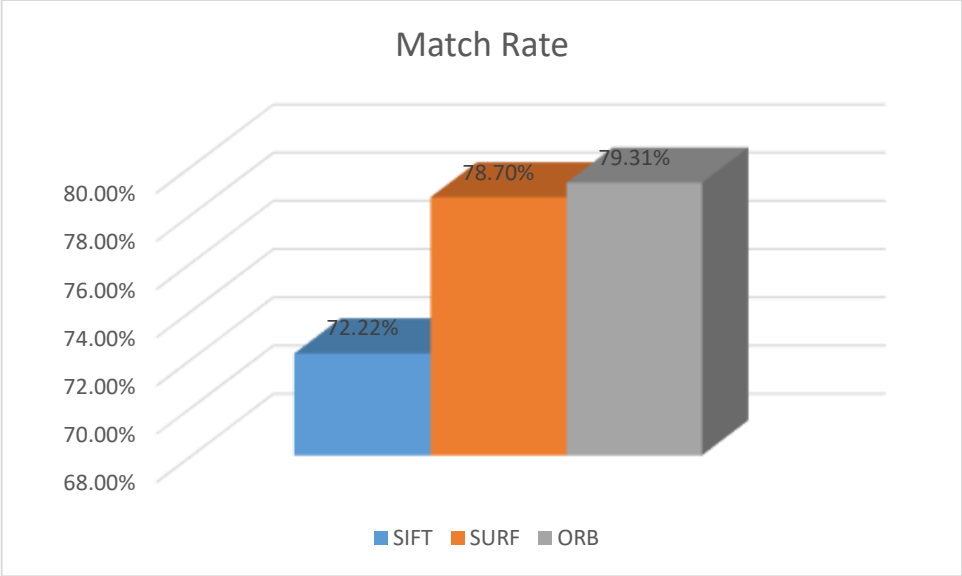

Figure 1: Comparison on Match Rate.

The following Figure 2 is a chart generated using the time taken (in seconds) to match the images of each algorithm. This chart exhibits the comparison of match time spent in seconds for extracting feature points using the algorithms SURF, SIFT, and ORB. This shows that the time taken for matching the images is very less in ORB algorithm compare with the remaining algorithms.

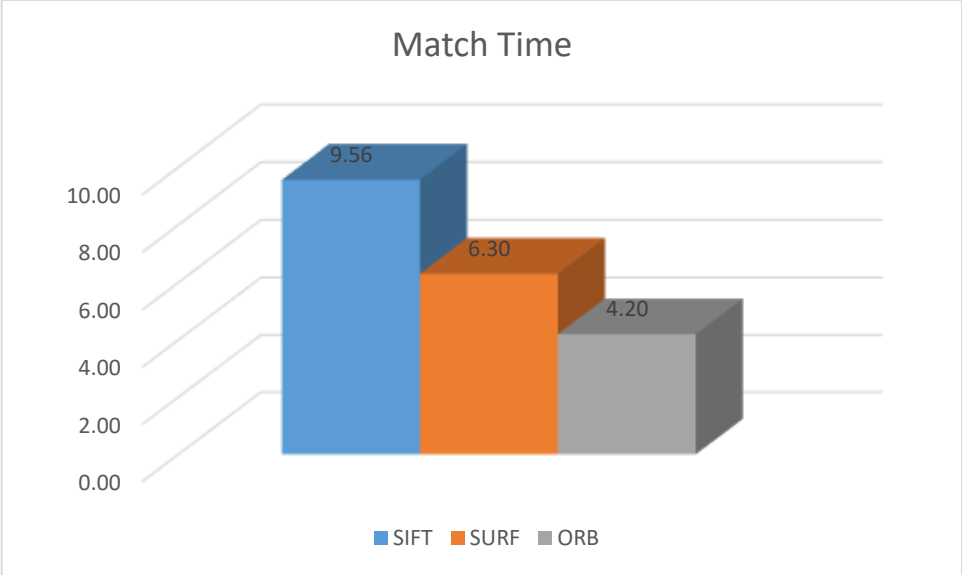

Figure 2: Comparison on Match Time

Overall view of Image Matching Techniques

The following Table 2 shows the overall comparison of the algorithms SURF, SIFT and ORB based on various parameters.

Table 2. Comparison on various parameters

Comparison Point	SIFT	SURF	ORB
Accuracy	60-70	75-85	85-90
Speed	Very slow	Intermediate	Fast
Gestures limit	Up to 20	Up to 30	50-60
Scale invariance	No	Yes	Yes
Rotation invariance	Yes	Yes	Yes
Complexity	Least complex	Less complex	More complex

Even though the complexity of ORB is more in the above Table 2, based on the other aspects like accuracy, speed, gestures limit, scale invariance and rotation invariance, the ORB is the best algorithm.

CONCLUSION

This paper compares the image matching algorithms which are having combined global and local features on the basis of various measures such as accuracy, processing speed, flexibility to use for various data sets, invariance to rotation, scale and illumination, etc. Based on the feature detection and feature extraction techniques discussed above, it is observed that SURF algorithm is the one of the best alternatives for image matching problems. However, the selecting optimization criteria such as processing match point, detected match point pair, correct match point pairs and match rate speed, it is suggested that ORB algorithm is boon for the upcoming decade. This paper concluded that Oriented fast and Rotated BRIEF **(ORB)** is one of the best strategic techniques for image matching techniques for the past half a decade.

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