Evaluation of Video Quality Based on Objectively Estimated Metric

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Abstract: **Multimedia applications, and especially encoded video services, are expected to play a major role in the 3rd generation (3G) and beyond mobile communication systems. Given that future service providers are expected to provide video applications at various price and quality levels, quick and economically affordable methods for preparing/encoding the offering media at various qualities are necessary to be developed. This paper presents a method for objective evaluation of the perceived quality of MPEG-4 video content, based on a quantification of subjective assessments. Showing that subjectively derived perceived quality of service (PQoS) vs. bit rate curves can be successfully approximated by a group of exponential functions, the proposed method exploits a simple objective metric, which is obtained from the mean frame rate vs. bit rate curves of an encoded clip. The validity of this metric is assessed by comparing subjectively derived PQoS results to the corresponding ones, which come from the proposed objective method, showing that the proposed technique provides satisfactory PQoS estimation.**

Index Terms: **MPEG-4, objective measurements, perceived quality of service (PQoS).**

I. INTRODUCTION

The mobile communication systems of the 3rd generation (3G), among which UMTS is the most dominant, will provide the platforms for a multitude of novel services and applications. Multimedia-enriched services, including Internet access, downloading, and streaming of short video clips, etc., are expected to lead in usage, operator revenue and bandwidth consumption in mobile networks. The delivery of on-demand mobile media will enable many powerful services (like video telephony and playback of short video clips, etc.), making even more important the need for quality of service in 3G networks.

One of the 3G visions is that multimedia services will be sold in a consumer mass market based on the provision of content at a requested quality [1]. There are a number of approaches to this, one being the use of perceived quality of service (PQoS) concept. The evaluation of the PQoS for multimedia and audiovisual content that have variable bandwidth demands will provide a user with a range of choices covering the possibilities of low, medium, or high quality connections, indication of service availability and cost. The future end users will be able to choose the QoS level that they want to start the session with, so that the service provider can launch the service with a set of parameters that match those requested by the user [1].

The application of the PQoS concept gives the operator (or even the service provider) the capability of a better exploitation of the network resources for delivering multimedia applications (like MMS-video) to the users, because it is possible to allocate only those radio resources sufficient to maintain user satisfaction. Since this is true for each user, then the overall allocation of the radio resource results in an optimization of the system spectral efficiency.

The information society technologies (IST) project Enthrone (FP6-507637) aims to promote the adoption and usage of the perceived quality of service (PQoS) concept in upcoming 3G networks. In this context, one of its major objectives is to develop efficient and cost-effective solutions for the delivery of the envisaged services at a requested (user perceived) quality. This is essential for those services targeting a consumer mass market (existing and new QoS-based interactive services) and will in turn justify the investment to such services and technologies for the business entities involved in a 3G (and beyond) venture.

In order to provide audiovisual content at different perceived quality levels, it is necessary to define the variation of PQoS as an equation of the encoding bit rate. Precise curves of PQoS vs. bit rate can be derived using an audience of people, who are watching a short video clip and score its quality, as perceived by them. However, this procedure is expensive and time consuming. For actual commercial applications, objective measurement of PQoS for any type of video content is required. In this respect, this paper defines a simple metric for the measurement of the PQoS level and presents a method that is capable of making objective measurements of the perceived quality of audiovisual content, in the form of a short video clip. The results of this method can be used by a service provider in order to encode the various available on-demand media clips at bit rates, which correspond to specific quality levels. In this way, the provider achieves an optimization of the storage requirements and system bandwidth efficiency.

The rest of the paper is organized as follows. Section II presents literature review and related work in the issue of PQoS evaluation. In Section III, a quantification of subjective assessments is presented. Section IV describes the proposed objective PQoS evaluation method. Section V extends the experimental measurements to real captured video clips, proving therefore the validity of the proposed metric to no-reference clips. Section VI examines the efficiency of the proposed method by comparing subjectively derived data to the corresponding ones that result

Manuscript received October 17, 2003; approved for publication by Hanseok Ko, Division I Editor, April 20, 2005.

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from the proposed method. Finally, Section VII concludes the paper.

II. LITERATURE REVIEW AND RELATED WORK

Lately, emphasis has been put on developing methods and techniques for evaluating the perceived quality level of video content. These methods can be mainly categorized into two major classes, the subjective and objective ones.

The subjective test methods involve an audience of people, who watch a video sequence and evaluate its quality as perceived by them, under specific and controlled watching conditions. The mean opinion score (MOS) is regarded as the most reliable method of quality measurement and has been applied on the most known subjective techniques: The single stimulus continue quality evaluation (SSCQE) and the double stimulus continue quality evaluation (DSCQE) [2]–[4]. However, the MOS method is inconvenient due to the fact that the preparation and execution of subjective tests is costly and time consuming. For this reason, a lot of effort has recently been focused on developing cheaper, faster and easier applicable objective evaluation methods. These techniques successfully emulate the subjective quality assessment results, based on criteria and metrics that can be measured objectively. The objective methods are classified, according to the availability of the original video signal, which is considered to be in high quality.

The majority of the proposed objective methods require the undistorted source video sequence as a reference entity in the quality evaluation process and due to this are characterized as full reference methods [5], [6]. These methods are based on an error sensitivity framework with most widely used metrics the peak signal to noise ratio (PSNR) and the mean square error (MSE).

However, these overused metrics have seriously been criticized that they do not provide reliable measurements of the perceived quality [13]. For this reason, a lot of effort has been focused on developing assessment methods that emulate characteristics of the human visual system (HVS) [7]–[10] using contrast sensitivity functions (CSF), channel decomposition, error normalization, weighting and finally Minkowski error pooling for combining the error measurements into a single perceived quality estimation. An analytical description of the framework, which these methods use, can be found in [11].

However, it has been reported [12], [13] that these complicated methods do not provide more reliable results than the simple mathematical measures (such as PSNR). Due to this some new full reference metrics that are based on the video structural distortion, and not on error measurement, have been proposed [14], [15].

On the other hand, the fact that these methods require the original video signal as reference deprives their use in commercial video service applications, where the initial undistorted clips are not accessible. Moreover, even if the reference clip is available, then synchronization predicaments between the undistorted and the distorted signal (which may have experienced frame loss) make the implementation of the full reference methods difficult.

Due to these reasons, the recent research has been focused on developing methods that can evaluate the PQoS based on metrics, which use only some extracted features from the original signal (reduced reference methods) [16] or do not require any reference video signal (no reference methods) [17], [18].

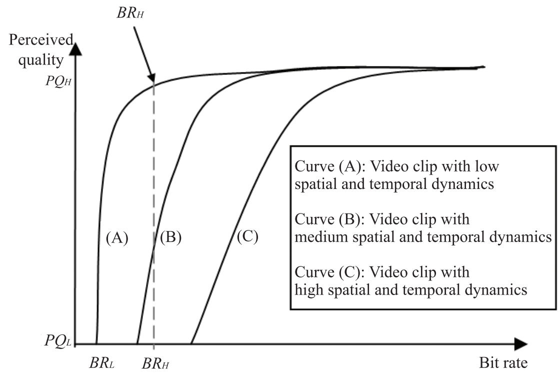

Fig. 1. PQoS vs. bit rate curves.

All the aforementioned post-encoding methods may require repeating post-encoding tests in order to determine the encoding parameters that satisfy a specific level of user satisfaction, making them time consuming, complex and impractical for implementation on the 3G/4G multimedia mobile applications. Due to the fact that the 3G/4G vision is the provision of audiovisual content at various quality and price levels [1], there is great need for developing methods and tools that will help service providers to predict quickly and easily the PQoS level of a media clip. These methods must be able to determine the specific encoding parameters that satisfy a certain quality level, without the need of repeating post-encoding tests and quality evaluations.

In this context, this paper presents a novel objective evaluation method, based on a quantification of subjective evaluation results, which will enable the quick and easy estimation of the PQoS level for MPEG-4 coded video clips, alleviating therefore the time requirements of the already existing methods.

III. DEFINITION OF METRICS FOR EVALUATING PQOS

Among the standardized digital video encoding formats (MPEG-1/2/4), the MPEG-4 [19] is mostly preferred in the distribution of interactive multimedia services over IP, while MPEG-2 is almost exclusively used in DVB networks. Furthermore, MPEG-4 is most suitable for 3G networks, because it provides better encoding efficiency at low bit rates, compared to the other two formats, given that UMTS can reach up to 2 Mbit/sec maximum bit rate. The most reliable method to measure the perceived quality level of audiovisual content is to use subjective evaluations. Curves of PQoS vs. bit rate can be derived using an audience of people, who are watching a short video clip and score its quality, as perceived by them [4], [20]–[23]. Such curves are shown in Fig. 1. Curve (A) represents a video clip with low temporal and spatial dynamics, whose content has “poor” movements and low picture complexity. Curve (C) represents a short video clip with high dynamics. Curve (B) represents an intermediate case. According to these subjective experiments, it can be derived that when the encoding bit rate drops below a certain threshold, which is depended on the video content, then the quality practically collapses.

Moreover, the quality improvement is not significant for bit rates higher than a specific threshold, which is also dependent on the spatial and temporal activity of the clip. Finally, it is derived that the variation of the quality level versus the encoding bit rate is a non linear increasing function, with slope depending on the video dynamics. Thus, it is evident that video dynamics play a major role in the shape of the PQoS vs. bit rate curve. Furthermore, as more than one video may have similar dynamics, each curve corresponds to a family of videos with related characteristics (dynamics).

This paper proposes that each PQoS vs. bit rate curve can be characterized by (a) the low bit rate (BR_L), which corresponds to the lowest value of the accepted PQoS (PQ_L) by the audience, (b) the high bit rate (BR_H), which corresponds to the minimum value of the bit rate for which the PQoS reaches its maximum value (PQ_H) (see BR_H for curve (A) in Fig. 1), and (c) the shape and subsequently the inclination of each curve. From the curves of Fig. 1, it can be deduced that video clips with low dynamics have lower BR_L and higher inclination than clips with high dynamics.

A general analytical expression for the curves in Fig. 1 has not yet been derived and there is still work to be done in theoretical level. Furthermore, the fact that these curves are derived from subjective tests deprives their use in practical and commercial systems. A simplified approach to these curves, based on metrics that can be derived objectively, would be very useful for applications in commercial systems.

The method proposed in this paper is based on an exponential approximation of the curves of Fig. 1. Each curve can be approximately described by an equation of the form

$$PQ = (PQ_H - PQ_L)(1 - e^{-a(BR - BR_L)}) + PQ_L, \quad BR > BR_L \text{ and } \alpha > 0 \tag{1}$$

where PQ is the perceived quality level of a specific video clip at bit rate BR, with PQ_H and PQ_L being the maximum and minimum quality levels, respectively. The parameter α defines the shape and subsequently the inclination of each curve.

From (1), it is evident that the PQ level of a specific video clip can be defined, provided that BR_L and parameter α are known (considering that PQ_H remains practically constant for all the test videos). In this respect, in the following sections a correlation between BR_L and parameter α is derived, which entails that the objective evaluation of only one metric (i.e., BR_L) is sufficient to estimate the various PQoS levels of a video clip.

IV. OBJECTIVE ESTIMATION OF BR_L AND CORRELATION WITH PARAMETER α

For the needs of the proposed method, five test video clips with different content dynamics each, were used. Their initial encoding format was MPEG-2/PAL at 12 Mb/s. These well known video clips have been developed by Tektronix corp. and Sanoff laboratories and are shown on Table 1. Each test video clip was transcoded from its original MPEG-2/PAL format at 12 Mb/s to DivX MPEG-4 format, at various constant bit rates (CBR) from 50 kbps to 500 kbps. For each bit rate, a different MPEG-4 file was created. CIF (common intermediate format) resolution (352×288), smoothness parameter equal to 80% and constant frame rate with 25 frames per second (fps) were common parameters for the transcoding process in all test videos.

Table 1. The five test video clips.

Clip 1	Low dynamics	Suzie
Clip 2	:	Cactus & Comb
Clip 3	:	Table tennis
Clip 4	High dynamics	Flower garden & Mile
Clip 5		Mobile & Calendar

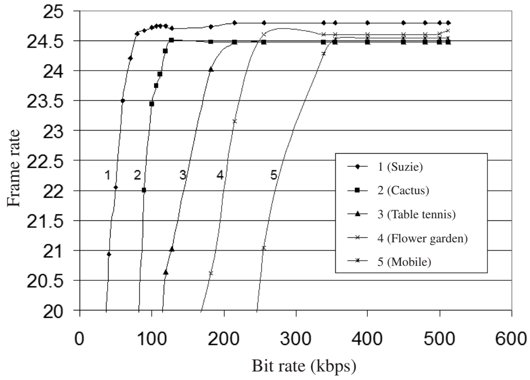

Fig. 2. The mean fps vs. bit rate curves for CIF resolution and 80% smoothness parameter.

Each MPEG-4 video clip was then played back using a suitable Microsoft media player, featuring an option to measure the mean value of fps over the whole duration of the video clip (statistics option). During playback, it was observed that the perceived quality decreases as the bit rate drops, even though the mean frame rate remains constant to the initial value (i.e., 25 fps for the experiments of this paper), as measured by the player statistics tool. It was also observed that when the bit rate drops below a certain threshold, picture pauses appear. These can be measured by the mean frame rate, which drops below the initial value (25 fps), as measured by the statistics tool.

The variation of the mean frame rate during playback, versus encoding bit rate is shown in Fig. 2, for the various test video clips. Note that since the statistics tool measures mean values, the points on the curves do not correspond always on integer values. The content of each video clip and its corresponding numbering is shown in Table 1. Clips 1, 2, $\cdots$, 5 are listed in ascending order, concerning the dynamics of their video content. From Table 1 and the curves of Fig. 2, it is evident that the value of the bit rate, below which the mean frame rate drops under its original value (25 fps), depends on the video content dynamics of the clip. In other words, video clips with high dynamics (e.g., Mobile & Calendar) require higher encoding bit rate to maintain the mean fps value at its initial value (i.e., 25), than video clips with lower dynamics (e.g., Suzie).

In order to correlate curves of Figs. 1 and 2, the following assumption can be made. When the frame rate drops below 25 fps, the perceived quality is considered to be unacceptable. So, it is possible to consider that the BR_L value of each curve in

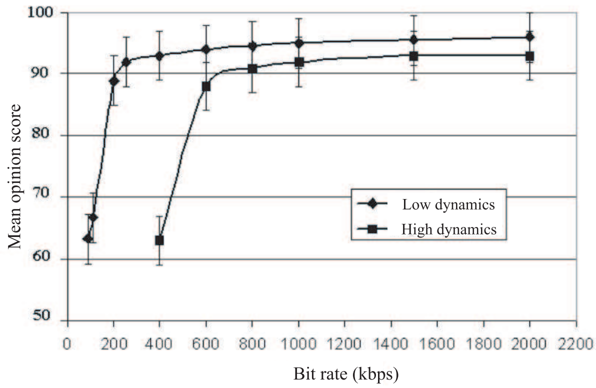

Fig. 3. Mean opinion score vs. bit rate derived from subjective test for videos with high and low dynamics.

Fig. 4. Comparison between two frames from the test signal "Suzie" encoded with MPEG-4/CIF at $BR_L = 90$ kbps and $BR_H = 2.5BR_L = 225$ kbps.

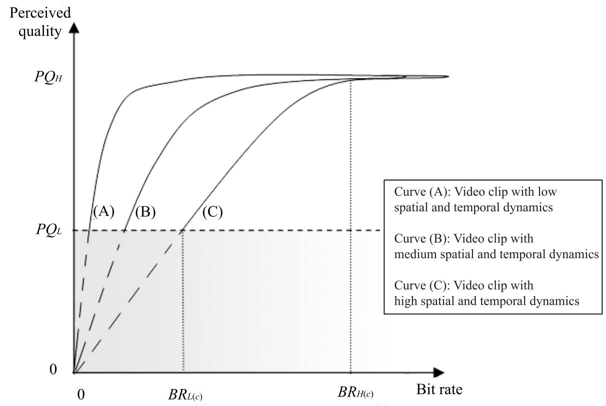

Fig. 5. Theoretical approach of equation $BR_H = 2.5BR_L$.

Fig. 1 is equal to the objectively measured bit rate in Fig. 2, where the curve starts to bend. Both values correspond to the minimum level of accepted perceived quality (PQ_L).

Therefore, this paper proposes that BR_L can be objectively defined by the encoding bit rate, below which the target-initially selected frame rate (25 fps) cannot be achieved. This means that for lower bit rates than BR_L, the frame rate drops below its initial value. The explanation of this phenomenon lies on the fact that the rate algorithm of the encoder is not able to achieve the target low bit rate value by altering only the quantization scale. Therefore, the encoder is forced to exclude some frames from the encoding process. By this way the total information is minimized, and the target low bit rate can be successfully achieved. The bit rate, at which the frame loss begins, depends on the spatial and temporal complexity of each video sequence. This observation is reconfirmed by the experimental results of Fig. 2, where the frame loss for high dynamics clips occurs at higher bit rates in comparison to low dynamics clips. Although in MPEG-4 encoders, it is possible to select the encoding frame rate (typically 10 to 30 fps), for reference reasons, the frame rate that was used for all the test signals in this paper, was equal to 25 fps.

In order to specify the shape of an exponential curve, like the ones in Fig. 1, it is sufficient to define one point of the curve and parameter α (see (1)). This point can be (BR_L, PQ_L), where PQ_L is the lowest acceptable perceived quality level. Parameter α can be defined using a second point of the curve, which can be selected to be (BR_H, PQ_H), where PQ_H the maximum achieved quality level. The value of BR_L can be objectively measured, as explained above. The value of BR_H can be obtained indirectly, from BR_L.

In order to define the relation between BR_L and BR_H, a subjective evaluation process was used. In this respect, an audience of ten people was asked to watch and score twenty high dynamics and twenty low dynamics video clips, which were encoded at various constant bit rates with DivX MPEG-4/CIF format and constant frame rate equal to 25 fps. Encoding bit rates were varied from 80 to 2000 kbps, depending on the video dynamics. Fig. 3 illustrates the mean opinion score (MOS) vs. the encoding bit rate for the quality assessment of the twenty high and low dynamics test signals, respectively. The scale that was used in these subjective evaluation experiments, is the DSCQS ITU-R [3], [22] hundred scale, which considers best possible quality $PQ_H = 100$ (i.e., excellent quality) and lowest acceptable quality level $PQ_L = 60$ (i.e., fair quality).

From Fig. 3, it can be verified that, when the bit rate exceeded a specific threshold (1000 kbps for high dynamics and 250 for low dynamics clips), the viewers assessed that the quality is not substantially improved any more. Given this and provided that the value of BR_L was around 400 kbps and 90 kbps, for high and low dynamics videos, respectively, it can be deduced that when the ratio BR_H/BR_L equals to 2.5, the quality has approximately reached satisfactorily its best quality level. Fig. 4, depicts two representative frames derived from the test sequence Suzie, encoded at $BR_L = 90$ kbps and $BR_H = 2.5BR_L = 225$ kbps with MPEG-4/CIF, from where the substantial quality improvement can be observed.

The above experimentally derived expression of BR_L and BR_H (i.e., $BR_H = 2.5BR_L$) can be theoretically justified, based on the proposed exponential approximation of PQoS vs. bit rate curves. Considering that the curves of Fig. 1 can be extended to values below PQ_L (i.e., to unacceptable/annoying quality levels), Fig. 5 can be derived. It is assumed that, theoretically, all curves converge to $PQ = 0$, although the gray area (dashed lines) is not acceptable for actual services provision. From this figure, it can be deduced that the subjectively derived PQoS vs. bit rate curves can be represented as segments of an exponential curves family, which can be described by the

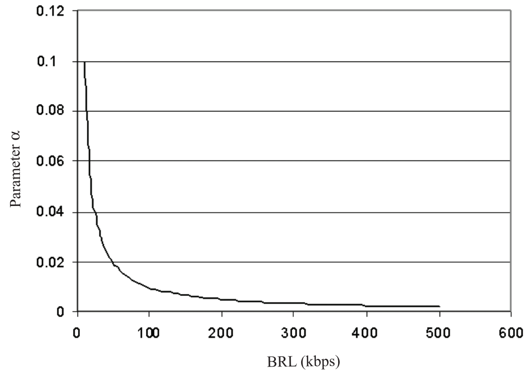

Fig. 6. Parameter α vs. BRL.

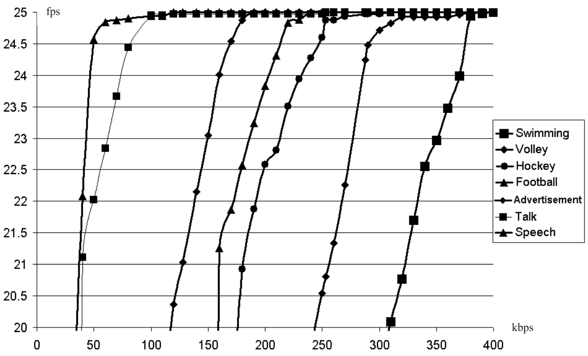

Fig. 7. Mean fps vs. kbps for actual/non-reference video clips (CIF resolution).

expression

$$PQ = PQ_H(1 - e^{-\alpha BR}) \tag{2}$$

where only the parameter α, and subsequently the slope, changes according to the video dynamics. Therefore, (2) covers all the possible PQoS curves that may be derived from any group of clips with low, medium or high spatial and temporal activity level. Equation (2) can be directly derived from (1) without loss of generality by setting $PQ_L = 0$ and $BR_L = 0$.

From (2), the BR_L value, which corresponds to PQ_L, can be expressed as

$$BR_L = \frac{\ln \frac{PQ_H}{PQ_H - PQ_L}}{\alpha}. \tag{3}$$

Thus, replacing in (2) the BR value with the expression $k \cdot BR_L$, it is deduced that

$$PQ = PQ_H \left[1 - (\frac{PQ_H - PQ_L}{PQ_H})^k \right]. \tag{4}$$

Finally, replacing in (4) $PQ_H = 100$, $PQ_L = 60$, and $k = 2.5$, which are the test parameters of the subjective evaluation procedures in this paper, it is deduced that when $BR = 2.5BR_L$, then the derived PQoS level approximates satisfactorily the maximum perceived quality level at a percentage of 90%. Moreover, solving (3) by α, it can be derived that

$$\alpha = \frac{\ln \frac{PQ_H}{PQ_H - PQ_L}}{BR_L}. \tag{5}$$

Replacing in (5) $PQ_H = 100$ and $PQ_L = 60$, it is deduced that

$$\alpha = \frac{0.92}{BR_L}. \tag{6}$$

Fig. 6 illustrates the graphical representation of (6).

Therefore, it is evident that the determination of the exponentially approximated curve of PQoS vs. bit rate for a specific video clip is possible, by first finding the value of BR_L from the corresponding curve of fps vs. bit rate (Fig. 2) and then using this BR_L value as input to (6), in order to find the corresponding value of parameter α. These two values (i.e., BR_L and parameter α) are sufficient to define the corresponding exponential (1) and ultimately define the bit rates that correspond to the various quality levels.

Referring to the curves of Fig. 1, it is obvious that the number of the significantly different quality levels depends on the dynamics of the video clip. Using a typical scale of PQoS, a low dynamic video clip will have short distance $[BR_L, BR_H]$ and therefore it is meaningless to offer the specific video clip at a lot of quality levels. Correspondingly, for a high dynamic video clip the offering quality levels will be many. So, it is up to the service provider to determine about the intermediate quality levels of a video clip, based on the bit rates that correspond to the lowest and highest quality levels, which are defined by the proposed method.

V. EXTENSION OF THE PROPOSED METHOD

The proposed method was also tested on actual video clips with various dynamics. The encoding format of these clips was MPEG-4 with 352×288 resolution (CIF) and 25 fps. Fig. 7 depicts the mean fps vs. the encoding bit rate for video clips, captured from a typical satellite TV program. From these figures, it is obvious that video clips with high dynamics (like swimming/sports) appear to have BR_L values higher than video clips with low dynamics (like talk show). So, it is evident that the metric BR_L is able to distinguish actual video content according to its dynamics.

The frame rates vs. bit rate curves were also derived for the five reference signals (Table 1) for the case of QCIF resolution. Fig. 8 shows the corresponding BR_L values of the five reference videos, when encoded with CIF and QCIF resolution, respectively.

From Fig. 8, it can be deduced that the reduction of BR_L is more than 50% when QCIF is used instead of CIF resolution. Provided that in the upcoming 3G mobile communication networks (UMTS) the user terminals will be equipped with small color screens (supporting QCIF resolution) and provided that the bit rate must be kept in significant low levels, it is obvious that QCIF resolution will dominate in the distribution of multimedia files in 3G mobile devices. To this direction the proposed method aims to contribute, as a part of real commercial applications.

Therefore, the objectively measured metric BR_L is able to

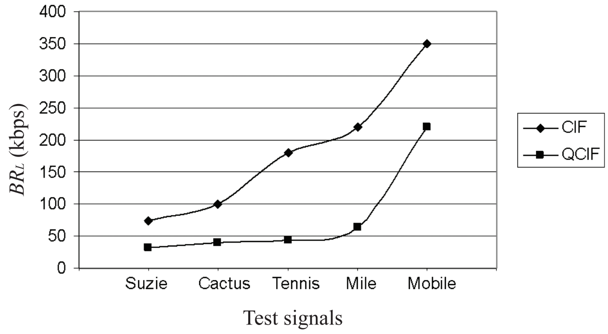

Fig. 8. The values of BR_L for CIF and QCIF resolution.

Table 2. The subjectively and objectively estimated BRL for the four test signals.

Test signal	Objectively estimated BR_L (kbps)	Subjectively estimated BR_L (kbps)
Suzie	75	80
Cactus	100	100
Table tennis	180	170
Flower garden	220	200
Mobile & Calendar	350	380

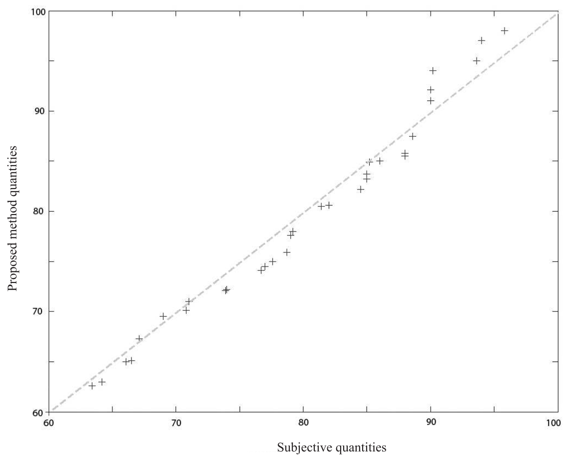

Fig. 9. The Q-Q plot of the subjectively and objectively derived data.

quantitatively estimate the perceived quality of a video content. This metric applies for both CIF and QCIF resolution and its validity has been successfully tested not only for reference video clips, but for actual TV clips, as well. The proposed method can be used for the provision of video content at different quality levels (and corresponding prices), a feature, which is considered significant in the provision of multimedia services in the upcoming 3G networks.

VI. EFFICIENCY EVALUATION OF THE PROPOSED METHOD

This section examines the efficiency of the proposed method. In this respect, it was performed a comparison between the quality evaluation data derived from subjective procedures and the data, which the proposed method provides. Regarding the efficiency evaluation, two separate tests were performed, where it was examined the efficiency of the proposed objective metric (BR_L) and the efficiency of the proposed exponential approximation method for estimating the PQoS level of an encoded video clip.

a. Efficiency evaluation of the objectively estimated BR_L

In order to examine the validity of the objectively estimated BR_L metric, the five reference video clips of Table 1 were used in CIF resolution. For these five reference signals, the objectively estimated BR_L values were derived (Table 2) from the corresponding fps vs. bit rate curves, which are depicted in Fig. 2. Furthermore, the same test signals were used as test bed in a subjective evaluation procedure, where the audience was asked to select the encoded video with the lowest acceptable quality level (i.e., tilling artifacts may appear but the video motion should be smooth, without pauses and interruptions). By this way the corresponding BR_L values were estimated subjectively. The results are depicted in Table 2 in conjunction with the corresponding objective ones.

Based on these results, it can be derived that the proposed metric provides accurate estimations and emulates successfully the corresponding subjective evaluation results with a worst case error equal to 10%.

b. Efficiency evaluation of the proposed exponentially based method for estimating the PQoS vs. bit rate curve

The efficiency of the proposed method for predicting the PQoS level of a test signal, was examined by comparing the quality evaluation results derived from a subjective evaluation process to the corresponding ones, which came from the proposed method. In this respect, an audience of ten people was asked to watch and evaluate the quality of five test signals, containing various TV captured dynamic contents (ranging from static to very active video contents). The test sequences were encoded from their original digital video (DV) format to DivX MPEG-4/CIF format at various constant bit rates (ranging from 80 to 1500 kbps) and 25 fps. The total number of the encoded test sequences was 35. Finally, the MOS for each encoded sequence was derived from the statistical process of the individual evaluations.

Afterwards, the proposed objective method was applied on the test signals that were used in this subjective evaluation process. By calculating objectively the corresponding BR_L values from the frame rate vs. bit rate curves and making use of the relation (6), then the determination of the (1) for each video clip was possible. Finally, the quality levels that correspond to each encoded bit rate, which was used in the subjective test, could be easily and quickly estimated, by simply solving (1).

Having derived both the subjective and objective scores for each encoded test signal, a Q-Q plot was drawn, in order to examine the efficiency of the proposed method. A Q-Q plot is illustrated based on values, which have been derived from two samples, and examines whether these two samples come from the same distribution type. If the samples do come from the same distribution then the plot is linear.

Fig. 9 depicts the Q-Q plot for the subjectively and objectively derived data for all the encoded sequences. As it can be observed, the distribution of the points is around and very close to the linear diagonal, which demonstrates the satisfactory fit of the two sets. Therefore, the proposed method of this paper provides, quickly and easily, reliable results of PQoS evaluation for MPEG-4 coded clips. In this respect, the proposed method can be commercially used and applied in the upcoming 3G/4G mobile communication systems, where multimedia services will be offered at multiple quality levels.

VII. CONCLUSIONS

The provision of audiovisual content at different perceived quality levels requires curves of PQoS vs. bit rate, which are usually derived via subjective methods, using an audience of people. This paper defines a metric for the quantitative estimation of the PQoS level and presents a method that is capable of making objective estimations of the perceived quality of audiovisual content. Showing that subjectively derived PQoS vs. bit rate curves can be successfully approximated by a group of exponential functions, the efficiency of the proposed technique is tested and proved that provides quick and efficient PQoS estimation, emulating successfully the corresponding subjective evaluation results. A series of experiments was also conducted with real video content, captured from common TV programs, showing that the proposed method can successfully estimate the PQoS level for encoded video clips in both CIF and QCIF formats. Given that in 3G/4G mobile communication systems, the multimedia services will be offered at various perceived quality levels, the proposed method can be valuable in 3G/4G mobile communication applications.

ACKNOWLEDGMENTS

The work in this paper was carried out in the frame of the information society technologies (IST) project Enthrone (FP6-507637).

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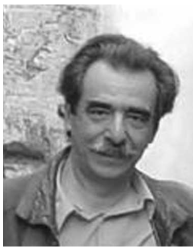

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