TV Image quality evaluation based on the HVS model

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***Abstract* — In modern television, TV images suffer various transformations resulting in a processed image, whose quality can be assessed through a series of conversion factors, which characterize the processing of the TV image. Video quality assessment is an important problem that the producers of TV sets as well as TV programs producers have to face in order to ensure a higher video quality for the chief user. This article proposes and implements an alternative subjective method of TV image quality assessment, derived from the standardized method Double Stimulus Continuous Quality Scale (DSCQS).**

***Index Terms* — Double Stimulus Continuous Quality Scale, assessment, quality, HVS model, TV images.**

I. INTRODUCTION

The human explores the environment by investigating the physicochemical properties of its elements and through the sensory organs receives a certain amount of information that influences its capacity to adapt to the physical reality [1]. The visual information is the most consistent part of the information provided by the environment, being also indispensable in any field of technical or scientific activity.

During its evolution the human became a primarily visual being, developing most of its neurological resources for the sense of sight, thus 80-90% of the human brain neurons are involved in visual perception [10] [11]. It may be said that the human is capable of visually analysing and understanding the environment "in a fraction of a second" and afterwards use this information for a long time in daily activities.

While viewing a TV image the observer's brain interprets the light stimulus applied to the human visual system and builds a unique model of the surrounding world through its physical and mental skills. In other words the television images address to the human visual system as a final observer that can consider them acceptable or enjoyable to view.

II. THE QUALITY CONCEPT OF A TV IMAGE

Practically, the quality refers primarily to the costumer's satisfaction mentioning that the needs of the consumers are either very sophisticated or less sophisticated, but all will appreciate the quality. Also there must be taken into consideration that there is no absolute quality because quality is a variety of features that are addressed to different people with different needs and demands.

Starting from the general concept of quality, the quality of a TV image is a set of characteristics that define the image and reflect the degree of visibility of relevant information that can be extracted by human observers or by specialized computer systems.

In general a TV image is subject to degradation during the entire processing path: image capture (camera), processing (digitization, compression), transmission, reception and image playback in order to be evaluated. Since the human observer is the final evaluator of the TV image quality is beneficial and important to incorporate the human visual system in the processing and assessment applications of the TV image quality [1].

TV image quality is essentially an aesthetic opinion that grows out of the subjective experience of viewing motion images. The subjective experience is formed by the interaction between the visual signal applied to the human eye and the observer's brain that interprets the visual signal [2].

TV image quality is assessed taking into consideration the following important features:

- Clarity
- Temporal resolution or refresh rate
- Tonal resolution
- Spatial resolution
- Image brightness
- Image contrast [1]
- Colour fidelity playback
- Geometric accuracy
- Image outline [4]
- Presence/absence of artefacts
- Presence/absence of noise.

The ability of a human observer to asses a TV image is a function dependent on a number of physical and psychological factors, such as:

- Specific non-linearity of the video camera's components
- Optical imperfections of the human eye
- The observer's experience in assessing TV images.

Since the mechanism of visual processing of the images supplied by the retina to the human brain are insufficiently explained it is impossible to formulate a measure of a television image intelligibility based on a perception model.

III. FACTORS THAT AFFECT THE TV IMAGE QUALITY

In television practice, the quality of a TV image is determined by quality of the processes it passes through, as seen in Figure 1 [1].

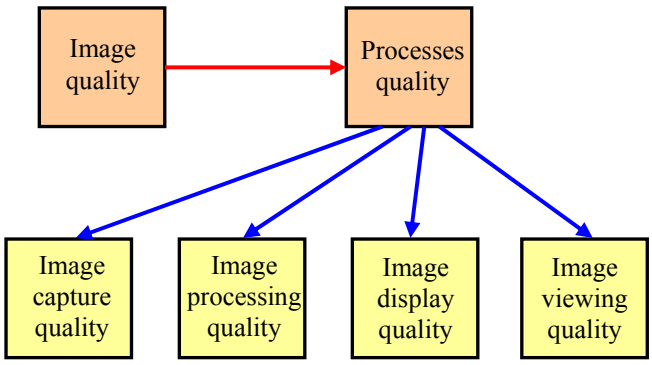

Figure 1. Image quality components

In modern television, TV images suffer various transformations resulting in a processed image, whose quality can be assessed through a series of conversion factors, which characterize the processing of the TV image [7] [10]. In general the producers of TV programs monitor that image processing doesn't reduce the quality of the processed image, but very often do not manage this. The specialized literature presents a variety of artifacts that are distinguished in processed TV images, using a variety of compression algorithms:

- Blocking effect
- Blurring
- Staircase effect
- Ringing
- False edges
- Mosquito effect
- Aliasing
- Flicker effect.

IV. SUBJECTIVE EVALUATION OF TV IMAGE QUALITY

Video quality evaluation is an important problem that the producers of TV receivers as well as TV programs producers have to face in order to ensure a higher video quality for the chief user – the viewer. The transition to digital television causes either the international identification and standardization of new quality assessment methods or the adaptation to the current needs of the classical standard methods [12].

The necessary combination for video quality assessment is brain – eye and it is a detector in permanent change, very efficient in the comparative assessment of video quality but rather weak in absolute quality evaluation (especially for the non-experts) [2].

The subjective evaluation is using human observers for the assessment, the comparison or the determination of image quality that do the subject of this test. The subjective evaluation is the most efficient way to determine the actual quality of TV images and impossible to be replaced by objective assessment because the measurement techniques of the subjective evaluation base on a crucial factor, namely the human observer's impression while viewing motion images.

In the sphere of subjective assessment there are several different methodologies, categories of observers and also norms and standards for the design and definition of the subjective tests. The subjective evaluation is used in order to obtain the necessary results for two purposes: setting (improved images) and opinion (cataloguing the performance of a system/ video equipment) [5]

Most often, in practice the following methods of quality subjective assessment are used:

- *DSCQS* (*Double Stimulus Continuous Quality Scale*) – multiple reference scene pairs with the reference and degraded scenes randomly, scoring is on a continuous quality scale from excellent to bad where each scene of the pair is separately rated but in reference to the other scene, method is based on the difference in rating of each pair;
- *DSIS* (*Double Stimulus Impairment Scale*) – multiple reference scene, degraded scene pair, reference is always first, scoring is commonly known as a five point scale from imperceptible to very annoying;
- *SS* (*Single Stimulus*) – no repetition of test scenes, different scoring methods (adjectival – 5 half-grade scale, numerical – 11-grade scale, non-categorical – continuous scale with no numbers or a large scale);
- *SSCQE* (*Single Stimulus Continuous Quality Evaluation*) – continuous program evaluated over long period, scoring is a distribution of the amount of time, this method relates well to the time variant qualities of compressed television system.

Human sensitivity to various deterioration of the image is a function dependent on the viewing experience and on the imperfections' observation time. The television images played on the TV sets screens are perceived by the human observer according to a series of quality factors such as:

- Individual goals and expectations: according to human observers' passions is expected that each will have different requirements on the video quality of the television images.
- The viewing's specific conditions form a combination of parameters so that the human observer is able to detect elements within the evaluated image [7]:
    - The lighting of the room where the evaluation is taking place
    - The viewing distance
    - The viewing time
    - The size of the items that are to be observed
    - The contrast between the items to be observed and the background image
- Individual goals and expectations: according to human observers' passions is expected that each will have different requirements on the video quality of the television images.
- The type and parameters of the TV sets screen:
    - Representative types of TV sets screens: CRT, LCD, PDP, projection systems etc.;
    - The screen's parameters: brightness, contrast, colour play, response time etc. and

the size, the aspect ratio and the screen resolution [8] [3] [9];

- The fidelity of the playback image, meaning the capacity to play the television image with minimal distortions introduced by the transmission path;
- Associated sound transmission because the sound has great influence on the perception of the quality of TV images. [10];
- The qualities of the human observer implied in the observation process.

V. A PROPOSED METHOD FOR THE SUBJECTIVE EVALUATION OF TV IMAGE QUALITY

According to ITU-R BT.500-10 Recommendation a methodology for video quality subjective evaluation was used and an alternative version of the DSCQS (*Double Stimulus Continuous Quality Scale*) method is proposed.

The subjective evaluation procedures require some conditions for the test image viewing: the viewing room conditions and the conditions for the TV set used in the test.

For the viewing room the following minimum conditions were provided:

- The viewing distance has to be equal to the height of the screen multiplied by three
- The viewing maximum vertical angle of 15°
- For optimal view the room has to be dark, the ambient lighting has to have maximum 3 lux.

For the video tests a TV set with slim CRT and a diagonal of 86 cm was chosen, the following mandatory conditions being respected [6]:

- The colour TV set will be warmed up for at least 20 minutes before the test;
- The static and dynamic focus will be adjusted for maximum visibility of fine details;
- Colour purity must be optimal;
- Raster geometry will be adjusted for minimal errors;
- The displayed image should not produce convergence errors;
- Screen brightness will be adjusted to 12 lux (the brightness will be measured from a distance of 50 cm with a Peak Tech 5025 luxmeter, disposed perpendicular to the screen).

The observers will be chosen depending on age and sex. 24 non-experts observers will be selected with ages between 21 and 50 years old (proportional to each age group), half female and the other half male. All observers will be trained and initiated before the evaluation. It is also necessary that the observers pass the *Snellen Eye Chart*© and *Ishihara*© tests in order to obtain convincing results in the subjective evaluation [6]. The alternative proposed method is based on the successive viewing of a series of an X and Y pair images, where X is the reference image (original) and Y is the processed image with the H.264 algorithm by a SoC system of the DVEVM 6446 development platform, produced by Texas Instruments Company (Figure 2).

Figure 2. The DVEVM 6446 development platform

Figure 3 shows the image sequence and the corresponding display times. The proposed method assumes that the observers will know from the start the images' display order.

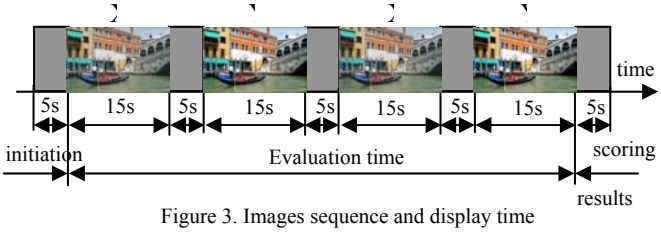

Figure 3. Images sequence and display time

The observers will analyse both images and the subjective quality of the reference and test images will be evaluated using a damage double and continuous scale (according to figure 4) from 0 (bad quality) to 100 (excellent quality). The five known levels of quality deterioration are taken into consideration as follows: very good (99...80), good (79...60), fair (59...40), poor (39...20) and very low (19...1).

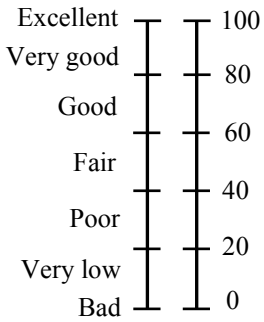

Figure 4. The deterioration scale

The possible problems that require attention during testing are:

- Poor image or inappropriate reproduction of details;
- Unsatisfactory colour, contrast or brightness reproduction;
- Unsatisfactory reproduction of motion images;
- Image accompanied by noise or various artifacts.

The evaluation consists of four series of video presentations, each being composed of four viewings of the same video sequence.

A number from 1 to 4 will announce verbally each series of presentations. The first video sequence of the series will be announced as X and the second sequence as Y. The video pairs will be repeated until the end of the series. X marks the reference images and Y marks the test images but it is not known which of the two has a higher quality.

The observers will note the score as illustrated in the example of figure 5.

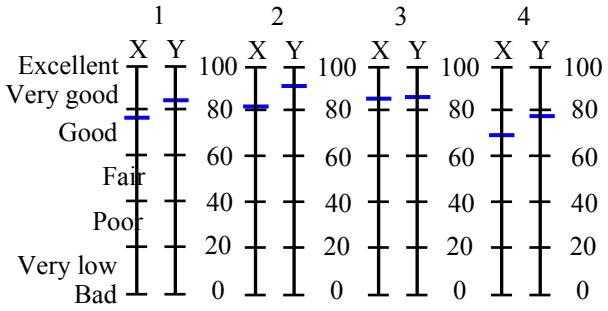

Figure 5. Example of a TV image qualities scoring sheet

The final results will be statistically processed and presented graphically as seen in figure 6. Thus a dependency relationship can be found between the subjective quality and chosen parameter (for example: the compression algorithm).

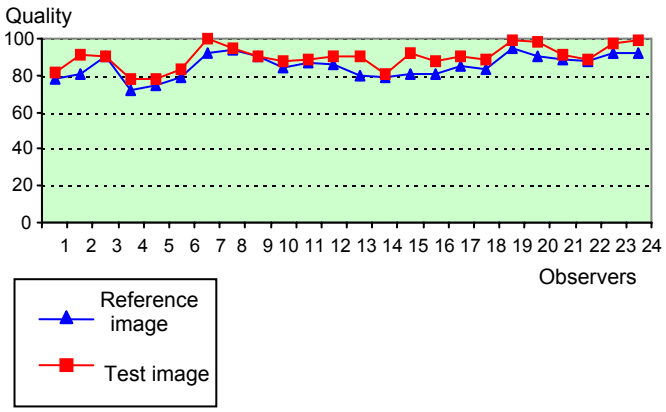

Figure 6. A comparison between reference image evaluation and the processed image [6]

After processing the results it is considered that the test image (image processed using the digital techniques of the DVEVM 6446 development platform) is superior to the reference image, thus demonstrating the improvement possibility of the TV sets performances using SoC-type systems for video applications.

VI. CONCLUSIONS

An alternative method for subjective evaluation of TV images, derived from the standardized method Double stimulus Continuous Quality Scale (DSCQS), was proposed and implemented.

The proposed evaluation method was used for assessing and comparing a reference image (original) and a processed image with the H.264 algorithm by a SoC system of the DVEVM 6446 development platform produced by the Texas Instruments Company.

A special form for the evaluations score marking was accomplished. The SoC ability to improve the image quality was demonstrated.

REFERENCES

[1] S.J. Băluță, M. Pearsică, T. Florea, „Calitatea imaginii – de la definire concept la aplicații”, Editura Matrix Rom, București, 2008

[2] R. Gregory, “Eye and Brain. The Psychology of Seeing”, Fifth edition, Oxford University Press, UK, 1998

[3] A.M. Lund, „The influence of video image size and resolution on viewing-distance preferences”, SMPTE Journal 102(5), pp.407-415, 1993

[4] G. Nicolae, „Măsurări electronice în sistemele de radiodifuziune”, Editura Tehnica-Info, Chișinău, 2007

[5] D.G. Pelli, B. Farell, „Psychophysical methods. Handbook of Optics: Fundamentals, Techniques and Design”, 2nd edition, McGraw-Hill, 1995

[6] S. Pohoață, „Teză de doctorat”, Universitatea „Ștefan cel Mare”, Suceava, Romania, 2009

[7] P. Sprawls, „Image Characteristics and Quality”, http://www.sprawls.org/ppm/2/IMGCHAR/

[8] J.H.D.M. Westerink, J.A.J. Roufs, “Subjective image quality as a function of viewing distance, resolution and picture size”, SMPTE Journal 98(2), pp.113-119, 1989

[9] S. Winkler, „Digital Video Quality. Video Models and Metrics”, John Wiley & Sons Ltd., The Atrium, Southern Gate, Chichester, West Sussex, England, UK, 2005

[10] S. Winkler, C. Fuller, „Audiovisual quality evaluation of low-bitrate video”, Proceedings SPIE Human Vision and Electronic Imaging, San Jose, California, 2005

[11] R.A. Young, „Oh say, can you see? The physiology of vision”, Proc. SPIE Human Vision, Visual Processing and Digital Display, vol. 1453, pp.92-123, San Jose, California, USA, 1991

[12] W. Zou, P. Corriveau, „Methods for evaluation of digital television picture quality”, SMPTE 138th Technical Conference and World Media Expo, pp.146-157, October, 1996