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Similarity Score of Two Images using Different Measures

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Abstract— **In the field of computer vision and image processing, image similarity has been a central concern for decades. If you compare two pictures, Image Similarity returns a value that tells you how physically they are close. A quantitative measure of the degree of correspondence between the images concerned is given by this test. The score of the similarity between images varies from 0 to 1. In this paper, ORB (Oriented Fast Rotated Brief) algorithm is used to measure the similarity and other types of similarity measures like Structural Similarity Index (SSIM), pixel similarity, Earth mover's Distance are used to obtain the score. When two images are compared, it shows how much identical (common) objects are there in the two images. So, the accuracy or similarity score is about 87 percent when the two images are compared.**

Keywords— ***Image Processing, Similarity, Pixel Similarity, Structural Similarity, Earthmover's Distance***

I. INTRODUCTION

In this paper, different similarity measures are used to obtain the similarity score between the two images. The computer vision is widely used in many applications in robotics, medicine, engineering, astronomy, etc. The first step in each task assigned to vision-based applications is description of image features [8]. Feature matching is at the base of many computer vision problems, such as object recognition or structure from motion [7]. Multidimensional distributions are often used in computer vision to describe and summarize different features of an image [6]. The goal is to find the score of the similarity and match the related characteristics. Image similarity indices play a crucial role in the development and evaluation of many image processing and pattern recognition algorithms [3]. Mostly these similarity measures were used in image retrieval, semantic search, image registration, classification applications.

Comparing the images is one of the major challenges in image processing. If different algorithms are applied to an image, an objective measure is required to compare the output images. Here, each of these similarities were implemented and are used to compare the similarity score of two images. The similarity measure that provides efficient scores were SSIM, Pixel similarity measure, earth mover's distance, ORB. If there are two images, then how can the similarity be measured between them? In this way the question arises. But the answer to this depends on the problem given. For example, if the researchers are provided with two images, the similarities can be measured in many ways such as pixel by pixel comparisons; sift similarities, Mean squared error methods and so on.
So, based on the problem, the type of similarity measure can be selected. Here, some of the efficient similarity measures were implemented such that by studying, the suitable measure can be selected and used. By using similarity measures such as structural similarity (SSIM), pixel comparisons, Wasserstein distance (earth mover distance), ORB the similarity score of two images corresponding to the measure used are to be obtained. Brute Force (BF) Matcher is also used to match the similarities between images. A main trade between speed and efficiency is also a part of the image similarity calculation.

II. RELATED WORK

There are many methods inorder to find the similarity between two images like SIFT, mean squared error. SIFT is nothing but Scale Invarient Feature Transform. It detects the key points and extracts the features and finds the similarity between two images which is similar to ORB (Oriented Fast Rotated Brief). But here the SIFT algorithm is quite slow and it takes more time when it has large number of key points in the case of higher dimensions compared to ORB.

And for Matching Similarities there is BF Matcher and Flann Based Matcher. FLANN Based Matcher is used for large datasets. It works more faster than BF Matcher, but BF Matcher is preferred because it derives all possibilities and finds the best matches. It is feasible to solve a search problem using Brute Force methods. The benefit of this method is that to use one of these algorithms, you do not need any domain-specific expertise.

For solving the problem, a Brute Force algorithm aims to use the simplest possible approach.

III. PROPOSED WORK

Measure of similarity between two images can be obtained by comparing two images. If they have any of the similarities matched, then the similarity score has been obtained between the two images from the matched similarities by using the openCV package.
Here, there are different types of measures which can determine the similarity score or measure. In this paper, Types of similarity measures are used to obtain the similarity score with respect to each similarity measure.

A. ORB (Oriented fast Rotated Brief)

Ethan Rublee, Vincent Rabaud, Kurt Konolige and Gary R. Bradski developed this algorithm. ORB (Oriented fast Rotated brief) feature detector is used to find the key points and descriptors of the image to find the similarity score. It is used as the best alternative for SIFT and SURF [7].

ORB is a combination of fast keypoint detector and brief descriptor to improve the performance in any tasks. Fig (1) describes the whole process of ORB.

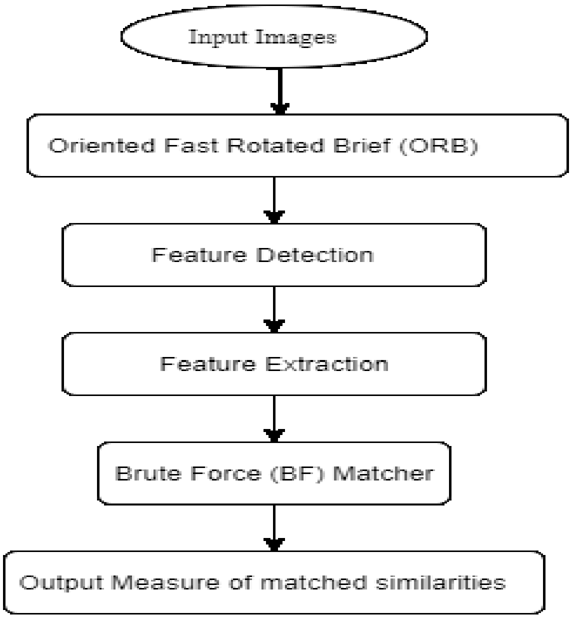

Fig. 1. ORB Block Diagram

In this implementation, structural similarity index (SSIM), Pixel similarity, Earth Mover's Distance (Wasserstein distance) are used. Using each similarity measure, the similarity score has been obtained.

Brute Force Matcher (BF-Matcher)

Brute-Force is an easy match. In the first set, it takes the descriptor of one function and is matched using some distance calculation with all other features in the second set. And it returns the nearest one.

It takes two parameters such as norm type which determines the measurement of the distance to be utilized and crosscheck checks and returns the matches which are best. Thereby it horizontally stacks two images and draws lines indicating the best matches from the first image to the second image. If two images are provided, then it draws the matches between the images.

Owing to the great number of parallels, it often takes more time to use the brute-force algorithm, but it is Highly accurate. Its performance and removal capability of outliers by setting parameters, they can be enhanced [8].
BF Matcher will explore all the options and the best matches will then be found.

B. Structural similarity Index (SSIM)

A type of measure for calculating the resemblance between two images is the Structural Similarity (SSIM) index. If the other image is of perfect quality, the SSIM index can be interpreted as a quality indicator of one of the images being compared.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad [3]$$

Here, SSIM index will be defined as below in such a way that between two images given x and y where x={ x_i |i=1,….,M} and y={ y_i |i=1,….,M}, C_1 , C_2 are two positive constants and μ_x, μ_y are the summations of x and y, σ_x and σ_y are variances of x and y and σ_{xy} is the variances. SSIM max value is 1 which will be achieved if the given two images are equal (identical) [3].

Based on the image quality-based assessment of SSIM, it provides a good percentage of quality measure with respect to accuracy [4].

C. Pixel similarity

The similarity of the pixels is defined using the indices of the pixels. The most basic formula for calculating number of pixels (n) is n=size in inches * Pixels per Inch. Therefore, when finding a new pixel value, the impact of the normal pixels near or far from the Centre pixel differs.

By providing the pair of images, each represented by a set of features, the similarity of the image is defined by comparing the set of features based on a similarity function. The set of features can be computed for the whole image globally, or for a specific group of pixels locally, such as regions or artefacts.

D. Earth Mover's distance (EMD)

It is also known as Wasserstein distance or metric in mathematics which is used to measure the distance between two distributions of probability over a region. It is mostly used in semantic search which is nothing but image retrieval. It is the minimum amount of work done to transform one distribution to another.

Here w_{p_i} and w_{q_i} are the number of matched weights (similarities). P={(p_1,w_{p_1}),…..,(p_n,w_{p_n})} is the n clusters signature where p_i is cluster representative similarly Q={(q_1,w_{q_1}),…..,(q_n,w_{q_n})} is the n clusters signature where q_j is cluster representative, $d_{i,j}$ is the ground distance between p_i, q_j along with $f_{i,j}$ which is the flow between p_i and q_j.

$$WORK(P,Q,F) = \sum_{i=1}^{m}\sum_{j=1}^{n} f_{ij}d_{ij}$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} f_{i,j} = \min\left(\sum_{i=1}^{m} w_{p_i} \sum_{j=1}^{n} w_{q_j}\right) \quad [6]$$

$$EMD(P,Q) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} d_{i,j}f_{i,j}}{\sum_{i=1}^{m}\sum_{j=1}^{n} f_{i,j}}$$

IV. PROCEDURE

Initially, by taking the input of two images, it can resize and normalize the image with a fixed size provided with the parameters like height and width. This would be helpful for further processing tasks of the images.

So, we can take any size of the image such that later for future processing the image size is adjusted and normalized.

Then, histograms for the images are obtained which is used to compare the images. A visual representation of the frequency of different color values in the image is called Histogram. For a grayscale 8-bit picture, the histogram is a vector of 256 units where the nth value indicates the percentage of the pixels at the specified level of darkness in the image. The values of the histogram add up to 1.

It is important to normalize the exposure of the images for further processing. While normalizing it gets the sum of values accumulated by each position in histogram and determines the normalization values for each position of CDF (Cumulative Distribution Function).
Here, in this the histogram is obtained using CDF so it is called cumulative histogram. It is a map that counts the total number of values for pixel intensity in all up to the new bin containers.

Now, by using each similarity measure we compute the similarity score between two images by giving the path of the images as arguments so that it computes and returns the float valued similarity score as output.
If the similarity score is near to 1, then the similarity match between the provided images is more. That is, the images are more likely to be similar. Whereas if the score is near to 0, then the given images were not much similar.

Using ORB (Oriented Fast Rotated Brief) feature detector, we measure the similarity by getting the images and finding the key points and descriptors.
And then BF (Brute Force) Matcher is initialized and computes with respect to match similarities between two images.

Finally, output the similarity scores computed by each of the similarity measure between two images. Below Fig. 2. represents the workflow representation of the whole process.

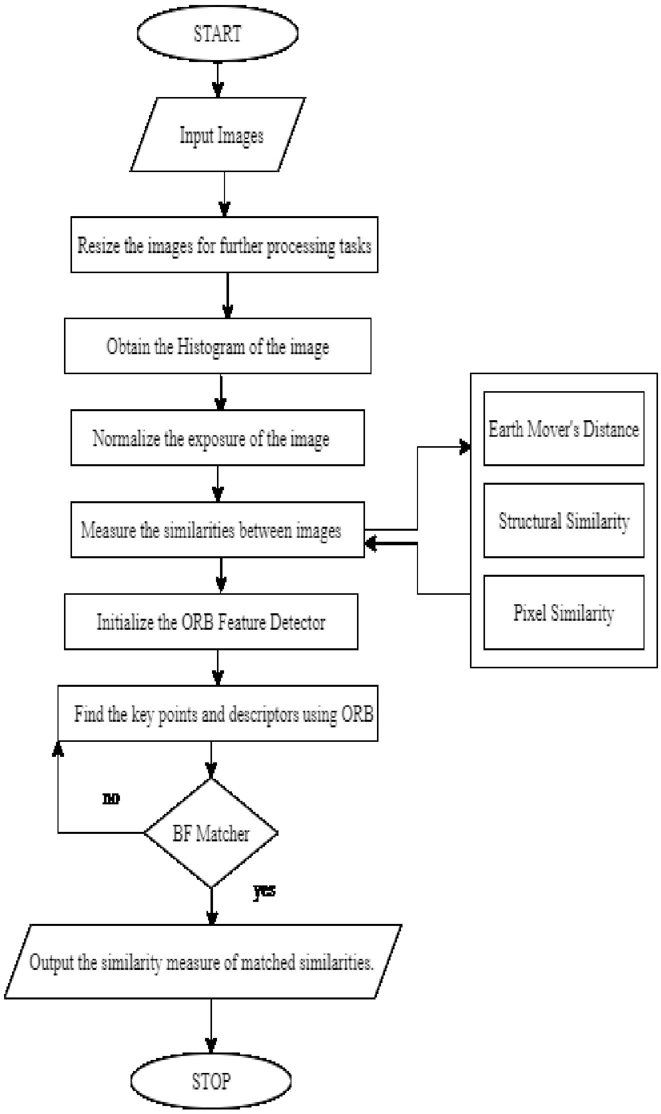

Fig. 2. Workflow Representation

The pseudo code for obtaining similarity scores using different similarity measures is mentioned below as following.
Step1: Start.
Step2: Provide the input of 2 images.
Step3: Prepare the images for the image processing tasks (resizing the images by specifying the resized image sizes).
Step4: It returns the resized images with the specified size.
Step5: Obtain the Histogram of image. The histogram's values sum to 1.

Step6: Get the sum of values accumulated by each position in hist.
Step7: Determine the normalization values for each unit of the CDF.
Step8: Normalize each position in the output image
Step9: Measures the Earth Mover's distance (Wasserstein distance) between two images by taking the paths of image files as arguments and returns the Wasserstein distance.
Step10: Measures the structural similarity between two images by taking the paths of image files as arguments.
Step11: Measures the pixel similarity between two images by taking paths of image files as arguments.
Step12: It initializes the ORB (Oriented Fast Rotated Brief) Feature detector to detect and extract the features and obtain measure of similarities.
Step13: Get the images that are normalized and resized and generates the key points and descriptors with ORB.
Step14: Find the matches between the images using the Brute Force (BF) Matcher and store all the matches of the descriptors in an array.
Step15: Measure the score of similarity of all possible matches using the above-mentioned steps 6,7,8.
Step16: Output the similarity scores of all measures used.
Step17: Stop.

V. RESULTS

To verify the similarity of two images using different similarity measures two images are taken as input of any size as in the process the provided images are resized and normalized. It finds the similarities between two images and draws the matches using brute force matcher as shown in the below outputs provided. But different measures are used such as Structural Similarity Index (SSIM), Pixel Similarity, Oriented Fast Rotated Brief (ORB), Earth mover's distance to obtain similarity score because each measure has its unique way of measuring the similarity. So, the similarity scores of each measure used are tabulated below such that we get to know how similar they are.

Input1

Here, two different roses are taken as input images as shown in the below Fig. 3 and Fig. 4. and comparing them, we get the following similarity measures as output as shown in the below Fig. 5. Similarity scores for input 1 are obtained by using different similarity measures are tabulated in the below TABLE 1.

Fig. 3. Input Image

Fig. 4. Input Image

Output1

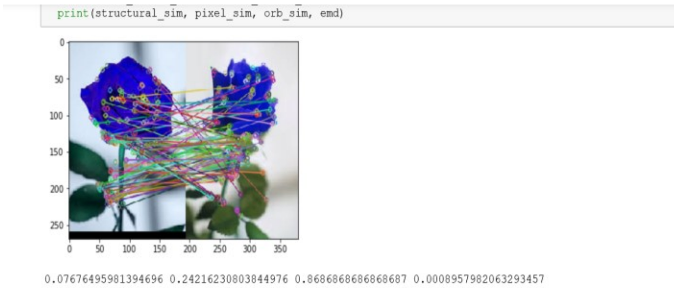

Fig. 5. Output 1

TABLE 1 SIMILARITY SCORES FOR INPUT 1

Similarity Measures	Similarity score obtained
Structural Similarity Index	0.07676495981394696
Pixel Similarity	0.24216230803844976
Oriented Fast Rotated Brief	0.8686868686868687
Earth Mover's Distance	0.0008957982063293457

Input2

Here, Jaguar and Leopard are taken as input images as shown in the below Fig. 6 and Fig. 7. and comparing them, we get the following similarity measures as output as shown in the below Fig. 8. Similarity scores for input 2 are obtained by using different similarity measures are tabulated in the below TABLE 2.

Fig. 6. Input Image

Fig. 7. Input Image

Output2

Fig. 8. Output 2

TABLE 2 SIMILARITY SCORES FOR INPUT 2

Similarity Measures	Similarity score obtained
Structural Similarity Index	0.007089963414041768
Pixel Similarity	0.3861435572306315
Oriented Fast Rotated Brief	0.25
Earth Mover's Distance	0.0023203641176223755

Input3

Here, two cars are taken as input images as shown in the below Fig. 9 and Fig. 10. and comparing them, we get the following similarity measures as output as shown in the below Fig. 11. Similarity scores for input 3 are obtained by using different similarity measures are tabulated in the below TABLE 3.

Fig. 9. Input Image

Fig. 10. Input Image

Output3

Fig. 11. Output 3

TABLE 3 SIMILARITY SCORES FOR INPUT 3

Similarity Measures	**Similarity score obtained**
Structural Similarity Index	0.033799602140554726
Pixel Similarity	0.2692546433093501
Oriented Fast Rotated Brief	0.6964285714285714
Earth Mover's Distance	0.003895670175552368

Input4

Here, two images as input in such a way that second image has the object of first image as input images as shown in the below Fig. 12 and Fig. 13. and comparing them, we get the following similarity measures as output as shown in the below Fig. 14. Similarity scores for input 1 are obtained by using different similarity measures are tabulated in the below TABLE 4.

Fig. 12. Input Image

Fig. 13. Input Image

Output4

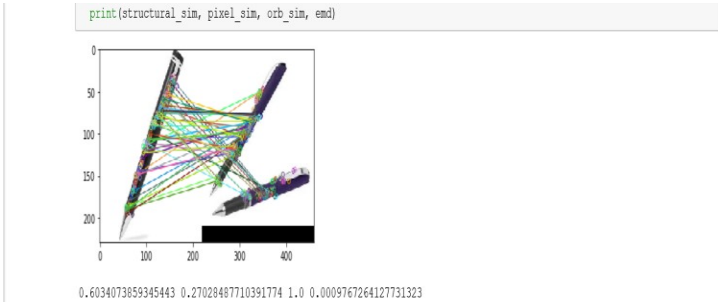

Fig. 14. Output 4

TABLE 4 SIMILARITY SCORES FOR INPUT 4

Similarity Measures	**Similarity score obtained**
Structural Similarity Index (SSIM)	0.6034073859345443
Pixel Similarity	0.27028487710391774
Oriented Fast Rotated Brief (ORB)	1.0
Earth Mover's Distance	0.0009767264127731323

VI. CONCLUSION

Measuring the similarity score between two images by using ORB feature detector, it detects the key points and descriptors of the images and then matches the similarities using Brute Force matcher. Different similarity measures provide the similarity score with respect to the input provided. But these measures such as pixel comparison sometimes may vary whereas ORB (Oriented Fast Rotated Brief) works faster compared to SIFT and SURF. In Future work, when we provide two images these measures can be improved to identify the common objects and highlight them with square box such that we can know the similar objects between the images.

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