

Blind Measurement of Blocking Artifacts of Images Based on Edge and Flat-region Detection

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Abstract—Image compression based on DCT often produces distortion of blocking effects, which seriously affect the visual quality of images. In order to detect the distortion of blocking effect, a new approach based on the flat region is presented in this article. The approach has a good correlation to characteristics of human perception, because human eyes are sensitive to the blocking effect which is produced at the flat regions of images, and it is also obvious in images. Furthermore, the approach is a non-reference image quality assessment. It does not only improve the efficiency, but also enhance the practicality of the algorithm. The approach has low complexity, high accuracy and good transplantation.

Index Terms—no reference, image quality assessment, flat region, blocking effect detection

I. INTRODUCTION

With digital video media technologies developing, such as IPTV, Internet video, multimedia conferencing and so on, the digital video quality assessment has become a research focus.

There are two types of image quality assessment, subject quality assessment and object quality assessment. The subjective measure is the method which under certain conditions different observers are selected to make a different score to different reference videos and distorted videos by a five-mark system which are divided into five equal intervals with the following adjectives from top to bottom: Excellent, Good, Fair, Poor and

Bad^[1]. Then all scores which different observers gave are weighted and generate the mean opinion score (MOS). Though this metric has good relation to the images practical quality, it is so complex and need long time, to some extend, it is a waste of time, different results of the same image are given by different people. It is so difficult for human to model the metric, and it is easy to affect by different factors, therefore it is not suitable for engineering project. The objective quality assessment is different to the subjective one, while it is given by one or more measure targets to reflect the quality of images^{[2][3]}.

By contrast the objective quality assessment metric is very simple, which doesn't need involvement of people, only give an algorithm to assess images. There are three types of metrics in the object quality assessment^[4], the Full-Reference metric, the Reduced-Reference metric and the Non-Reference metric. The first two need references, the only difference is the level of relying on the reference. Such as the common metrics of MSE and PSNR, which are not able to use if there are no references. Non-Reference metric is based on a such condition which have no references, and gives the ideal results, which have good correlation to the MOS. So it is the inevitable trend of future development^[5].

In no reference quality evaluation system, there is a known type of distortion method: According to the specific type of distortion and effects, seek out distortion strength. For example, JPEG2000 compressed images^[6], using natural scene statistics model defines no reference JPEG2000 image compression quality evaluation index^[7]; Based on the pixel alteration and edge information of the Senate without JPEG2000 compressed image quality evaluation^[8]; Development of a JPEG2000 compressed image blur altered and no reference image quality assessment index^[9]; Proposed one kind based on

Manuscript received January 1, 2012; revised June 1, 2012; accepted July 1, 2012.

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the energy spectrum distribution of the JPEG2000 no reference image quality evaluation method. According to JPEG compressed image^[10], the use of some spatial activity measurement indicators to the Senate without JPEG compressed image quality evaluation^[11]; According to the JPEG or MPEG signal based on Discrete Cosine Transform (DCT) domain of the natural scene statistics model of no reference quality assessment algorithm; Xiaoli Yin, Xiangzhong Fang and Guangtao Zhai direction for JPEG images based on semi fragile digital watermarking algorithm for no reference image quality assessment method^[12]; Bin Lou presents a method based on local energy ratio JPEG distortion measurement method^[9]; Kay was proposed based on Wavelet Domain Hidden Markov Tree (HMT) statistical characteristics and no reference image quality assessment method^[13], but from the experiment result, but also only in the JPEG distortion image effectively; PAN, Lin and Raharaja is proposed based on block boundary direction statistical distortion of the JPEG image measurement method^[14]. According to the blur alteration^[15], Integrated JNB concept to probability summation model, proposed one kind based on the perceived no reference image sharpening / blur scale^[16]; Based on multi-scale wavelet transform local phase coherence evaluation, put forward a kind of no reference image blur evaluation index; Boxin Zuo, Delie Ming, Zhengguang Ao and Wenjuan Zheng proposed one kind based on the edge detection of no-reference blurred image evaluation model^[17]; Zhengyou Wang, Jincai Ye, shuang Wu and Zhenxing Li from the perspective of blur distance detection, this paper presents a combination of edge detection and no reference image blur estimation method^[18]; Xiaofu Xie, Jin Zhou and Qinzhang Wu propose a no-reference structural sharpness (NRSS) no-reference image quality evaluation method, will be used for blurred image quality evaluation^[19]; According to the blur distortion, and the blurred image is added on the basis of Blur^[20] and the measurement of blur boundary extension^[21] Methods. For noise image, Zhengyou Wang and Wen Xiao proposed a mask-based no-reference image quality assessment method^[22]. Some algorithms for a particular piece of alteration, such as Wang, Bovik and Evans proposed one kind based on the FFT edge block alteration no-reference algorithm^[23]; Vlachos based on sub-sampling image cross correlation between block alteration measure^[24]; Fuzheng Yang, Yilin Chang and Shuai Wan are combined with human visual the luminance masking and masked character presents a for block-coding no-reference video quality assessment method^[25]; Park, Na and Kim with H.264/AVC quantification and block models for two kinds of parameters to the Senate without evaluation of video quality^[26]; Zhang, Zhou and Tian proposed a Sobel operator weighted reference block effect evaluation scale^[27].

This paper presents a new approach of blocking effect detection based on the flat-region, the metric conforms to the human visual perception well, it not only improves the algorithm efficiency, but also the correlation to MOS. Because the blocking effect in the flat region is obvious,

and it has more sensitivity to human vision. The remainder of this paper is organized as follows: Section II discusses block artifacts and related research work. Section III describes the algorithm in detail. Section IV analyzes and explains some experimental results. And a general conclusion is presented in Section V.

II. BLOCKING ARTIFACTS AND RELATED RESEARCH WORK

In the use of DCT digital image coding system, if the whole image DCT transform, that is to say the image pixel DCT transform, this work is quite large, the efficiency is very low, especially in processing video, the processing speed is not acceptable. Therefore, at present people put forward block based DCT coding method therefore. First, the image is divided into 8×8 pixel block, Then for each DCT transform and then get 64 DCT coefficients, this process greatly reduces the amount of computation, improve the efficiency of the algorithm. Block mode is not just a way, there are many other ways, according to the video image details using the corresponding original block mode, as of 16×16 block method. But, Block based DCT transform, ignore block and block the correlation between. Because for each DCT coefficient quantization, In order to apply DCT coefficient quantization coefficient, must discard some of the image has little effect on the high frequency information. However, When the quantitative comparison and rough, block edge a large number of high frequency information will be lost, make image block edge jump discontinuity, this is block the effect of distortion, as shown in Figure 1.



a. The original sailing b. The block effect of severe sailing figure

Figure 1 The general procedure chart of the proposed metric

The research of blocking effect detection is a hot topic. Such as using the direction of edge to detect blocking effect^[5]. Reference[28] presents a metric, images are divided into blocks, the size of block is 8×8 pixels, the visibility of the block reflect the level of blocking effect of images. Reference [29] combines the visibility of the block and the smoothness between the blocks to reflect the blocking effect of images. Reference [30] and [31] use the Fourier transform to process images by the step

size of 8 pixels, then analyze the signal to estimate the distortion of the blocking effect. These methods are based on the blocking partition metric to measure the blocking effect of images, and the size is 8 pixels $\times$ 8 pixels, these metrics have the disadvantage of low flexibility. First of all, not all images are coded by block of 8pixels $\times$ 8pixels. Secondly, the blocking effect is caused randomly, and it is not always the size of 8pixels $\times$ 8pixels. Reference[32] represents a metric based on the masking effect of HVS, this metric simulate the Weber's rule, but the complexity of the algorithm is so high and not suitable for large amount of data computation. So far, the research of image quality assessment using flat-region is so limited in native and abroad, so the paper can't list the recent relevance research about the application of flat-region.

Artifact detection is error-prone and likely to be inaccurate in real-world images. It is therefore important to use the most reliable data for the detection. In [35], strong edges in an image has been used for blurring detection. Following the similar thinking, we try to detect blockiness from flat regions for more reliable results.

The proposed method takes into such considerations: Firstly, use the operator of Sobel to detect the edges of the processed images, and then go to a further step to detect the real edges^[5] of the processed images, wipe off the non-edge pixels, to some extend, it can reduce the complexity of algorithm, avoid wasting time. Furthermore, the new approach improve the accuracy of detection results. At last, statistic and compute the edge pixels which are in the flat-regions, and the images evaluation results are obtained. The evaluation results are given by weighting the block rate (BR) and the block strength (BS). If the BR is bigger, means there is more blocks in the image, and if the BS is bigger, means the block is more visible. So this two factors can make sure the distortion of blocking effect.

III. BLOCK DETECTION BASED ON THE FLAT REGION

The general procedure of the proposed approach is show in figure 2.

A. Block Detection Based on the Flat-region

This paper integrates the methods and principles of edge detection, flat-region detection and the blocking effect detection^{[33] [34] [36]}. It not only improves the accuracy of blocking effect detection, but also reduces complexity of metric. Because the approach presented is based on the flat-region, and detect the real edge of images. The two aspects make this metric be a high-performance metric. The main steps of the algorithm are as follows:

- (1) detect the edges of the processed images. The paper uses Sobel operator.
- (2) according to the characteristics of the pixels of the edge, in order to make sure the pixels are the real edge or not. So make a further process of the results of (1), eliminate the non-edge pixels.
- (3) Repeat the former three steps, detect the horizontal and the vertical directions of the image.

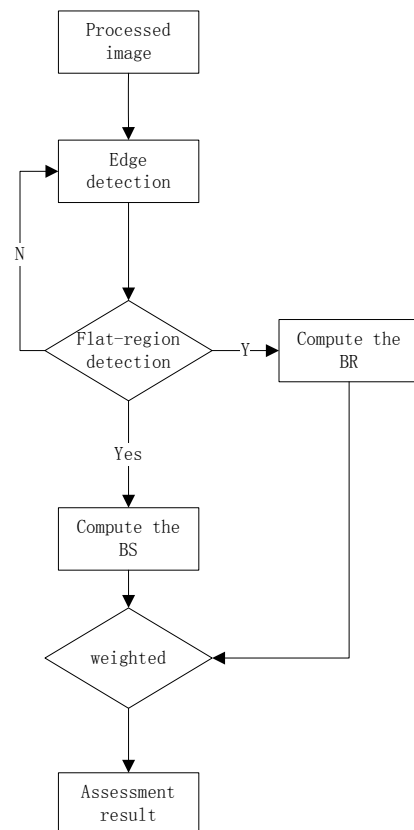


Figure 2. The general procedure chart of the proposed metric

(4) Compute the block rate (BR) and the block strength (BS) of the image.

(5) The final result is given by the BS and BR weighted;

B. Method and Principle of the Edge Detection

Edge is a set of the pixels whose gray values step changed, it is the fundamental characteristic of images. It appears between target and background, target and target, region and region. Width and direction are the two basic characteristic of edges. Along the direction, gray values of pixels change moderately, while along the vertical direction of the edge, change greatly. There are two types of changes, step changes and slope changes. The former one change greatly and the latter one has a turning point.

Edge detection is the fundamental technology of the image processing and computer vision areas. How to get the edge in a rapid and accurate way is always a hot topic at home and abroad, but edge detection is a difficult problem in image processing area. There are some classical methods, such as the operator method of edge, curved surface fitting method, threshold method, and so on. In recent years, with the development of Mathematical theory and artificial intelligence, there are many other edge detection methods are proposed, such as wavelet transform and edge detection method of wavelet packet, and some methods based on Mathematical Morphology, Fuzzy theory and neural network. There are

some operators of edge detection which are in common use, such as Roberts operator, Sobel operator, Prewitt operator, Kirsch operator, LOG operator and so on.

This paper uses Sobel operator for edge detection, and gets real edge of the processed image in further step. The details of the algorithm are as follows:

(1) process the image $F(x,y)$ using the Sobel operator, the result is $S_h(x,y)$, show in the equation (1).

$$S_h(x,y) = F(x-1,y+1) + 2F(x,y+1) + F(x+1,y+1) - F(x-1,y-1) - 2F(x,y-1) - F(x+1,y-1) \quad (1)$$

(2) according to the characteristic of the edge, the grad of the real edge is bigger than the adjacent pixels. Let the real edge as $E(x,y)$, show in the equation (2):

$$E(x,y) = \begin{cases} 1 & \text{If } S_h(x,y) > S(x,y-1) \text{ and } S_h(x,y) > S(x,y+1) \\ 0 & \text{other condition} \end{cases} \quad (2)$$

Through the two steps, the real edge will be extracted. The accuracy of edge detection has greatly affected blocking effect detection.

C. Flat-region Detection

According to the gradient magnitude, an image can divide into three regions, the edge-region, the texture-region and the flat-region. The flat-region is the smooth part of the image, namely, the magnitude of gradient is smallest than other two regions. The blocking effect is obvious in the flat-region according to human perception. So it can improve the consistency with the MOS. The details of the flat-region detection are as follows:

(1) Find the corresponding pixel that the value of $E(x,y)$ is 1, then compute the gradient of adjacent 4 pixels, and compare to the threshold T_h , show in the equation (3), (4):

$$n_j = \begin{cases} 1 & \text{If } S_h(x,y) < T_h \\ 0 & \text{other condition} \end{cases} \quad (3)$$

$$N = \sum_{j=-2}^2 n_j \quad (4)$$

(2) According to the value of N , judge the pixel in the flat-region or not, if the value of N is bigger than 2, then the pixel is in the flat-region.

D. Block Effect Detection

Due to the image compression using BDCT on the basis of block as a unit, ignores the relativity between blocks. When an image was compressed in a low bit rate, the larger length of quantization step and crudely quantize the parameters of DCT between the adjacent blocks, result in the discontinuity of the block boundaries after reconstitution. This phenomenon of distortion is blocking effect. The greater the compress ratio is, the more serious the blocking effect is. So it is seriously affected the image quality. We can know from this that blocking effect can be measured by computing the edge. The proposed method uses the block strength (BS) and

the block rate (BR) together to measure the blocking effect. The details of method are as follows:

Block strength computation. It is available to get pixel values of the edge of block from equation (1) to (4), then BS can be computed out, show in the equation (5) and (6):

$$B_S(i,j) = \begin{cases} Sobel_h(i,j) & \text{If } N > 2 \\ 0 & \text{other condition} \end{cases} \quad (5)$$

$$BS = (\sum_{i=1}^m \sum_{j=1}^n B_S(i,j)) / (m * n) \quad (6)$$

m, n are the size of the image, N is the result of equation (4), and the BS denotes the block strength.

(1) Block rate computation. Block rate is the proportion between the pixels which were caused blocking effect and the total pixels of the image, it can be computed by equation (7) and (8):

$$B_R(i,j) = \begin{cases} 1 & \text{if } N > 2 \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

$$BR = (\sum_{i=1}^m \sum_{j=1}^n B_R(i,j)) / (m * n) \quad (8)$$

(2) Get the final result Block_R by weighting the BS and BR, show in the equation (9).

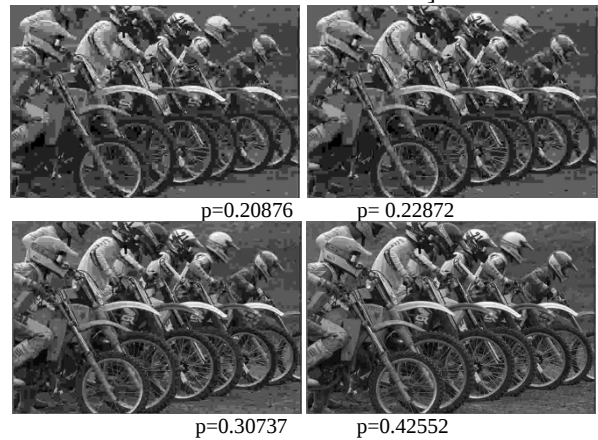
$$Block_R = \alpha BS + \beta BR \quad (9)$$

(3) The values of α and β were defined as follows, show in the equation (10).

$$\alpha + \beta = 1 \quad (10)$$

IV. EXPERIMENT RESULT AND ANALYSIS

The database the paper used is the JPEG serial of the LIVE image database^[37]. Firstly, test 7 images of the bike serial. The compression coefficient $p=[0.20876 \ 0.22872 \ 0.30737 \ 0.42552 \ 0.56447 \ 1.0323 \ 1.4875]$.



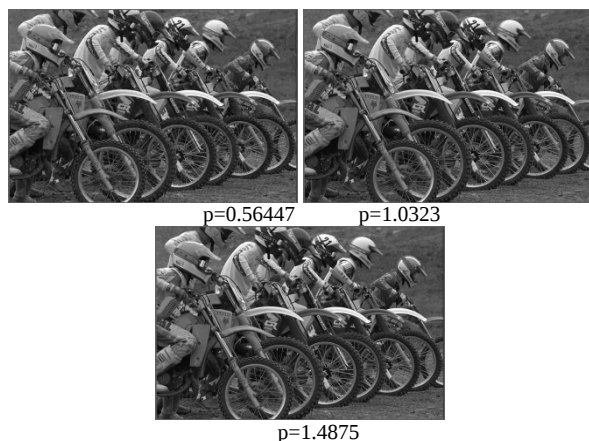


Figure 3 Bike serial images of blocking effect

The correlation between the test results and compression coefficients is showed as the figure 4.

According to figure 4, the larger compression coefficients are, the more serious distortion the image is. But when the compression coefficients are large enough, the result of the metric will not grow in direct proportion. This phenomenon just conforms to the characteristic of the human vision perception, because the human vision is less sensitivity to the image with strong blocking effect. It has good correlation between the test results and the MOS. the coefficient of correlation between the test result

of bike serial and the compression coefficients reaches 96%.

Live image library of JPEG series a total of 29 groups as the embodiment of the algorithm accuracy, in the experiment of Ocean Series, bikes Series, sailing3 Series and caps Series Conduct a separate test, and with the MSE, PSNR Algorithm for comparison, results and block the effect of distortion degree of uniformity. Table I-V shows.

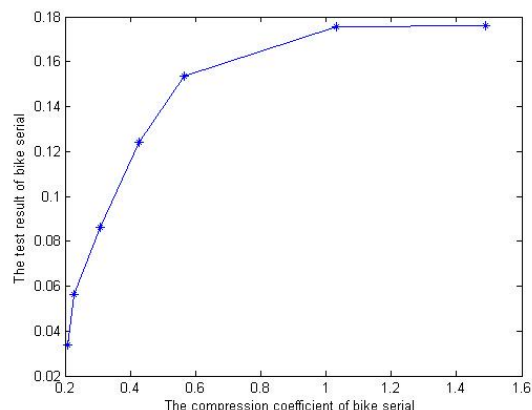


Figure 4 the correlation between the test results and compression coefficients

TABLE I.
MANFISHING SERIES TEST VALUE

Bit rate Comparison value	The original	0.21134	0.33917	0.42286	0.56739	0.95764	1.6232
DMOS fraction		92.905	58.59	48.375	42.615	19.466	8.6231
MSE		396.31	177.11	133.16	91.498	42.762	16.761
PSNR		22.151	25.648	26.887	28.517	31.82	35.888
The algorithm	0.15072	0.000336	0.002823	0.006395	0.018679	0.044184	0.092682

TABLE II.
OCEAN SERIES TEST VALUE

Bit rate Comparison value	The original	0.15037	0.29797	0.48142	0.81917	0.881	1.4233
DMOS fraction		108.77	59.649	34.606	19.872	14.345	6.8371
MSE		233.94	71.803	43.263	23.218	21.105	10.216
PSNR		24.44	29.569	31.77	34.473	34.887	38.038
The algorithm	0.22816	2.34E-05	0.0056	0.024177	0.064001	0.068592	0.11846

TABLE III.
BIKES SERIES TEST VALUE

Bit rate Comparison value	The original	0.20876	0.22872	0.30737	0.42552	0.56447	1.0323
DMOS fraction		84.886	83.034	63.691	53.28	43.04	28.55
MSE		576.76	517.16	350.93	241.83	176.94	86.28
PSNR		20.521	20.995	22.679	24.296	25.653	28.772
The algorithm	0.052335	0.001797	0.001202	0.00277	0.007333	0.009116	0.021311

TABLE IV.
SAILING3 SERIES TEST VALUE

Bit rate Comparison value	The original	0.16271	0.16271	0.33148	0.59313	0.91991	1.8247
DMOS fraction		100.24	99.972	53.616	28.508	18.029	11.74
MSE		246.74	246.74	56.452	26.183	14.391	5.1923
PSNR		24.208	24.208	30.614	33.951	36.55	40.977
The algorithm	0.23868	0.000644	0.000644	0.012405	0.038294	0.084235	0.18737

TABLE V.
CAPS SERIES TEST VALUE

Bit rate Comparison value	The original	0.15312	0.15312	0.1993	0.40535	0.42483	0.85118
DMOS fraction		91.831	91.344	70.025	30.003	33.966	12.565
MSE		169.76	169.76	74.864	25.527	24.01	9.6965
PSNR		25.832	25.832	29.388	34.061	34.327	38.265
The algorithm	0.30643	0.000465	0.000465	0.002297	0.019436	0.020357	0.11063

Figure 5 shows a three series of subjective value DMOS and the algorithm for the evaluation of the correlation between the values .

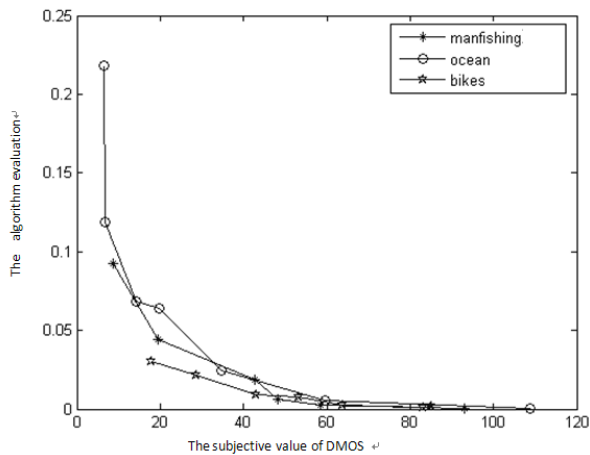


Figure 5 Three series of images and the subjective value of DMOS

In order to reflect the good correlation between the proposed method and the DMOS, the paper take the JPEG for experiment, it contains 204 images wiped off 29 original images, the result is showed on the Figure 6. In order to highlight the advantage of the proposed metric, the paper do the experiment on the whole images, without based on the flat-region, the result is showed on the figure 7. To make a comparison of the two figures, the proposed metric has better correlation. The coefficient of correlation of the proposed metric reaches 94.7%. And the latter one not based on the flat-region is only 83.4%. Therefore, the proposed metric is better than the metric in reference^[28].

V. CONCLUSIONS

Image quality assessment is an open topic in image processing field. The objective quality assessment is obviously superior to the subjective quality assessment. In addition, the non-reference metric is the best metric in the object quality assessment. It not only has high

efficiency, but also is the most convenient and practical metric. The experiments prove that the proposed metric has a good correlation to the MOS, and has a good simulation to the characteristics of human vision. The proposed metric is a non-reference metric, what's more, it has strong adaptability.

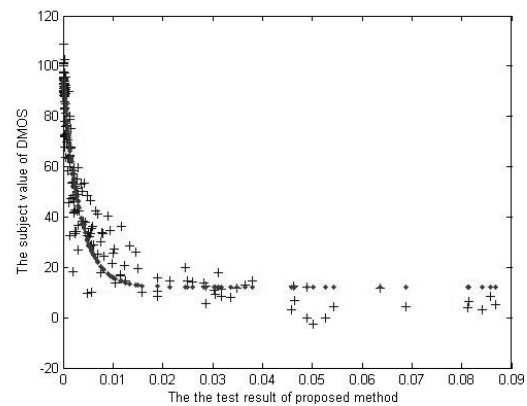


Figure 6 The correlation between the proposed metric and DMOS

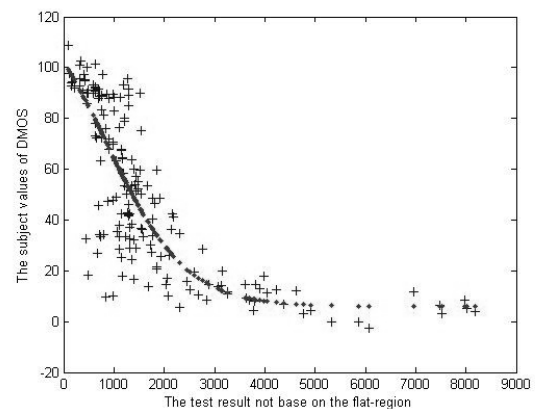


Figure 7 The correlation between the metric without based on the flat-region and DMOS.

ACKNOWLEDGMENT

This work was partially supported by the National Natural Science Foundation of China (No: 60963011, 61162009), the Jiangxi Natural Science Foundation of

China (No: 2009GZS0022), and the Special Research Fund of Shijiazhuang Tiedao University (No: Z9901501).

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