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Comparison of Quality Measurement Methods for Geometrically Transformed Images Matching

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مقارنة بين طرق قياس الجودة لمطابقة الصور المتحوّلة هندسيًا

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الملخص:

ضمان الجودة لمطابقة الصور هو المطلب الرئيسي للباحثين، خاصة عندما يتعلق الأمر بالصور المتحورة هندسياً للمجالات المعتمدة على معالجة الصور مثل الاستشعار عن بعد، والهندسة العسكرية، والأمن. بناءً على ذلك، كان هناك العديد من التحديات بخصوص معالجة الصور بكونها أكثر تعقيدًا عندما يتعلق الأمر المتحولة الهندسي لأنه سيسبب في فقدان الصورة لحوافها وتجعل من الصعب تحديد الميزات الثابتة. هنالك العديد من الدراسات التي تم تطبيقها على مبدأ قياس الجودة، ولكن القليل منهم من حاول مقارنة قياس الجودة. في هذا البحث، قمنا بتقييم بعض طرق قياس الجودة لمعرفة كيفية تأثرها بالتحور الهندسي في عملية المطابقة وكيف يمكن لهذه الطرق اكتشاف الفرق بين الصور المتطابقة. لقد حققنا نتائج مميزة من شأنها أن تساعد في اختيار أفضل طريقة لقياس الجودة.

الكلمات المفتاحية: التحول الهندسي، المدرج التكراري، RMSE، قياس الجودة ، PNSR، تدوير الصور.

Abstract:

Quality assurance for image matching is the main concern for researchers, especially when it comes to Transformed Images for multidisciplinary fields such as remote sensing, military, security, medicine, and multimedia fields. Based on this, there have been many challenges to the application of image technology. Image matching gets more complicated based on the geometric transformation because the image will lose its edges and make it harder to determine the local invariant features. Related studies were applied for different methods, and few attempted to compare the quality measurement. In this paper, we assessed some quality measurement methods to find out how they are affected by the geometric transformation in the matching process and how these methods can detect the difference between the matched images. We have achieved a significant result that would help in choosing the best method for quality measurement.

Keywords: Geometric Transform, Histogram, RMSE, Quality measurement, PNSR, Image Rotation.

1. INTRODUCTION

Quality measurement is a necessity for image matching as being one of the hot topics in image processing and Machine Learning over the last decade (Bian et al.). In addition, the main concern for all image processing and computer vision specialists is the quality of the processed or manipulated images, which have to be maintained and evaluated correctly. Some modifications affect image processing such as rotation to identify the invariant feature of the transform image (Zhang and Qu 053002-1). However, the main concern is about the Quality of the matching process, and how to approve the outcomes, for instance, medical images processing is currently a research trend and very sensitive and has to be done accurately to provide the best service for CT and MRI clinicians and Doctors (Feng et al.). In addition, it has been used as a standard statistical metric to measure the quality of meteorology, image compression quality, and climate research studies (Chai and Draxler 1247).

When Image Transformation causes a geometric effect, the Matching process gets more complicated because extracting invariant local features requires an accurate method to spot the map region (Jiangsheng et al. 1). The current quality measurement tools have a different workflow to compute the accuracy. For example, Mean Square error calculates the accumulative error rate to ensure the similarity of the compared image by dividing the target image into blocks. At the same time, PNSR defines the peal noise value for the matching process. With any geometric transformation, these blocks will increase the value of the error rate.

Geometric transformation such as image rotation is required for some computer vision applications such as feature extraction and matching (Ashtari et al. 3370). Quality Measurement helps determine the best method for image processing (Sheikh et al. 1). There is a dozen of methods for assessing the qulity of the compared image.

2. LITERATURE REVIEW

Image matching quality needs more scrutiny and attention especially when it is a geometrically transformed (Al-Najjar and Chen 5; Ashtari et al. 3370; Feng et al.; Li and Zhang 45). An image-matching framework based on the generalized Hough transform has been presented by (Li and Zhang 45). The current methods can measure the similarity but these methods are affected by transformation such as rotation (Li and Zhang 45). (Al-Najjar and Chen 5)there are many different types of image quality metrics implemented for getting the quality of an image, but there are still limitations.

A transform Image Comparison Algorithm was proposed in (Li and Zhang 45), this study indicates the importance of image degradation assessment and how to manipulate them accurately. Their new proposed method does not solve geometrically transformed images and recommended this issue as a future work.

Another method is called histogram which extracts image features to match them. (Mahmood and Lee 14) proposed Histogram as a matching method and showed the ability of this method in extracting identical images even though it is transformed.

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Root Mean Square Error (RMSE) can help determine the cumulative error rate to identify the similarity, but this method requires splitting the image into blocks. These blocks will lose their position based on the transformation action. (Chai and Draxler 1247) referred to using RSME as a testing tool will not be enough because of the distribution of the errors.

3. METHODOLOGY

Three methods have been proposed for this experiment to compare them based on their result to find the similarity and how accurate they are. A geometric transform was applied to the target image. Our dataset of samples is considered to be a colored image. One after another, the researchers degraded those samples interchangeably. First, they were noised to check them and assess their quality, then they were rotated to specify interest points for more complexity. This would help appraise those methods.

In this experiment, the researchers performed the following tasks:

1- Reading the original image.
2- Duplicating the original image to be a target image.
3- Applying rotation as a geometric transform action.
4- Converting both images into a binary to prepare them for the chosen methods.
5- adding some noise to the target image by using salt and pepper.
6- Applying the matching method to find the similarity between both images.
7- Calculating the error rate to measure the quality of the matching process.

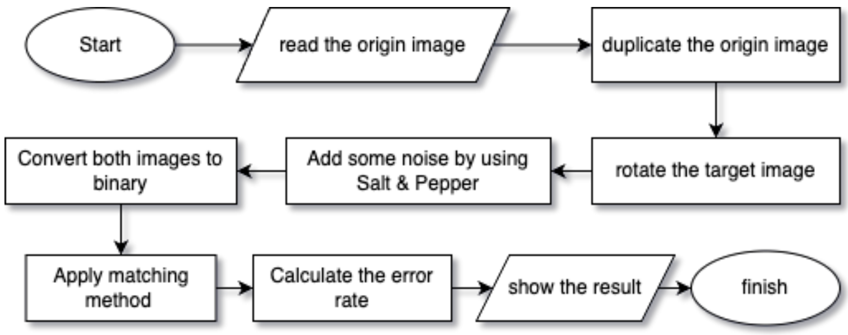

Fig. (1) Shows the flowchart of our model.

In the seventh step, three methods have been chosen to evaluate the matching processing. These methods are widely used, but only a few or none tried to compare them.

3.1 Histogram

Feature extraction helps to identify the invariant local features as shown in figure 2. Histogram will focus on the interesting points to calculate the intensity of the target image (Won; Zehani et al. 6).

Where *Hist* is the image features' array and *n* is the total number of pixels and *Xi* is the average for RGB colors.

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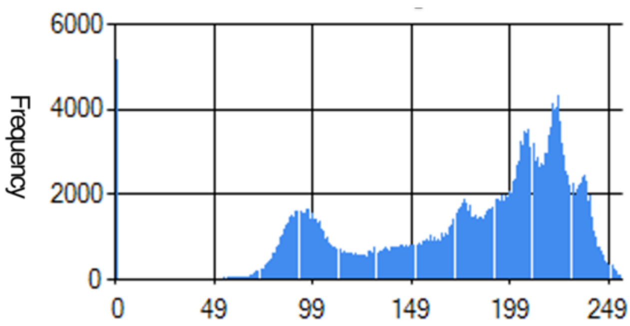

Figure (2): draws the result of the Histogram for the input image.

3.2 Root Mean Square Error (RMSE)

To Find RMSE, we need to define the MSE first, then calculate the root for MSE. Suppose that *x*= and *y*= {yi|*i* = 1, 2,··· , N} are two finite-length, discrete signals (e.g., visual images), where N is the number of signal samples (pixels, if the signals are images) and x_i and y_i are the values of the *i*-th samples in x and y, respectively (Wang and Bovik 99).

$$\mathrm{MSE}(\mathbf{x}, \mathbf{y}) = \frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)^2. \qquad (1)$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum\sum(E_{ij} - o_{ij})^2} \qquad \mathbf{(2)}$$

3.3 Peak Signal-to-Noise Ratio (PSNR)

This ratio is one of the quality measurement methods. The PSNR block finds the peak signal-to-noise ratio between the original image and the targeted image. The higher the PSNR, the better the quality of the matching process for images.

This method depends on MSE value. Therefore, to compute the PSNR, the block first calculates the mean-squared error to find the cumulative error by using equation (1). Then we use PSNR to find the peak error by using the following equation:

$$PSNR = 10\log_{10}\left(\frac{R^2}{MSE}\right) \qquad (3)$$

The samples are represented in 8 bits, meaning the maximum number of pixels is 255. therefore, our dB value will be 20*log10(255) =48dB. The value will be adjusted based on the MSE value.

4. RESULTS AND DISCUSSION.

First, we chose rotation as a geometric transform and applied some noise by using salt and pepper to add more complexity periodically for seven samples. The image size for samples was 512x512.

This experiment consists of nine samples. The first one is just a copy of the target image with no change to confirm the identical match. Then we chose to apply some

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rotation and noise as shown in table (2). The second sample is the original image with 2% noise and then increase it see how these methods are affected.

We started our experiment with Histogram. Sample (2), which was only rotated, shows an identical match. But when we started to add the noise histogram, the bins number increases simultaneously as shown in figure 4. The difference is occurred by the noise.

On the other hand, RSME and PSNR, give different values with rotated images. For example, in sample (2), the RSME value was 69,08 as an error rate, meaning there was a difference between this rotated image and the original image. Also, the PSNR value was 32,76 dB which is less than the identical matching value of 48dB.

Table (1): shows the seven samples of this study.

	FUNCTION	Hist.	RMSE	PSNR
Sample1	Copy of the Origin	0.00	0.00	Inf
Sample2	Rotate	0.00	80.12	32.12
Sample3	Noise 2% without rotate	15.95	20.82	37.97
Sample4	Noise 2% and rotate	15.95	82.02	32.01
Sample5	Noise 3% without rotate	23.81	25.09	37.09
Sample6	Noise 3% and rotate	23.81	82.93	31.97
Sample7	Noise 4% without rotate	31.69	29.12	36.51
Sample8	Noise 4% and rotate	31.65	83.79	31.92

On the other hand, SME and PSNR have a noticeable change. MSE result for sample 3 was 26.29, but when we rotated the image, the result on Sample4 was 73.27. it is the same with PSNR, the result was 36.98dB without rotation and 37,00dB with rotation which means PSNR recognized the image but shows a slightly different or less quality-matched image. These results are clearly illustrated in Figure (3).

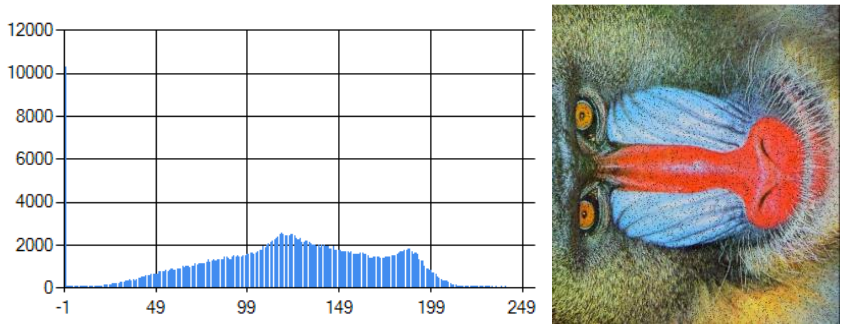

Figure (4): draws the result of the Histogram for the last sample.

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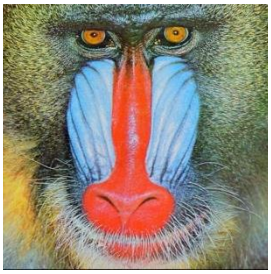
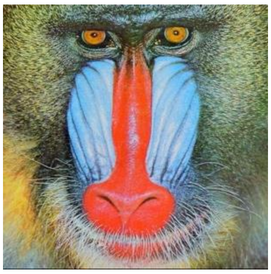
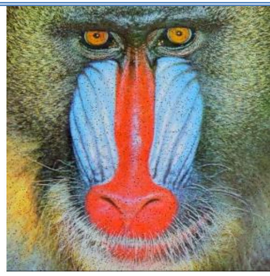
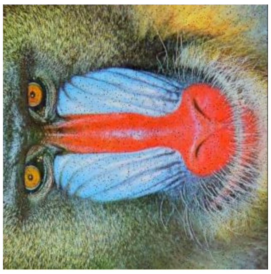
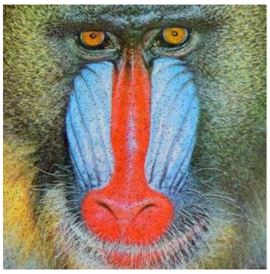
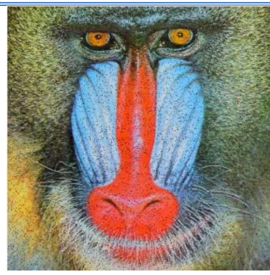
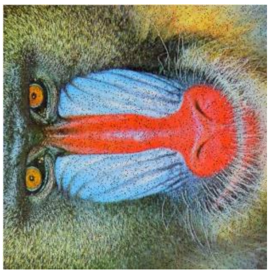
Table (2) shows the results of the matching methods.

 **Sample 1 (Original)**	 **Sample 2**	 **Sample 3 - Rotated**	 **Sample 4 – Noise 2%**
 **Sample 5 - Noise 2% and rotated**	 **Sample 6 - noise 3%**	 **Sample 7 - Noise 3% and rotated**	 **Sample 8 - Noise 4%**
 **Sample 9 - Noise 4% and rotate**			

From table (1), It is obvious that Histogram results are not affected when Rotation was applied to Sample 3 and Sample 4 have the same value of 15.99, this Difference value is because of the noise, but the result for sample 2 was zero which means it is an identical match even though it is rotated. While RMSE and PSNR returned a slight difference for sample 2.

All methods are clearly illustrated in figure 3. In this chart, RMSE is obviously affected by the rotation in samples (3, 5, 7, 9), since it depends on matching blocks in size 16X16, which means the first block will change it is position on the target image, therefore, error rate will be higher.

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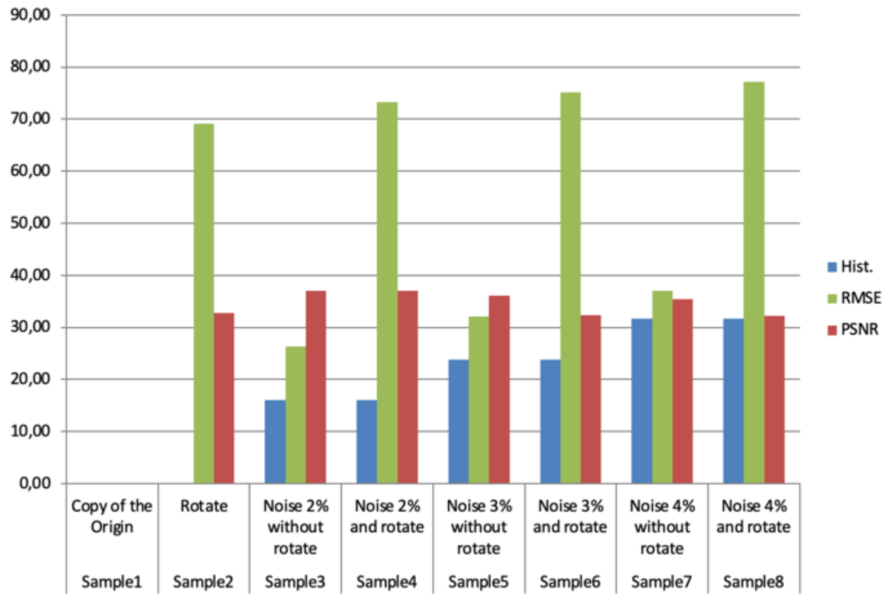

Fig. (3) illustrates the comparison of the chosen methods.

5. CONCLUSION

In this study, the researchers compared the matching quality for three different methods. It has been concluded that the histogram has the best matching performance compared to RMSE and PNSR. The histogram calculates the overall average for the extracted features of the target image even though it is affected by the rotation and the added noise (Zhou et al.). Image transformation has less impact than image enhancement on histogram performance, especially with rotation transformation.

Regarding RMSE performance, it is clear that transformation makes it more perplexing to find out the similarity and to measure the quality of this matching process. Splitting the image into blocks will cause image degradation since each block will be reallocated on the target image.

PSNR performance is decreasing when it comes to transformation process. Solving this issue requires edge detection to determine invariant features to match them.

Thus, it is recommended that Edge be detected before weighing up results to identify interest points and establish that the study meets the quality requirements. Also, it delivers the best service and improves the impression about the given result for these methods which require Griding images to determine the similarity or the difference for any process.

6. FUTURE WORKS

After having finished the present study, the researchers will continue to study these methods to improve the quality measurement for the similarity experiment. Focus will be on automating Geometric Transformation detection to prevent underestimating the used method.

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