



AccepTV

Solutions for perceptual video quality measurement
and acceptability control of audiovisual services



Video Quality Analyzer

Key Features

► Overview

Video Quality Analyzer (VQA) is the state-of-the-art solution to measure perceived video quality and to get detailed analysis reports on video quality and visual distortions.

Fully based on the modelling of the human visual system (HVS), VQA produces quality scores which are highly correlated with the human judgement of visual quality.

And good news: VQA evaluation is free.

► The difficulties in traditional video quality measurement

Video processing technologies evolve very quickly. For example, MPEG4/AVC (H.264) encoding, DVB-H broadcasting and HDTV display provide new services to the end-users and new technical challenges to broadcasters, content providers and video equipment manufacturers. Things go even further with HEVC and UHD TV.

The most decisive technical challenge to face is video quality optimization since, in the end, it is mainly video quality that leads the end-users to adopt new services.

But quality is a subjective notion. It may vary in an important manner from one observer to another. Therefore the most precise way to measure video quality is to collect human judgements, directly from human observers. This is called subjective video quality assessment. It consists in placing human observers in a normalized room and asking them to judge the quality of the videos they are being presented. To judge video quality, the observers use a voting scale which depends on the used protocol (for example, it ranges from 0 to 100 in the SAMVIQ protocol).

But subjective quality assessment is a very difficult task since many precautions have to be taken to make sure that the collected human judgements can be trusted. Indeed, these tests have to be performed in a normalized room in which the viewing distance and the ambient illumination have to be controlled. The test protocol must also be normalized, like the SAMVIQ or ACR protocols for example. Observers' sight should be tested too in order not to recruit observers having visual deficiency (short-sighted and not corrected observers, colour-blind observers). Normalized statistical methods have to be employed as well to detect and eliminate the observers that provided incoherent judgements. At last, the confidence interval of each mean opinion score (MOS) should be computed in order to

- **Video and audio quality analyzer** with DMOS prediction (perceived quality: QoE)
- **Measurement of blockiness, blur, contrast, flatness for both the reference video and the measured video**
- **Human vision modeling**
- **Compatible with the main encoding formats and containers:** MPEG-1, MPEG-2, MPEG-4, H.264, YUV (4:2:0, 4:2:2, 4:4:4), AVI, TS, MOV, WMV, MXF, ...
- Compatible with **all ratios** (4/3, 16/9, 1.85, 2.21, 2.35, custom ...)
- Compatible with **all resolutions** (SD, 720p, 1080i, 1080p, custom...)
- CBR and VBR **bitrate measurements**



Main Applications

know the precision of the tests results and to decide when the tests have reached a sufficient precision so they can stop.

Not only is subjective quality assessment difficult but it is also time consuming. Setting up the normalized room, performing the subjective tests and computing the results usually takes from 1 to 2 weeks for a set of 30 videos.

► The solution to these difficulties: VQA

Video Quality Analyzer (VQA) enables to measure perceived video quality without having to perform subjective video quality assessment tests. Thanks to the state-of-the-art precision of its video quality measurement technology, there is no need to set up a normalized tests room and to spend time recruiting observers and performing subjective testing.

VQA quickly provides precise video quality measurements but it also generates very detailed analysis reports on video quality and visual distortions.

When measuring video quality, VQA also measures the video bitrate. This feature enables VQA to generate various "Perceived video quality vs. Video bitrate" curves which enable to determine optimal encoding bitrates.

► VQA for broadcasters

These measurements provided by VQA are essential for any broadcaster or content provider who wants to precisely **determine the optimal broadcasting bitrates to reach given quality levels.**

Determining these optimal broadcasting bitrates enables users to save money on bandwidth cost or to broadcast more programs or services using the same bandwidth.

► VQA for content providers

VQA is also an irreplaceable tool to **compare different video encoders** (different manufacturers, different firmware versions) in order to **select the one providing the highest quality.**

Once this selection has been made or if encoders had been bought beforehand, VQA enables to find the optimal encoding parameters (bitrate, GOP size, quantification, pre-processing...) in order to maximize perceived video quality.

► VQA for video equipment manufacturers

- **select the best software or hardware video encoder** on the market
- **determine the optimal bitrates** to broadcast at a given quality level
- study the variation of **perceived video quality with respect to the video bitrate**
- **optimize encoding parameters**
- **test a SDTV, HDTV or mobile TV broadcasting chain**
- **validate non regression** of new firmwares
- **control the quality** of a VOD encoding process
- **test video decoders** (Set Top Boxes)

Key Advantages

- High precision of the computed video quality scores (compared to the quality judgments given by human observers): linear correlation coefficient between computed video quality scores and subjective scores > 0.924



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Solutions for perceptual video quality measurement and acceptability control of audiovisual services



VQA is a powerful tool to **accelerate the development of video encoders**. Indeed, during firmware optimization, VQA enables to make the right decisions and to choose the new tools that have to be implemented to efficiently increase perceived video quality.

VQA also permits to verify non regression before releasing firmware updates.

► Video quality measurement technology overview

VQA produces quality scores which are highly correlated with human judgement of visual quality thanks to its video quality measurement architecture which reproduces the behaviours of the display device and of the human visual system (HVS).

This technology is based on the architecture represented in Fig. 1.

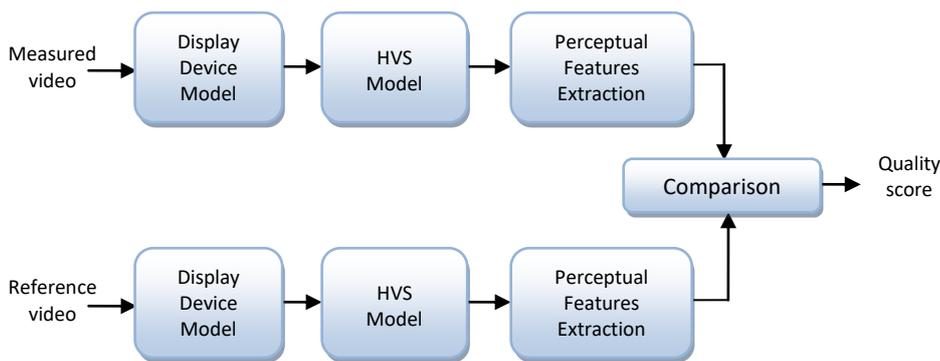


Fig. 1 – Video quality measurement technology architecture

In this architecture, the key processings are the HVS modeling and the perceptual features extraction. The HVS modeling projects the video into a perceptual representation domain. This step mainly corresponds to the processing performed in the retina and in area V1 of the visual cortex.

Then, perceptual features are extracted. They are similar to the features extracted in areas V1 and V2 of the visual cortex. They mainly describe structural information, visual contrast, activity and colour, at a local level.

At last, the perceptual features extracted from the measured video are compared to the perceptual features extracted from the reference video. These distortions produce a quality score which is then projected on a DMOS scale to constitute the "predicted DMOS".

► MOS, DMOS and "Predicted DMOS" explained

Key Advantages

- Integrated HTTP server for distant results consultation and automatic reporting (TXT, CSV, HTML)
- Integrated database to store results
- Automatic monitoring of an encoding process (watch folder): measure the quality of each new video in a folder (and its subfolders)
- Audio decoding, audio synchronization and audio quality measurement
- Send reports/alerts by email
- User-chosen audio/video decoders: integrated decoders or external (DirectShow) filters
- Work in real time



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Solutions for perceptual video quality measurement
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MOS stands for “Mean Opinion Score”. The MOS of a given video sequence is the mean value of all the subjective scores collected during subjective video quality assessment tests for this video sequence. **When the MOS increases, quality increases.**

During the subjective video quality assessment tests, the observers judge the quality of distorted videos but they may also judge the quality of their reference videos. Since reference videos are not distorted, they get very well scored by human observers. However they rarely get the maximum value. For example, on a voting scale ranging from 0 (lowest quality) to 100 (highest quality), a reference video may have a MOS of 95, meaning that most observers found its visual quality excellent but some observers (or all of them) gave it a score lower than 100. This may be due to the fact that these observers didn't like the video content very much (for example, the video represented soccer whereas some observers don't like that or the video had a little but visible acquisition noise).

The DMOS is the “Differential Mean Opinion Score”. **The DMOS of a video is the MOS of its reference minus the MOS of this video.** Therefore, if the DMOS is 0, it means that the measured video has the same quality as its reference video. And **when DMOS increases, quality decreases.** When measuring the quality of a video using its reference video, the quality score to consider is the DMOS rather than the MOS. Indeed, using the DMOS rather than the MOS enables to decrease the effect of content familiarity or reference artefacts in the observers votes.

The Predicted DMOS is the score computed by a video quality measurement technology and which is supposed to be very close to the DMOS (given by human observers' votes).

Increasing the correlation between the computed quality scores and the subjective quality scores is a constant goal in AccepTV's advanced research. Today, VQA has the highest precision on the market since the linear correlation coefficient between the computed video quality scores and the subjective quality scores is greater than 0.924 (the maximum theoretical value is 1 but it cannot be really reached since the subjective scores vary by nature and a maximum practical value of 0.95 is commonly admitted).



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Solutions for perceptual video quality measurement and acceptability control of audiovisual services



► Main interface

The main interface of VQA, represented in Fig. 2, gathers all the parameters required to easily perform video quality measurement of several files. It also provides useful information on video and audio formats, synchronization, bitrate and quality analysis.

The screenshot shows the AccepTV Video Quality Analyzer interface. It features two main video preview windows: 'Reference file' and 'Measured file'. The 'Reference file' window shows a video of a tree in a forest, and the 'Measured file' window shows the same video with some distortion. Below the preview windows, there are controls for file selection, video and audio format information, and playback controls. On the right side, there are several panels: 'Synchronization parameters' with fields for frame offsets and spatial/zoom sync options; 'Quality measurement parameters' with fields for temporal and spatial offsets; and a 'Task manager' section with buttons for 'Stop', 'Start', and 'Open'. At the bottom, there are buttons for 'Measure Video Quality', 'Process all frames', and 'Check sync parameters'. The interface is annotated with several orange callout boxes:

- Reference video (selection, audio video streams description, seek bar)**: Points to the reference video preview window.
- Measured video (selection, audio video streams description, seek bar)**: Points to the measured video preview window.
- Progress bar and remaining time**: Points to the progress bar below the measured video preview.
- Run synchronization only**: Points to the 'Synchronize videos' button in the synchronization parameters panel.
- Synchronization parameters (search windows sizes)**: Points to the synchronization parameters panel.
- Settings, wizard and Watch Folder**: Points to the 'Settings...', 'Wizard...', and 'Watch folder...' buttons in the left sidebar.
- Run synchronization then run measurement in one click**: Points to the 'GO (synchronize, then measure video quality)' button.
- Information during synchronization and measurement**: Points to the 'Task manager' section.
- Status (task manager, http server, database, Watch Folder)**: Points to the status information in the task manager section.
- Measurement parameters (detected synchronization offsets and frames range to)**: Points to the 'Quality measurement parameters' panel.
- Run measurement only**: Points to the 'Measure Video Quality' button.
- Open/close monitoring windows (quality curves, images, distortions, bitrate, waveforms, magnifying glass...)**: Points to the 'Monitoring' section in the left sidebar.



Fig. 2 – Main interface of VQA

► Using VQA in a typical case

Typical case overview

In a typical use case, the quality of a video at the output of an encoder is measured using, as reference video, the video at the input of the encoder. This case is represented in Fig. 3.

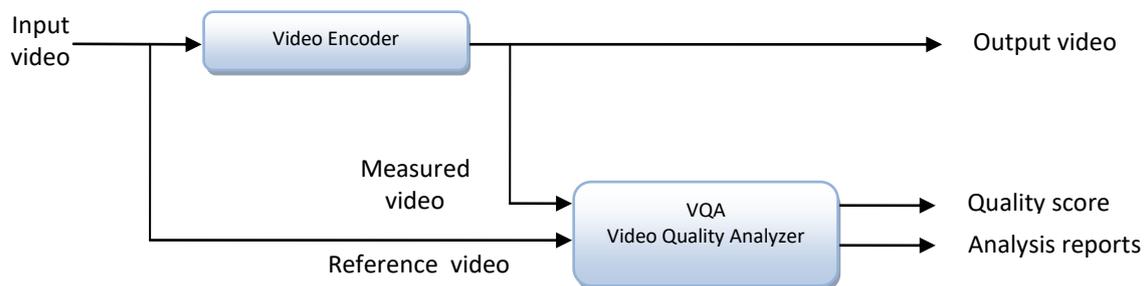


Fig. 3 – Typical use case of VQA

VQA default settings are predefined for this use case in which:

- There are temporal and/or spatial offsets between the measured video and the reference video but these offsets remain constant all along the measured video (there are no frames lost)
- There is no resizing before encoding (for example, the input format and the output format are both 1080i).

Video and audio decoding

The measured video and the reference video (and their audio tracks) are often encoded, that's why VQA directly uses a decoder. The user can choose between the integrated decoding libraries or external decoders (DirectShow codecs). This choice can be made independently for the measured video and for the reference video. If the video is uncompressed or already decompressed, VQA supports the main YUV formats (4:2:0 planar, 4:2:2 planar, 4:2:2 UYVY, 4:2:2 YUYV, 4:4:4 planar) and YUV data encapsulated in AVI.

Synchronization (Alignment)

Before measuring video quality, it is necessary to temporally and spatially synchronize (i.e. align) the measured video and the reference video. VQA enables to perform these two tasks (synchronizing and measuring quality) in one click or separately.

The synchronization may use parallel processing in order to accelerate computation. This is recommended if the machine has several CPUs. The number of CPUs can be defined in the settings.



AccepTV

Solutions for perceptual video quality measurement
and acceptability control of audiovisual services



The only input required from the user is to define the sizes of the search window. For example, a temporal search window of 5 frames indicates that temporal offsets ranging from -5 to +5 frames will be tested. Including the "0 frame" offset, it means that 11 temporal offsets are going to be tested and the offset returning the highest synchronization between the videos will be selected. If the user is not sure about the search window to test, he can simply enter a "large" search window (+/-1500 frames which means +/- 1 minute at 25 fps for example).

In order to avoid synchronizing using black frames (at the beginning of a movie for example) or using still frames, synchronization is performed using frames containing spatio-temporal activity. These frames are automatically detected and used.

Spatial synchronization can also be performed in order to detect if frames have been shifted by one or several lines and/or one or several columns.

Zoom synchronization can be performed as well because it has been noticed that, on certain hardware, some lines or columns could be removed, resulting in a stretched output signal (for example, the 1080 input signal was transformed into a signal with 8 black lines and 1072 signal lines).

Video synchronization is frame accurate. More, when videos are interlaced, 4 reading modes can be tested during synchronization for each video (measured and reference):

- Mode 0 : normal mode, when frame N is asked, frame N is returned;
- Mode 1: swap fields, when frame N is asked, frame N is returned but with its top and bottom fields swapped;
- Mode 2: when frame N is asked, a frame constituted by the bottom field of frame N-1 and the top field of frame N is returned;
- Mode 3: when frame N is asked, a frame constituted by the bottom field of frame N and the top field of frame N+1 is returned.

When videos are progressive, only mode 0 is enabled. When videos are interlaced, testing several reading modes during synchronization enables to detect the correct synchronization to perform when using some hardware which transforms a top field first video (in input) into a bottom field first video (in output).

During synchronization, a monitoring window indicating the compared frames is displayed, as indicated in Fig. 4.

At last, audio synchronization is also performed if audio quality measurement is enabled (in the settings). Audio synchronization is sample accurate.



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Solutions for perceptual video quality measurement
and acceptability control of audiovisual services

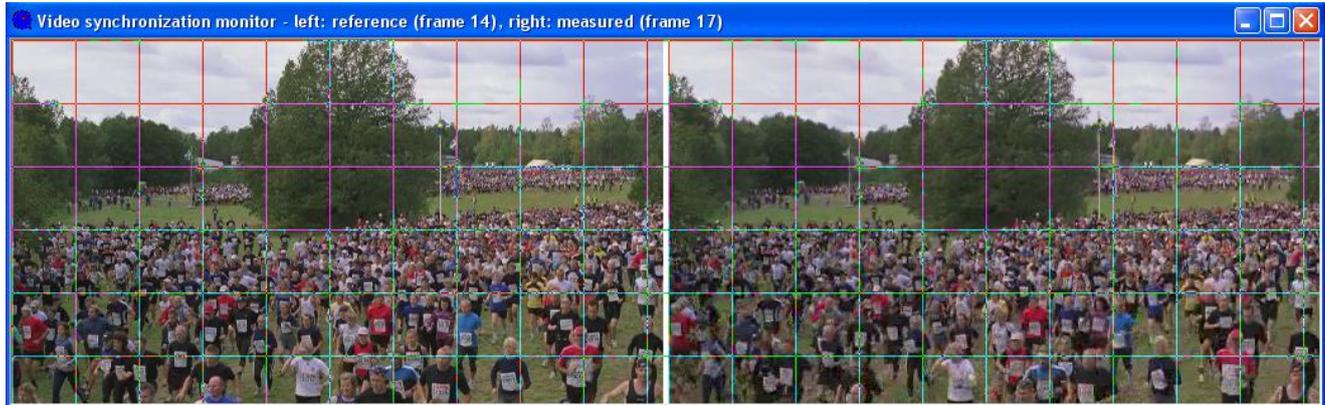


Fig. 4 – Video synchronization monitoring window

Video quality measurement and audio quality measurement

Video quality measurement can be performed on the whole video sequence (by default) or on a certain frames range.

Like synchronization, quality measurement may use parallel processing (if the machine has several logical CPUs) in order to accelerate computation.

During video quality measurement, several monitoring windows are available showing:

- the video quality curves (as represented in Fig. 5),
- the audio quality curve (if audio quality measurement is enabled in the settings),
- the measured frame,
- the reference frame,
- the seamless frame (left part of the reference frame and right part of the measured frame),
- the distortion frame (measured frame minus the reference frame),
- the bitrate curves: bitrate curve of the measured video and "bitrate vs. quality" curves.

The video quality curves contains 3 curves:

- the intrinsic frames quality curve (without temporal effect) ,
- the frames quality curve: the quality of each frame (with temporal effect) ,
- the DMOS curve : highly correlated with human judgement.

For each of these curves, when the curve goes up, quality increases (and when the curve goes down, quality decreases).

These curves are described hereafter.

When video quality measurement has been performed, a global quality score (DMOS) for the whole sequence is computed. All the computed results are stored in an integrated database. At last, characteristic frames (frames of worst and best quality) are saved to disk in order to display them in the results pages of the integrated web server. The adaptive thresholds which help determining which frames are considered as characteristic frames can be defined in the settings.



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Solutions for perceptual video quality measurement
and acceptability control of audiovisual services



Fig. 5 – The 3 video quality curves

The intrinsic frames quality curve (without temporal effect): This curve indicates the perceived quality of each frame, independently of its surrounding frames (without temporal effect).

The frames quality curve (with temporal effect): Compared to the intrinsic frames quality curve (without temporal effect), the frames quality curve (with temporal effect) computes the quality of a given frame by taking the quality of the previous frames into account. This corresponds to a property of the human visual system: humans are "quick to criticize, slow to forgive". In order to illustrate this behaviour, please consider human observers watching a good quality video. Now let's imagine that a visible distortion appears. When the distortion appears, the quality judgement of the human observers decreases nearly instantly ("quick to criticize"). However, when this distortion disappears, their human judgement takes several seconds to come back to its previous state that was judging that the video has a good quality ("slow to forgive"). This is the temporal effect implemented in this curve that indicates the quality of each frame, taking into account the previous judgements.



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Solutions for perceptual video quality measurement
and acceptability control of audiovisual services



The DMOS curve: Humans cannot assess the quality of each frame distinctively (because the frame rate is too high for that). Therefore, when human observers formulate a quality judgement, they perform a temporal integration over the feelings they had in the previous few seconds. So does the DMOS curve. Each point of this curve integrates the previous 5 seconds of frames quality scores (with temporal effect). That's why the DMOS curve only starts at the 125th frame when the video has a frame rate of 25.0 fps (because $25.0 * 5 \text{ seconds} = 125 \text{ frames}$, and 125 quality scores are required to compute a DMOS).

The DMOS values computed by VQA are highly correlated with the DMOS obtained during subjective quality assessment tests with human observers.

The measured frame: local analysis

As shown in Fig. 6, the measured frame window can emphasize the zones which are distorted above a user-defined threshold (selectable in the main interface of VQA and expressed on the DMOS scale).



Fig. 6 – Most distorted zones emphasized

► Using VQA for video which have been captured after broadcasting

Broadcasting may lead to transmission errors. If these errors are important (and especially with H.264 in which every transmitted bit contains more information than with MPEG-2), some frames may be lost.



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Solutions for perceptual video quality measurement
and acceptability control of audiovisual services



Lost frames change the synchronization and may lead to erroneous video quality measurements. To avoid that, resynchronization may be performed on each frame, before its video quality measurement, to ensure that video quality is measured using the correct reference frame.

Therefore, when the measured video may have lost frames, resynchronization should be enabled (in the settings) before proceeding.

► **Using VQA for video which has been resized (for DVB-H for example)**

When the measured video has been resized in an important manner (from HD to QVGA for example), the Lanczos resizing should be enabled (in the settings). This enables to use state-of-the-art resizing filters and to take a better reference video into account (compared to the use of the default nearest neighbour interpolation).

AccepTV's implementation of Lanczos filtering also permits users to test phase shifts. Indeed, several mobile TV encoders perform phase shifting when resizing video. If phase shifting has to be tested, the phase shifting search windows (along width and height) can be defined in the settings.

► **Web interface**

VQA runs an HTTP server (on port 80 by default) which enables to consult the synchronization results and the quality measurements remotely using a web browser (Mozilla Firefox, Chrome, Internet Explorer...). This web interface also enables an administrator to remove some results from the integrated database and to remove tasks waiting to be processed.

The web interface also enables to:

- see the list of processed videos with the audio/video quality measurement results and synchronization parameters (detected offsets, used search windows);
- consult and navigate (with zoom in/zoom out capabilities) the quality curves and bitrate curves;
- generate TXT, CSV and HTML reports;
- examine the characteristic images (with or without emphasizing the most distorted zones)
- superimpose several curves (for several measured videos having the same reference video)
- generate the "Perceived quality vs. Video bitrate" for several measured videos having the same reference video (each video is a point in the curve)

The main menu of the web interface is shown in Fig. 7 while Fig. 8 presents a page containing the characteristic frames (worst and best quality) of a processed video.



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and acceptability control of audiovisual services



Video Quality Analyzer - Windows Internet Explorer

http://127.0.0.1:8081/

Video Quality Analyzer
by AccepTV

Main menu

Processed videos	Display the list of videos for which visual quality has been measured.
Tasks	Display the list of tasks being processed.
Sync	Display the results of temporal and spatial alignment.
Failed sync	Display the list of videos for which synchronization has failed (adjust sync parameters manually).
DB content	Display the full content of the database.
HTML report	Generate a measurement report in HTML format (with images and curves).
HTML report in French	Generate a measurement report in HTML format (with images and curves). Text is in French.
Quick list	Generate the quick list of the results.
Administrator login	Enter the password to log in with administrator rights.
Change administrator password	Change the administrator password.

1 connected user(s) - 1 task(s) - 18 video(s) and 65 event(s) in database

AccepTV HTTP server v1.0 - Page generated in 0 ms

Done Internet | Protected Mode: Off 100%

Fig. 7 – Main menu of the web interface



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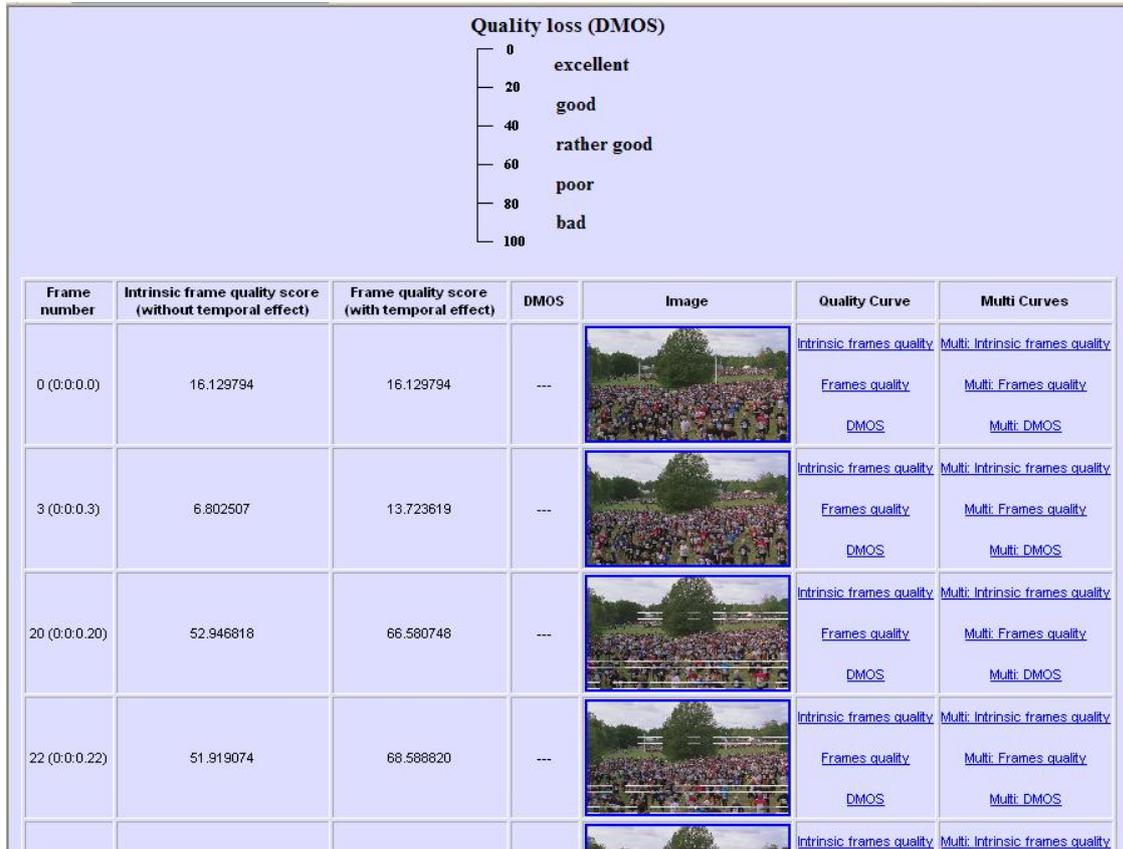


Fig. 8 – Characteristic frames

► Options

VQA is available with several options:

- **Option "Hardware"**: VQA can be supplied with an adapted hardware (high-end PC, in rackable 1U unit, rackable 3U unit, tower or mini-tower).
- **Option "ProcessX"**: playing, streaming and recording (and more) of videos over HDMI, SDI/HD-SDI, RJ45 (UDP, RTP) for automatic quality analysis of video equipment using a set of videos.

This option is particularly interesting for video equipment manufacturers. With this option, VQA turns into an **automatic video test platform**.

- **Option "YUV Convert"**: software to convert videos or lists of images to YUV formats and to apply video processing (cropping, reverse frames, downscaling/upscaling, fields swapping, insertion in a bigger video).
- **Option "3-year technical support and software updates"**: by default, technical support and software updates are included for one year with every license of VQA. With this option, you can extend this period to 3 years.



► Details on the option "ProcessX"

Video equipment manufacturers have to test every new version of their products in order to check the performances and verify non regression. This is particularly complex and time consuming when checking video quality.

The "ProcessX" option enables to **simplify this testing**. After having selected a set of reference videos, the user can play them to a video encoder (or stream them to a decoder) and capture the resulting videos **with just one click**. More, the **perceptual video quality** of the captured videos is **automatically measured** and a **detailed video quality report** is generated. This organization is shown in Fig. 9.

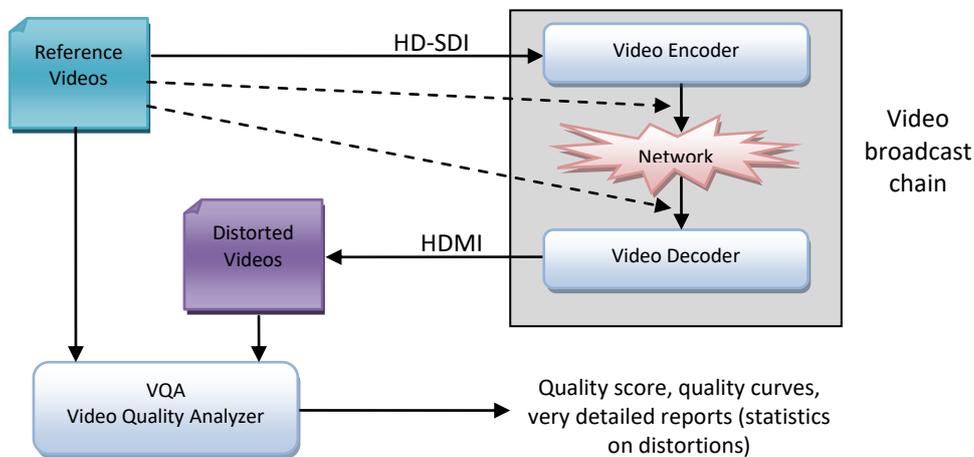


Fig. 9 – Automatic test platform organization

KEY FEATURES

- Perceptual video quality measurement
- Playing of compressed or uncompressed videos on HDMI, SDI, HD-SDI or Composite
- Streaming of compressed videos on an Ethernet RJ45 port (UDP RTP/RTSP)
- Capture of uncompressed video from HDMI, SDI, HD-SDI or Composite
- Bitrate measurement and automatic "Quality vs. Bitrate" curves generation for sets of videos

APPLICATIONS

- Video quality testing and validation of video encoders
- Video quality testing and validation of video decoders
- Video quality testing and validation of broadcasting chains

The main interface of "ProcessX" is presented in Fig. 10.

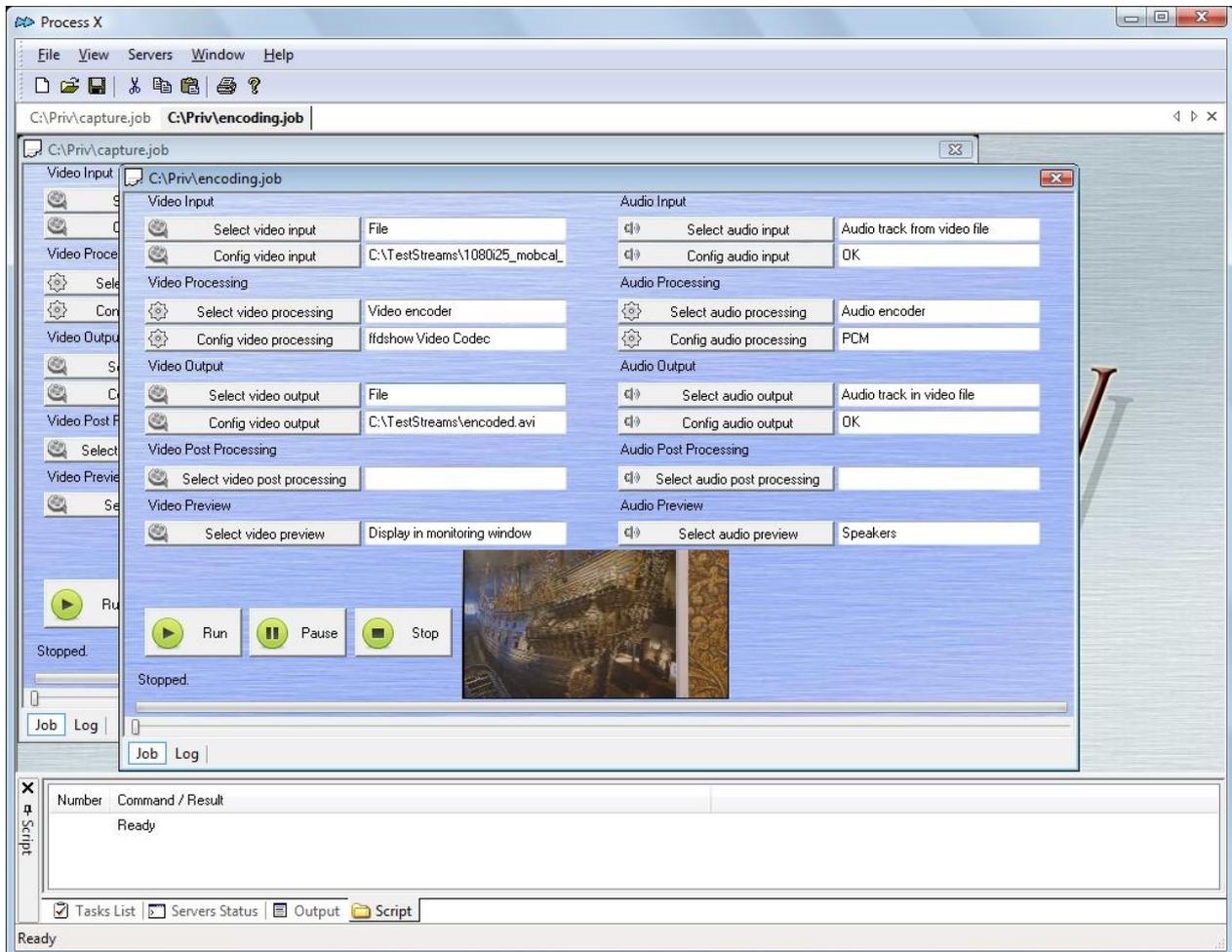


Fig. 10 – The ProcessX interface

► Shipping information

Reference	Description
VQA-400S	VQA software only
VQA-400HT	VQA with server type PC (tower)
VQA-400HM	VQA with server type PC (mini-tower)
VQA-400R1U	VQA with rackable 1U unit
VQA-400R3U	VQA with rackable 3U unit

Option reference	Description
VQA-PX	ProcessX option
VQA-YUV	YUV Convert option
VQA-3Y	3 year technical support and software updates