Analysis of Image Quality Based on Perceptual Vision

Liqin Xue1*, Yuning Hua[2],Yaping Qi[1]
[1]Dept. of Electronics & Inform., Shandong University of Science and Technology, Qingdao, 266510,China
TEL: 86(0)13608988418, e-mail:icxlq@hotmail.com
[2]Dept. of Electric Engineering, Shenyang Institute of Tchnology, Shenyang, 100015, China

Keywords : Image quality, perception, assessment, factor analysis

Abstract

This paper deals with image quality analysis considering the impact of psychological factors involved in assessment. The attributes of image quality requirement were partitioned according to the visual perception characteristics and the preference of image quality were obtained by the factor analysis method. The features of image quality which support the subjective preference were identified, The adequacy of image is evidenced to be the top requirement issues to the display image quality improvement.

1. Introduction

Image quality is one of the key properties of the display quality issues. It's the focus of the competition in the high-end display market. The degree to which an image satisfies the usefulness and naturalness requirements determines the quality level of image. Currently the requirement of the display image quality has varied to the impressive image creation from the information fidelity reproduction. However, vision physiology and psychology perception is the interaction process. It brings great challenge to the industry because the impact of psychological factors has not been involved in during display development.

So far the research on visual model for image quality focuses on the error determinability between the original and enhanced images. These methods fit for the specified testing mainly. The tradeoff is made on the accuracy and computing complexity based on the HVS method. Furthermore, the image fidelity specification was proposed to capture the lost signal and rebuild them. Traditionally, researchers have focused on measuring signal fidelity as a means of assessing visual quality. Signal fidelity is measured with respect to a reference signal that is assumed to have "perfect" quality. During the design or evaluation of a system, the reference signal is typically processed to yield a distorted (or test) image, which can then be compared against the reference using so-called full reference (FR) QA methods. This comparison involves measuring the "distance" between the two signals in a perceptually meaningful way.

Image quality model defined by Hauske partitioned the attributes of image, however it was used to analyzing the performance of image processing properties only, it was not taking consideration that the varieties of image quality was caused by preference introduced for consideration. Although psychovisual measures are difficult to develop, due to inherent complexity of the human visual system (HVS), they are necessary for keeping consistency between numerical improvement and perceived quality in image systems. Therefore, intensive efforts have been made in psychovisual metric research, especially in contrast measurement.

This paper discussed the relationship of image quality requirement considering the impact of psychological factors and the result of image enhancement applied on the display currently. The research aimed to validate that the adequacy of image is the top requirement issues to the display image quality improvement. Moreover, the common factors to present the audience preference based on the physiological visual system identified by the reliable quantitative approach. These results are to be the directive to image enhancement development.

2. Rationale

Measurement of visual quality is fundamental importance to numerous image and video processing applications. The goal of quality assessment research

is to assess the quality of images or videos in a perceptually consistent manner.

2.1 Image processing of vision

Images are carriers of visual information instead of two-dimensional signals. Since an image is the result of the optical imaging process, which maps physical scene properties onto a two-dimensional luminance distribution, Therefore, image processing is not as signal processing but instead as information processing.

Display image enhancement is not an isolated process but as an essential stage in human interaction with the environment instead. Hence, visuo-cognitive processing plays a vital role within the interaction process. The quality of an image is not in terms of the visibility of distortions in this image but instead in terms of the adequacy of this image as input to the vision stage of the interaction process.

2.2 The Relationship of image quality and perceptual vision

The transmission and process of scene is implemented by eye-brain system. the front end of the process is the physical reaction of the vision, and the back-end is the psychological reaction after the image came into the brain by optic nerve. Therefore, the image perception is related to the human memories and identification to image.

The field of digital image and video processing deals, in large part, with signals that are meant to convey reproductions of visual information for human consumption, and many image and video processing systems, such as those for acquisition, compression, restoration, enhancement and reproduction, etc., operate solely on these visual reproductions.

2.3 Factor analysis applied to image quality su bject assessment

Factor analysis is a mathematical tool which can be used to examine a wide range of data sets. It has been used in disciplines as diverse as chemistry, sociology, economics, psychology. The focus is the analysis of a 'factor space' or 'data space'. In principle, image quality characteristic could be derived from a subjective study that involves sufficient numbers of observations, times of test, and reception points to yield a sample that represents the population of possible program content and transmission conditions.

Comparing the criteria of image quality, the object data which represent the attribute of the image quality could be obtained by factor analysis method, and they could be the fundament to the image quality requirement assessment.

3. Image quality attributes and assessment environment

The assessment of image quality involves a great amount of subject factors and uncertain ones. Therefore the criteria can be set up considering the audience's requirement of image quality. The preference represents the main characteristics of image quality.

3.1 Image quality attributes partition

To build testing and assessment environment is a workable approach in order to analyze the directive of requirement and to identify the distance between assessment result and image enhancement expectation. The effect of each attribute could be deduced and the critical features which are important to image quality improvement could be identified as well.

There are four visual model including luminance, chrominance, resolution and motion definition. The image quality characteristic could be partitioned according to these models. Furthermore, the image characteristics and its coding were obtained through the feature decomposing based on image quality assessment standards. Table 1 lists the image quality characteristics based on the human vision sensitivity (HVS).

Table 1 Image quality index based on HVS

HVS	Image quality index	Coding
Brightness	Gradation of average brightness	x1
	Gradation of brig. in dark scene	x2
	Fidelity of black level	x3
	Dark noise	x4
	Contrast of dark scene	x5
	Gradation of bright scene	x6
	White saturation	x7
	Average contrast	x8
	Average Picture Level	x9
Color	Color saturation	x10
	Fidelity of hue	x11
	Fidelity of hue in various scene	x12
Resolution	Horizontal resolution	x13
	Vertical resolution	x14
	Smoothness	x15
	Sharpness	x16
Motion vision	sharpness of motion objects	x17
	Clearness of color edge	x18
	Reality of motion reproduction	x19

3.2 The source signal selection

The source signal provides the reference picture directly, and the input for the system under test. The test sequential image was selected from Video Essentials “Montage of Images” and most of the characteristics could be identified from this film. This film was displayed by JVC DVHS player and the test display were selected as three professional television. The test and assessment environment were setup according to the standard ITU-R Bt. 500.

4. Result analysis

4.1 Analysis of image quality Attributes

Principal components amounts to a variance maximizing (varimax) rotation of the original variable space were extracted. In a scatter plot the regression line as the original X axis, rotated so that it approximates the regression line. This type of rotation is called variance maximizing because the criterion for (goal of) the rotation is to maximize the variance (variability) of the new variable (factor), while minimizing the variance around the new variable.

The four image preference factors were extracted from the factor rotation results. Each factors include eigenvalues which account for percent value of the variances. Each factor was named according to the image quality included, as shown as Table2.

Table 2 Factor classification of image quality

Common Factor	Name	Image quality index	Eigenvalues
F1	Image gradation	x2 x5 x7 x8 x9 x10 x15	0.899 0.839 0.934 0.652 0.887 0.849 0.846
F2	Image beauty	x1 x4 x12 x16	0.826 0.777 0.803 0.817
F3	Image resolution	x13 x14 x17 x18	0.874 0.599 0.944 0.610
F4	Image reality	x3 x6 x11 x19	0.739 0.9922 0.726 0.909

The first common factor F1, which named as of image gradation, because luminance gradation in dark scene, contrast in dark scene, white saturation, average contrast, color saturation and sharpness are all express higher eigenvalues, and these elements represent the gradation of image.

The second factor F2, which named as the image beauty, because average brighten gradation, color saturation, dark noise, fidelity of tune in various brightness scenes, and the edge sharpness of object are all have higher eigenvalues, which represent the adequate of image and the acceptance.

The third factors F3, named as image resolution, which has higher eigenvalues on horizontal and vertical resolution, edge sharpness and color edges of motion object. these elements shows the state and motion pictures resolution which audience compared to the nature scenes.

Moreover, the fourth common element F4 has been retained for higher value in scree plot. The fidelity of dark scene, brightness expansion of bright scene, the fidelity of tune and the motion reproduction are all support the reality for the familiar objects and scenes, so that F4 was named as reality.

It was shown that the image preference is tightly related to the visual perception characteristics from the organization of the four common factors. No matter brightness, color, resolution or motion reproduction, almost every image have such image characteristics to support these four factors. Nevertheless, brightness gradation is the primary factor in image quality requirements.

5. Conclusion

The adequacy of image is evidenced to be the top re quirement issues to the display image quality improve ment. The reliable quantitative result is to be the refer ence to image enhancement. Moreover, this approach will be beneficial to the research of the image quality subjective quantitative assessment method.

6. References

1. T.J.W.M .Janssen, Understanding Image Quality. *Proceeding on Image Processing*, Vol (2), 7, (2001).
2. H.R Sheikh, A.C. Bovik. Image Information and Visual Quality. *IEEE Transactions on Image Processing*, Vol. (15): 430 – 444, (2006).
3. Methodology for the Subjective Assessment of the Quality of Television Pictures, ITU-R BT. 500-11, 2002.