Picture quality measurements for digital TV

At last a way of measuring the quality of television! There is surely no viewer who would not appreciate it. But to allay great hopes – or even fears – it is not the quality of the contents of TV programs that is meant. This will remain the subjective judgement of the viewer. Here quality means the quality of the picture itself, the requirements and methods of measuring it, the associated problems and newly emerging solutions.

New requirements through digitization

Colour television is now in its thirties and the technique is more or less perfect. Why then think about picture quality? The answer is to be found in the transition from the analog TV set to the multimedia home platform. This means that TV terminals are going to allow the viewer to receive innumerable TV programs and work with interactive data services [1]. The basis of all this is digital video broadcasting or DVB [2].

This change greatly affects the picture quality. In analog television, quality is determined by the length and quality of the transmission path. The possible degradations are familiar enough: noise, reflections and blurred pictures. The poorer the transmission path, the poorer the displayed picture. Not so with digital TV. Here the picture quality is essentially determined at the beginning of the transmission link through encoding and multiplexing several programs in a transmission channel (transport stream). Given errorfree transmission of the data signal, the picture quality remains unchanged over the entire path (FIG 1).

Quality problems caused by encoding

Encoding is performed in line with the MPEG2 standard, which enables better utilization of transmission paths by drastically reducing the data rate of the digitized picture. The 270 Mbit/s source signal is converted in several steps to a signal of 5 Mbit/s or even less. Data compression of course affects the video picture. The art of encoding is to make the changes to the data stream so that they remain undetected by the human eye. This is more and more difficult to achieve with decreasing output rate. The picture content itself also has an effect. The finer and more irregular the structures, the more difficult encoding becomes. The MPEG2 standard only describes the tools for data compression and the syntax of the transmission signal. Outlay and quality of the implementation of a video encoder are left to the manufacturers. The achievable picture quality is therefore not only determined by the data rate and the source picture but also by the type of encoder used.

The changes caused in the picture by encoding differ completely from those encountered in analog transmission. The most clearly visible effect is blocking (FIG 2). The reason for this is that to perform data compression the picture is divided into DCT (discrete cosine transform) blocks of 8 x 8 pixels, ie it is converted from the time to the frequency domain. As a result all the measurement techniques used so successfully for many years in analog TV for determining the picture quality have become redundant.

Subjective quality measurements to ITU

How do you distinguish a good encoder from a less good one? How do you determine the minimum acceptable data rate? And finally, how can you monitor picture quality during transmission? These requirements call for a test method that evaluates the picture signal itself and takes into account the perception capabilities of the human eye. The best way would be to include the viewer in the process. There is no accounting for tastes however, so the results obtained this way could only be subjective. For comparison and reproduction of results, the ITU (International Telecommunication Union) specified several test methods [3].
Two methods are used among others. With the DSCQS (double stimulus continuous quality scale) method the test sequence to be judged and the original (e.g. before processing) are presented to the test person. A quality mark on a continuous scale is assigned to the two sequences, each of which is about 10 s long, and the difference is further evaluated. The employed scale of 0 to 100 covers the quality levels excellent / good / fair / poor / bad as specified by ITU and all values in between (FIG 3). This method permits even very slight quality differences to be resolved.

With the second method, called SSCQE (single stimulus continuous quality evaluation), only the sequence to be assessed is displayed. During the presentation the test person moves a slider on a scale from 0 to 100 according to his/her subjective impression of picture quality. This value is sampled at a frequency of 2 Hz, thus yielding two quality values per second. The method can be used when no original sequence is available as a reference and thus corresponds better to the real-life situation of the TV viewer who cannot see the picture recorded in the studio.

Both methods take into account the subjective perception of the human eye. It was found, for instance, that quality degradation in fast-motion pictures or pictures showing very many details is not perceived to the same degree as in slow-motion pictures or pictures containing few details only (masking effect caused by high level of activity in time and content).
New objective test method from Rohde & Schwarz

To obtain reproducible results from subjective tests, long test sequences have to be performed, which are very time-consuming. This may be acceptable for basic investigations but not for the quality assessment required during program transmission. For this reason Rohde & Schwarz started up the “picture quality analysis” development project. The aim of the project was the development of a method for realtime, objective quality assessment of DCT-coded picture sequences without needing a reference signal.

As in other developments in the past, the Institute for Communications Technology of Braunschweig Technical University was brought in to collaborate. The worldwide successful MPEG2 Generator DVG and Measurement Decoder DVMD are the result of such cooperation in previous projects [4]. In the present project the institute headed by Prof. Ulrich Reimers has developed the desired method, which is based on picture data analysis. The result of the analysis, the DVQL-W (digital video quality level – weighted), corresponds to the subjective quality value obtained by the SSCQE method on a scale from 0 to 100. It also takes into account the above-mentioned masking effect of human perception. The correlation between the objective quality values (DVQL-W) obtained with the new method and the subjective quality assessments (to SSCQE) performed as a trial is better than 90% (FIG 4).

The new method was presented to an astonished expert audience during lectures given at the annual meeting of the FKTG in Erfurt in May 1998 and at the IBC show in Amsterdam in September of the same year [5]. The topic is also receiving a great deal of attention in national and international technical publications [6; 7]. The demand is great, so Rohde & Schwarz is working intensively on getting an instrument onto the market that uses this method among others for the quality assessment of DCT-coded picture sequences in realtime and without a reference signal.

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REFERENCES