PEVQ™

ADVANCED PERCEPTUAL EVALUATION OF VIDEO QUALITY

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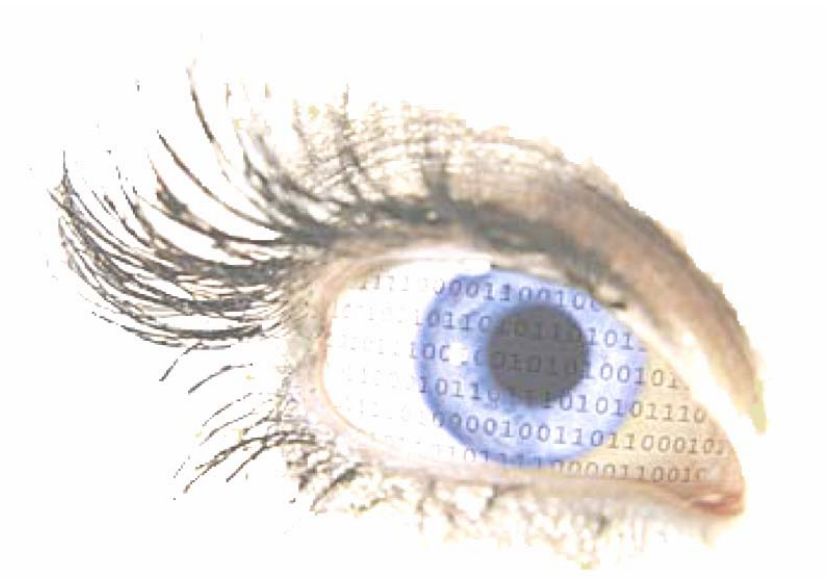

Further information:
www.pevq.org
www.peaq.org
www.pesq.org
www.3sqm.org
www.psqm.org

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1 EXECUTIVE SUMMARY

As with the new standards for global communications, like 3G/UMTS and WiMAX, new broadband mobile networks are becoming available, new services are added to the service provider's portfolio. Beside simple broadband data transmission services the providers offer more and more video and multimedia based services like …

- Video Telephony
- Video Streaming, and
- Video Messaging.

The quality of those services is crucial for the acceptance of the new offerings by the users, since nobody would pay for a service, too poor to be used. Hence, the demand for new quality measurement techniques is at hands.

OPTICOM has become well known in the industry over the last ten years of its existence, because of our achievements in successfully establishing state-of-the-art standards in the audio quality domain like **PESQ** (ITU-T P.862), **PEAQ** (ITU-R BS.1387) and **3SQM** (ITU-T P.563). OPTICOM now presents a new advanced measure for video quality. The Perceptual Evaluation of Video Quality (**PEVQ**) is like all the other measurements from OPTICOM based on the user's perception.

With OPTICOM's PEVQ OEM solution service providers are now in the position to monitor their video services as well as network equipment manufacturers and codec developers can test their hard- and software. T&M vendors get a new measurement technique at their hands to expand their portfolio by a reliable and effective video quality testing solution.

PEVQ was developed by OPTICOM in cooperation with the Institute for Mobile Communications at the University of Erlangen-Nuernberg, and comprises earlier work of KPN Research, the Netherlands.

PEVQ is available, now! And OPTICOM is more than happy to answer your questions.

2 INTERNATIONAL STANDARDIZATION

In the video domain, international standardization work is currently performed by the Video Quality Experts Group (VQEG), while the ITU-T is observing the progress. OPTICOM is actively participating in the VQEG work, while PEVQ is one of the promising models proposed for standardization. Results from standardization work are however not expected before the course of 2006. Of course, OPTICOM will take every means to ensure that PEVQ will continuously be kept up-to-date to incorporate the latest developments of this ongoing standardization work.

3 THE NEED FOR QUALITY TESTING

The need for testing the perceived quality of video information after transmission and decoding is a key element to guarantee for the customers' satisfaction, and thus the success of new video based services. The worst scenario that could, for example, happen to service providers is that the customers are annoyed by the poor quality-of-service in such a way that they are not likely to consider this new feature in the future at all. The second worst effect to be expected would be if customers are going to switch to a competitive operator that provides better service quality.

This is likely to spoil the revenue expectations for the value added by the video services on a large scale. However, all this is not unrealistically far-fetched, in particular when we keep in mind that customers expectations are well aligned from their daily television consume. Of course, mobile video transmission on every user's terminal represents an innovative advantage, still comparable to the introduction of mobile phones as such. Nevertheless, new technologies will not find acceptance if especially video information is not delivered in an acceptable quality. A bad video connection might severely disturb the speech link, even though the voice quality as such is excellent. These effects are known as audio-visual interaction and will be taken into account in the future design of perceptual measurements, too.

Let us take an example. As a matter of fact lossy coding techniques and noisy transmission channels may irreversibly destroy relevant parts of crucial information. A typical video coding technique using a simple block-matching algorithm can already tremendously impair a video signal, as depicted in the following sequences below. Figure 3-1 shows a single frame taken from a typical video stream – in this case, the red Ferrari of Michael Schumacher leaves the track and rushes into the green. The video content is undistorted and it can be seen that the Ferrari does not seem to be broken at all. Schumacher is doing ok – a vital information for every formula one fan watching the scene on his mobile.

Figure 3-1 Schumacher and the Ferrari are ok!

In Figure 3-2 a single frame from the decoded signal was taken – same scenery and action as in Figure 3-1, but this time, it cannot be seen whether the car is damaged or not, because of blocking artefacts and quantization noise the details got lost. The picture does not tell the true story, even worse it could give the wrong information on the outcome of the scene to a paying user.

Figure 3-2 Is Schumacher hurt and his car damaged?

The above example clearly proves that testing and quality-of-service assurance is of key importance and relevance for the business success of service providers, entering into the video domain, and the acceptance of new technologies as such.

4 SUBJECTIVE TESTING

The motivation for the development of objective models like PESQ, 3SQM and PEVQ is that they deliver quickly repeatable results with only a simple test setup for a much lower price than subjective tests. Subjective tests require a number of test persons, which have to listen to an audio file or watch a video sequence, while they have to score them. Often a separate room needs to be installed were the tests can take place; appointments have to be made with the test persons, and then it often takes even days until the first test results become available. In some applications subjective tests are even prohibitive.

However, subjective tests are a crucial task before objective measurement algorithms can be developed at all. This is because objective measurement algorithms model subjective tests. Only with a big fund of subjective measurement data objective algorithms can be made robust enough to accurately predict the human quality scoring.

At OPTICOM we conducted such subjective measurements of video quality in cooperation with the Institute for Mobile Communications at the University of Erlangen-Nuernberg. The picture below shows the test room, the scoring device and the display where the video sequences were played back. Of course all the used equipment and the test procedure were selected and prepared to match the required standards of the ITU-T and the VQEG.

Figure 4-1 Viewing test room at the University of Erlangen where OPTICOM conducted subjective tests. The test subject watches a scene on an adjusted TFT screen from a well defined distance. By pressing one of the keys, the test subject will be able to score the scene on the 5 point opinion scale.

5 INTRUSIVE TESTING

Intrusive test methods insert a reference signal into the device under test[1] (DUT) (near end side) while the processed and therefore possibly impaired file is recorded at the far end site (receiving side).

Like in a subjective test the used video signals are *natural[2] video samples (audio is optional)* with a length of several seconds. Using natural signals for the measurement is superior to applying artificial test signals, as they do not properly model a typical operation.

After the coding/transmission procedure the corresponding reference file and the processed (impaired) file are compared to each other.

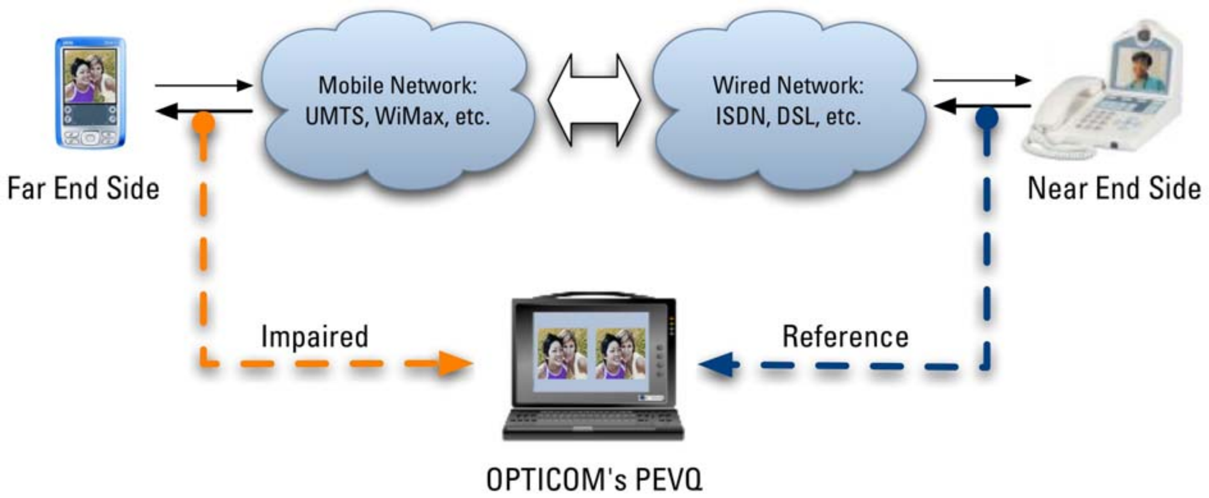

Figure 5-1 A typical setup for an intrusive test: The tester outputs a reference stimulus that is inserted into a network connection at the 'near end side' (origin), while the received signal at the 'far end side' (termination) is fed back to the tester for difference analysis.

However, due to the fact that the reference signal has to be inserted into the DUT, such measurements are called *'intrusive'*. The DUT can include a wide variety of codecs, networks, bandwidth, service types, etc.

[1] The device under test can be anything, e.g. a video codec, a wired/wireless network transmission line,

[2] 'natural' means in this context no artificially generated test samples, but samples of video content that is or will be most likely transmitted in such networks or coded by the appropriate codecs.

6 PERCEPTUAL EVALUATION OF VIDEO QUALITY

This chapter discusses OPTICOM's new video quality measurement algorithm in detail. The core of the algorithm is based on the research, which was done in the KPN laboratories by A.P. Hekstra and J.Beerends. OPTICOM improved the algorithm further and is now participating in the standardization competition carried out by VQEG and the ITU-T.

It must be noted that PEVQ is still in a very preliminary state and may therefore be subject to future improvements.

6.1 Structure of the PEVQ Algorithm

PEVQ is a full reference[3], intrusive[4] measurement algorithm for video quality. Its basic structure is shown in Figure 6-1.

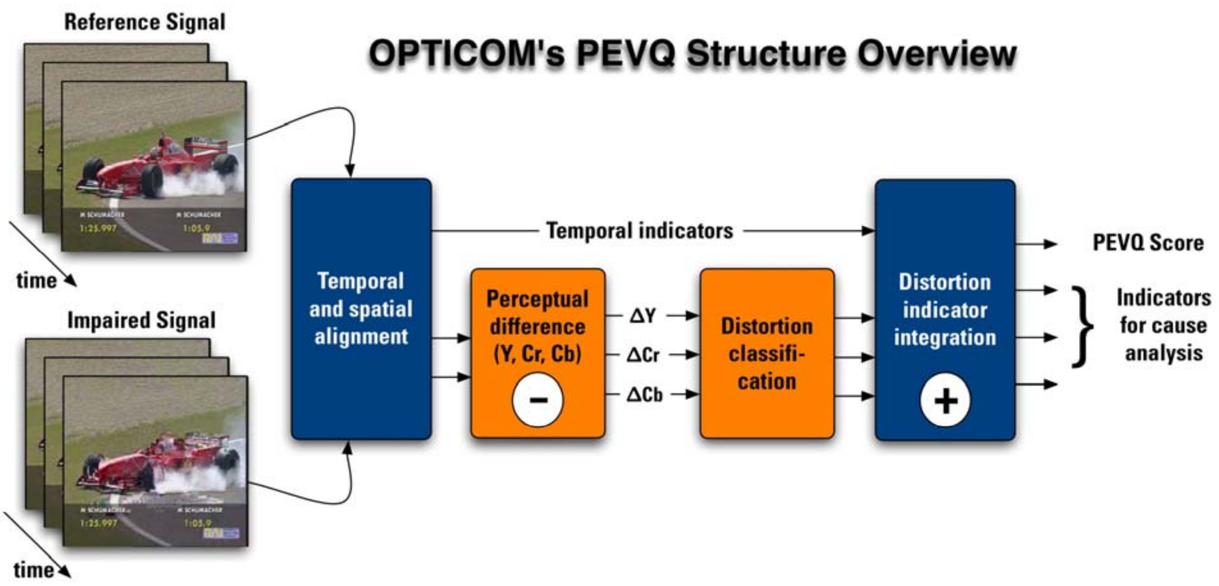

Figure 6-1 Block diagram of PEVQ

The algorithm can be divided up into four separate blocks. The first block – pre-processing stage – is responsible for the spatial and temporal alignment of the reference and the impaired signal. This process makes sure, that only

[3] Full reference measurement means that all information of the original, (not necessarily) undistorted video signal is required, thus it can be compared to the impaired video signal on a frame-by-frame basis. An alternative to this model would be the reduced reference model with which the reference signal is represented only by a few parameters instead of the complete video signal.

[4] Intrusive measurements need a reference signal, which is compared to the impaired signal being the result of a certain device under test (DUT). As a consequence for the DUT this means that a test signal (reference) will have to be sent through the DUT thus being an intrusion to the device.

those frames are compared to each other that also correspond to each other. It takes into account that variable temporal frame delays as well as shifts of the frame's content may have occurred due to the coding procedure.

The second block calculates the perceptual difference of the aligned signals. The perceptual difference is a weighted difference between a reference and an impaired signal with the emphasis on those artefacts, which are perceived by a human viewer. The module considers the differences in the luminance and chrominance domain and calculates quality indicators from them. Furthermore the activity of the motion in the reference signal provides another indicator representing the temporal information. This indicator is important as it takes into account that in frame series with low activity the perception of details is much higher than in frame series with quick motion.

The third block in figure 1 classifies the previously calculated indicators and detects certain types of distortions.

Finally, in the fourth block all the appropriate indicators according to the detected distortions are aggregated, forming the final result - the mean opinion score (MOS). The representation of the objective quality by a MOS is already known from speech quality models like PESQ and 3SQM. The MOS value describes the video quality on a range from 1 for very bad quality, to 5 for excellent quality. Beside the final quality score additional internal indicators are provided at the output of the algorithm for further cause analysis.

6.2 Supported File Formats

PEVQ is continously being improved. Missing features can be added quickly to this product. For further information please contact OPTICOM via email info@opticom.de or have a look at our web site www.opticom.de.

Supported frame format resolutions:

- CIF (352x288 pixels)
- QCIF (176x144 pixels)
- VGA (640x480 pixels)

Supported video file format:

- Microsoft AVI with RGB24 data

Supported frame rates:

- Basically all frame rates (30, 25, 15, 12.5, 8, 5, 2.5fps) are supported but it is recommended that reference files have a frame rate of 25fps. NOTE: Reference and impaired video file pair must have the same frame rate. If they have different frame rates up sampling of the file with lower frame rate is required – down sampling would possibly mean loss of information.

The current version of PEVQ is optimized for CIF sized video streams. VGA and QCIF formats should however work nevertheless, but with reduced prediction accuracy.

6.3 Features and Limitations of PEVQ

Currently there are no known limitations of PEVQ. But due to the early stage of the development, it is assumed that the prediction accuracy will continuously be improved.

6.4 Performance of PEVQ

Currently PEVQ is largely time consuming because of its very complex not optimized calculations. OPTICOM expects that within a very short time after this first release, the algorithm will be optimized to run at least in real-time on up-to-date PC systems.

6.5 KPIs Obtained from PEVQ

The intention of this subchapter is to give a short overview of PEVQ's key performance indicators (KPIs). PEVQ's KPIs are a number of extra parameters beside the overall quality of the video stream, which are partly also available at the output of the algorithm. They allow for a detailed cause analysis, if the quality of the measured video sequence is not satisfactory.

Note: In this first version of PEVQ only a few KPIs are presented. If you have e.g. suggestions on which parameters you are interested in or if you need further information towards this product please feel free to contact us info@opticom.de or visit our web site on www.opticom.de.

6.5.1 PEVQ Score

The PEVQ Score is the most important result and specifies the video quality on a MOS scale. The scale ranges from 1 for very bad quality to 5 for excellent quality. Please note that unlike the MOS scale, the PEVQ Score is not limited to the lower end of 1.0. When extreme artifacts occur scores smaller than 1.0 may be obtained. This behaviour is by design in order to allow for the assessment of severely distorted video sequences, whose quality is below the worst case of the MOS scale. The PEVQ Score is based on a multitude of perceptually motivated parameters. Most of these parameters are available internally only and are not presented as KPIs since their meaning to human beings is very limited.

6.5.2 Delay

The delay information is provided in the form of a buffer containing the delay for each test signal frame with respect to the reference signal.

6.5.3 Brightness

The brightness of the reference and the impaired signal.

6.5.4 Contrast

The contrast of the reference and the impaired signal.

6.5.5 PSNR

To allow for a coarse analysis of the distortions in different domains the peak signal to noise ratio (PSNR) is provided for the Y (luminance), Cb and Cr (chrominance) components separately.

6.5.6 Distortion Indicators

For a more detailed analysis the perceptual level of differences in the luminance, chrominance and temporal domain are provided.

7 PRODUCT AVAILABILITY

As the standardization is still ongoing but the need for video quality testing algorithms is at hand, OPTICOM is pleased to offer OPTICOM's new version for video quality testing in the first quarter of 2005.

7.1 Stand-alone OPERA Products

It can be expected that OPTICOM will release PEVQ as additional software plug-in to both, the OPTICOM OPERA stand-alone testers as well as the OPERA Software Suite. OPERA PEVQ will add the video capability to OPTICOM's general-purpose signal quality analyzer that today marks already the reference for PEAQ and PESQ perceptual measurements.

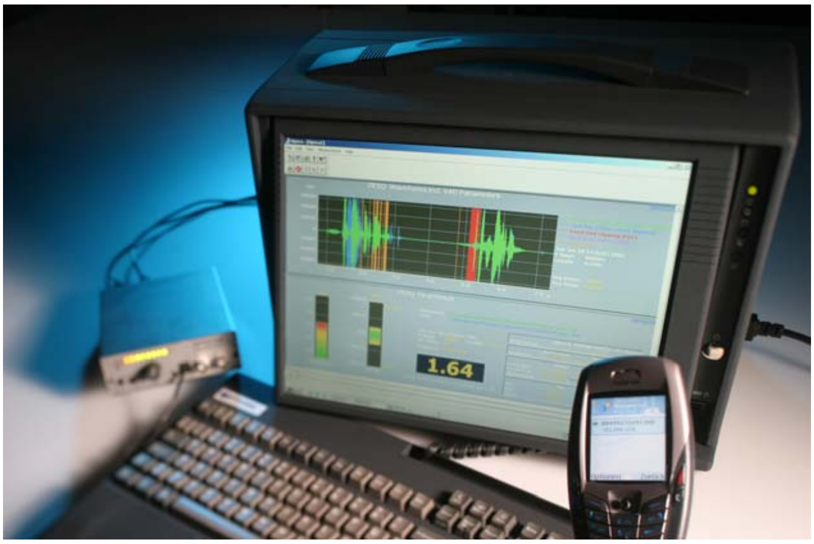

Figure 7-1 The OPTICOM OPERA Voice/Audio/Video Quality Analyser, offering PESQ, PSQM, PEAQ and soon also 3SQM and PEVQ analysis.

7.2 OEM libraries

In addition to the stand-alone OPERA products, OPTICOM will also add advanced PEVQ libraries for various common platforms to its portfolio of OEM libraries, available for licensing. An attractive licensing model will be available soon ensuring for a fast time-to-market for OPTICOM's OEM partners. It is expected that the licensing model will be composed of per unit or per channel fees, thus offering a flexible and largely scalable usage.

Today, an increasing number of 30+ well-known industry players, including the Who is who of the T&M manufacturers, are counted to our OEM licensees.

7.3 Integrated Network Management Systems

OPTICOM's licensing portfolio is completed with licensing models that are available for enterprise wide usage or company internal licensing. This will be a compelling approach to add PEVQ to existing or newly deployed QoS management systems, even if you are not an equipment manufacturer.

With its wide range of expertise, OPTICOM will also offer the services for integration and customer specific implementations.

8 ABOUT OPTICOM

OPTICOM, the world leader in perceptual voice and audio quality testing solutions and the technologies provider of techniques such as PSQM, PSQM+, PEAQ, PESQ and 3SQM addresses the testing advantages of utilizing ITU's current and proposed standards for today's and future networks.

Under the mission statement "quality is our business", OPTICOM focuses on top-notch developments to gain for its customers improved quality in audio and video communications. With the new OPERA™ family of perceptual analyzers, the company proves it's worldwide reputation for state-of-the-art solutions to improve the audio, video and multimedia quality of new media.

Its President Michael Keyhl founded OPTICOM in 1995 as a "spin-off" company of the Fraunhofer-Institute, Germany's leading organization for applied research. OPTICOM's developers benefit from their broad experience in the research and development of perceptual based coding and evaluation techniques, such as MP3 and NMR, lasting back to the late 1980's.

Through many international contacts and cooperation with leading research organizations, OPTICOM has today gained an active role in the international standardization business, e.g. of the new ITU-R standard PEAQ. OPTICOM is also continuously active in, or observing the work of the AES, EBU, ITU-T, ETSI, ISO/MPEG, VQEG and others.

After being successful in business for 10 years, the company is growing fast and seeking to expand the number of their employees. OPTICOM is located in Erlangen, Northern-Bavaria, GERMANY, and has just recently opened offices and distribution channels in the USA and Asia. For more information, please feel free to visit www.opticom.de.