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Binocular Integration Behaviors for Stereoscopic 3D Image Compression

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Abstract — **The objective approaches of 3D image and video quality assessment play an important role in a variety of image processing applications. The additional new challenges faced by 3D image quality assessment are asymmetric stereo compression, depth perception and virtual view synthesis than its 2D counterparts. These challenges are not faced by most commonly used 2D metrics (e.g., PSNR and SSIM).This is verified by the low correlation between the objective and subjective measures (MOSs). Under the assumption that human visual perception is highly adapted for extracting structural information from a scene, we introduce an alternative complementary framework for quality assessment based on degradation of structural information. Inorder to meet these freshly introduced challenges, in this paper, besides 2D-metrics, the binocular integration behaviors—the binocular combination and binocular frequency integration are used as the measures for stereoscopic 3D image. Subjective evaluations are conducted on the publicly available stereoscopic 3D image. Experimental results show that significant consistency can be reached between measured MOSs and proposed binocular metrics. The proposed metric can be used for both Color-Plus-Depth 3D images well. The proposed DOG decomposition may be replaced by Gabor filter bank which is another popular physiological model and the corresponding performance evaluation will be one of our future works.**

Index Terms— **Binocular Vision, Binocular brightness combination, Human Visual System(HVS), MS-SSIM, PSNR, Stereoscopic 3D Image, UQI, VSNR,WSNR.**

I. INTRODUCTION

The field of digital image and video processing deals with signals that are meant to convey reproduction of visual information for human consumption. Image quality assessment plays an important role in various image processing applications. A great deal of effort has been made in recent years to develop objective image quality metrics that correlate with perceived quality measurement. Unfortunately, only limited success has been achieved. Measuring the quality of stereoscopic 3D video is gaining importance, with an increasing amount of content being produced and consumed in 3D. As the technology becomes more widely adopted and mature, quality issues rise to the forefront of concerns. Quality issues for images and traditional 2D video have been studied quite extensively and commercial quality assurance (QA) tools are already being deployed to monitor video quality in real time. Most of these tools are designed to pick out common spatial and temporal distortions of the video resulting from compression and transmission. Generally Image Quality Assessment (IQA) can be classified into two categories. They are Subjective and Objective IQA. Subjective IQA is the ultimate evaluation for human visual system. But it's not mostly employed due to its high cost and complexity.

It's not applicable to the automatic systems. So, we go for Objective IQA .In the Objective IQA Mean Squared Error (MSE), which in turn derived the major similarity evaluation criteria (i.e., PSNR) for image/video compression standards. The traditional 2D objective metrics are suitable only for addressing the stereo images with Symmetric-Stereo compression. The perfect symmetric quality scenario is very unusual to be found in practical a stereo image which makes the traditional 2D objective metrics do not work well in 3D IQA. This work revisits the physiological findings in HVS and proposes a binocular integration behavior based computational framework for dealing with the challenges arisen in 3D IQA. The results demonstrate that significant improvement in performance consistencies between the proposed FI-metrics and the corresponding subjective MOS's can be achieved for both picture quality and depth quality assessments, even if the stereo images are synthesized from another stereo images. These binocular behaviors shed a light on a new paradigm for the developments of IQA on 3D images/videos.

II.WORK OF 3D IQA MODELS

There are many emerging research works of 3D IQA model for Stereoscopic images/videos. Furthermore, we propose a new philosophy in designing image quality metrics: The main function of the human eyes is to extract structural information from the viewing field, and the human visual system is highly adapted for this purpose. Therefore, a measurement of structural distortion should be a good approximation of perceived image distortion. It can be classified into two categories:

Color Information Only:

A multiple channel model is adopted to estimate the stereoscopic image quality assessment. The perceptual

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distortion of a stereo video is computed in DWT domain. Extracted edge information is used in Reduced reference (RR) quality assessment. A learning based quality metric ,StSD(Stereoscopic Structural Distortion) was proposed to address the quality assessment for symmetric or asymmetric video compressions (eg: HEVC) which is the State-Of-Art 3D IQA model for 3D video compression.

Color plus Disparity Information

The overall 3D perceptual quality is evaluated from the quality of color images and disparity maps. The binocular rivalry issues by modeling the binocular suppression behaviors. The No-Reference (NR) 3D IQA was addressed and the performance of research works is comparable and even better than Full-Reference (FR) 3D IQA models.

III. RELATED STUDIES ON BINOCULAR VISUAL SYSTEM

The new 3 challenges come from the interactions between the two eyes, a better understanding of the physiological studies is necessary for the binocular vision. It consists of the two path ways. Three Modules in the quality assessment of the stereoscopic images. They are:

1. Visual pathways of Binocular visual system

2. Binocular Brightness Combination

3. Effects of DoG bands

1.Visual pathways of Binocular visual system:

They describe (1) the visual response of two eyes,(2)the binocular combination behaviors in the visual pathways, (3)the visual information representations .

- **Dorsal Stream:**

  The dorsal stream is the downstream of the physical vision. It starts from V1 to V5.Its employed for about visual guided actions.

- **Ventral Stream:**

  The ventral stream starts from V1 to V4.Its employed for perception and visual guided actions.

  V1 transmits the two streams of visual information to extrastriate visual cortex. Streams have different contributions to stereopsis perception and to the other visual information.The ventral stream has neurons that specifically respond to and help to analyse 3D Binocular Disparity.

  V2 deals with relative binocular disparity detection.V3 deals with velocity, color, orientation and disparity. V4 deals with Perception and recognition.V5 deals visual guided actions.

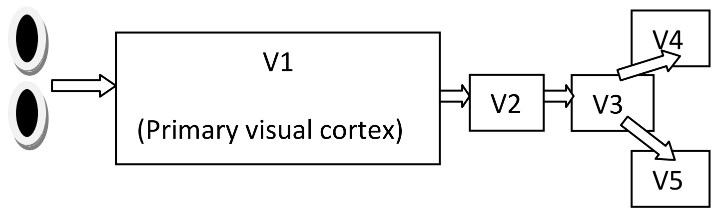

Fig.1. A Simplified illustration of ventral and dorsal stream for neural processing of visual information in brain.

2.Binocular Brightness Combination:

When the input brightness is asymmetric in both eyes there are some binocular behaviors brightness occurs for eg., Fechner's paradox , Cyclopean perception.

Fechner's Paradox:

This describes the phenomenon that when a bright light is applied to one eye then it appears less bright when a dim light is applied to the another eye simultaneously.

Cyclopean Perception:

The cyclopean perception is just the common vision behavior in our daily life.When the two eyes looks at an object it appears as a single image in the brain.

There are many models employed in binocular brightness combination.They are: Eye-weighting model, Quadratic Summation model, Vector Summation model, Neural Network model, Gain-Control theory model.

3.Effects Of DoG Bands:

The Difference of Gaussian is the feature enhancement algorithm. That involves the subtraction of one blurred version of an original image from another, less blurred version of the original. In the simple case of grayscale images, the blurred images are obtained by convolving the original gray scale image with Gaussian kernels having differing standard deviations.

The standard difference-of-Gaussians (DoG) edge detection operator have rendered it less susceptible to noise and increased its aesthetic appeal.

Visual Information Processing From V1 to V4:

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The disparity detection occurs in V1 region by neuron activities on cats. Further experiments are conducted in monkey with normal and anti-correlated Random Dot Stereogram (RDS).Binocular Frequency Integration behaviors is just the binocular related physiological discoveries.

Binocular combination neural behavior:

Many physiological findings about the asymmetric binocular brightness behaviors are necessary for the quality assessment of the asymmetric stereo compression.

The research work used the luminance and contrast masking to derive the just-noticeable-difference (JND) model. The detection ability can be increased in binocular vision and the binocular discrimination will converge to monocular .

Binocular Rivalry:

It's a perceptual effect that occurs when two eyes view mismatched images at the same retinal locations. The term mismatched represents the stimuli received by two eyes are sufficiently different from each other to cause match failures.

Binocular Suppression:

Binocular visual signal is a spatial patchwork of monocular input. In spatial region vision is dominated by either one eye or the other.

No binocular rivalry occurs when the binocular suppression is experienced.

IV. The Proposed Computational Framework

The multiple frequency channel representation is a plausible way to represent the quality assessment of stereoscopic image by employing the visual observation system. The existing 2D metrics is combined with the binocular integration behaviors.

Decomposition of stereo images by Difference-Of-Gaussian (DOG):

DOG filter bank is fed with input stereo images and is built with physiological findings.

Let V(I) be the vector of the DOG-bank-model of I, that is

$$V(I)=[I_{dog}(s_0),\ldots\ldots,I_{dog}(s_{n-1}),\ I_g(s_n)]$$

$$V(I)=[V_0,V_1,\ldots\ldots V_n]\text{-------------------------------}(1)$$

Binocular Combination and Frequency Integration:

Following the equ(1), the original left-eye image I^L and the right-eye image I^R can respectively be represented as

$$V(I)=[V^L_0,\ldots\ldots,V^L_{n-1},V^L_n],\text{----------------}(2)$$

And

$$V(I)=[V^R_0,\ldots\ldots V^R_{n-1},V^R_n],\text{------------------}(3)$$

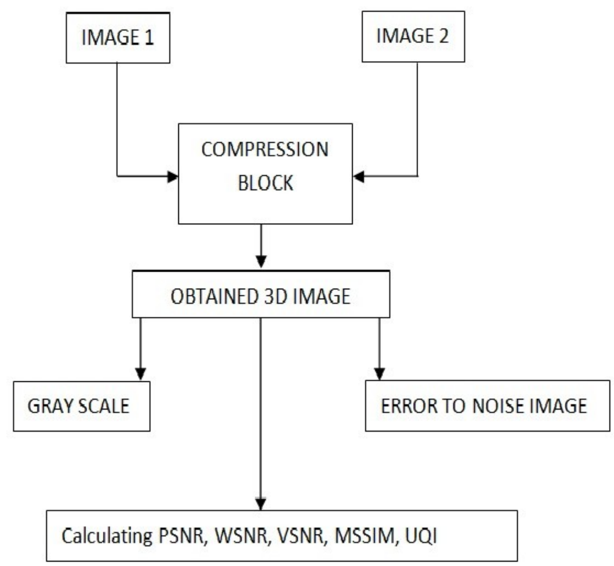
The energy of the DOG frequency band is given as,

$$E(V^L_i)=\sum_{q \in V^L_i} q^2,\ \text{-----------------------------}(4)$$

The gain g^L_i of DOG frequency band is given as

$$g^L_i=[1+E(V^L_i)]/[1+E_L+E_R]\text{--------------------}(5)$$

V.BLOCK DIAGRAM



The two images ie., left eye image and right eye image is given to the compression block. There its compressed into a single image and we obtain a 3D image. Then the gray scale value MSE and the 2D metric parameters are calculated for each image. The results are compared with the proposed metric and the quality of an image is calculated.

VI.EXPERIMENTAL RESULTS

The experimental results are calculated individually for the left and the right eye image. The reference image is compared with the left eye image and right eye image separately and the 2D metrics are calculated and combined with binocular integration behaviors to determine the quality of asymmetric stereo image.

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The subjective data collection, denoted as CML database. Then we denote demonstrate various performance evaluations of proposed FI-Metric on the CML database in the following metrics.

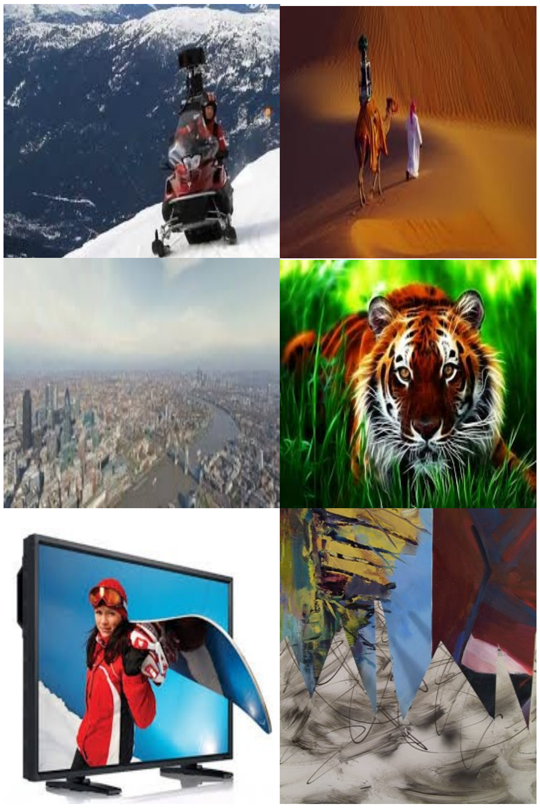
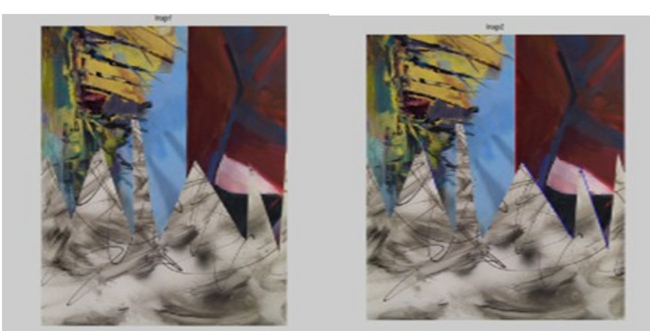
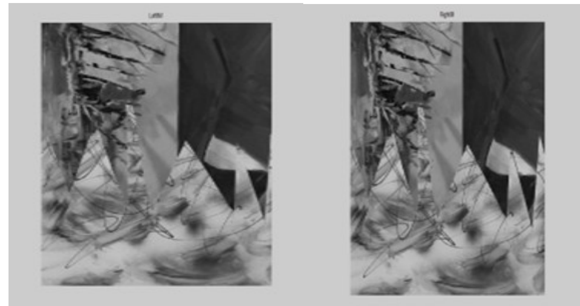


Fig 2: Left eye images of the test data.The 2-view configurations in MPEG CfP on 3DVC for each one of the test images.

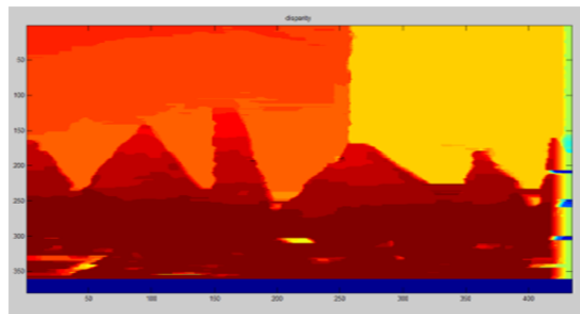
The experimental results consists of the following stages.They are illustrated below:



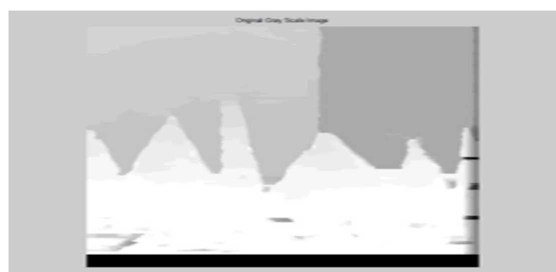
(a)



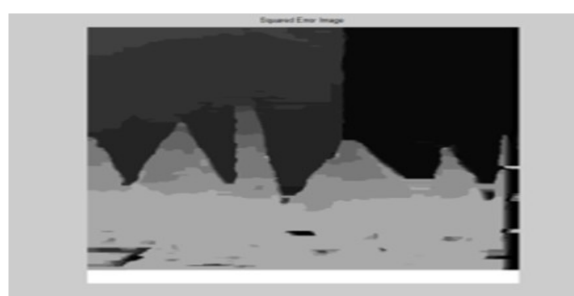
(b)



(c)



(d)



(e)

Fig 3:(a) The input left eye image and the reference image ,(b) Gray Scale image for the input left eye image and the reference image, (c) 3D Disparity values for the two images, (d) Gray scale for the 3D Disparity image,(e) Squared error image

Then the experimental results for the 2D-metric such as PSNR,VSNR,WSNR,UQI,MS-SSIM are calculated for the binocular integration behaviors such as Eye-Weighting

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model, Quadratic Summation Model, DOG and Warping Techniques.

PARAMETERS	PSNR	VSNR	WSNR	UQI	MS-SIM
DoG	0.0570	0.4311	0.1994	0.004	0.3032
Eye Weighting	0.0563	0.4073	0.1969	0.010	0.3032
Quadratic Summation	0.0568	0.3897	0.1986	0.021	0.3107
Warping Technique	0.1135	0.5196	0.1986	0.021	0.3107

This is the table for a single left-eye image (eg:Tsul) compared with the given datasets. Like this the quality of the 3D image is calculated by combining the 2D metrics(PSNR,MSE) with the binocular integration behaviors.

VII .CONCLUSION

Quality Assessment plays an important role in image processing applications.QA can be achieved by subjective and objective metrics.Since the subjective metric is complex and high cost objective metric is employed in QA.They are widely used in compression, communication, printing, analysis, registration, restoration and enhancement.These objective metric is widely employed for symmetric stereo 3D images.For asymmetric stereo 3D images 2Dmetrics is merged with binocular integration behaviors-binocular combination and binocular frequency integration.This revisit the use of HVS i.e., subjective metric along with BIB.Experimental results demonstrates that significant increase can be achieved between the MOSes and the proposed BIB.This approach provides new opportunities to investigate 3D image/video quality. The proposed metric can be used for both Color-Plus-Depth 3D images well. The proposed DOG decomposition may be replaced by Gabor filter bank which is another popular physiological model and the corresponding performance evaluation will be one of our future works.

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